REGIONAL AGGLOMERATION AND TRANSPORTATION IMPROVEMENTS IN POSTWAR JAPAN: THROUGH MACRO-ECONOMETRIC MODELLING

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1. INTRODUCTION

The rapid economic growth that Japan has experienced in the post-war era has resulted in monocentric effects of spatial agglomeration. Tokyo, which has historically always had a disproportionate denseness of population, is now even more obviously the centre of an intense agglomeration. This degree of intensity is seen clearly prominent when a comparison of regional population increase over the recent history is made for *Kansai and Kanto§1*; over 1920-85 the latter indicating a four-fold increase from 6.36 mill. to 25.0 mill., with a doubled national share from 11.3% to 21%, while the former though moves from 6.74 mill. to 17.4 mill., shows an almost stable national share marginally growing from 12% to 14.7%.[1]

Although the four National Development Plans implemented in the post-war period[2] were aimed at achieving a certain dimension of dispersion of this spatial agglomeration mainly through changes of transportation infrastructure, rather unfortunately had failed to produce the intended effect, but on the contrary had helped to aggravate the situation, propelling congestion and rocketing of land values both obviously resulting in disutility for individuals; and other environmental side-effects such as air pollution.

The focus of the study is to view the concepts behind the process of spatial agglomeration in Japan: the historical scenario, and thereby analyse strategic policies leading to the reduction of adverse effects. In this respect we adopt a macro-econometric modelling approach to fulfill the objectives.

Rest of the article is structured as follows. In Section 2 we discuss the preliminaries in formulation of the model, including the data requirement, availability, and compilation in brief. Section 3 looks into the general outline of the model that we introduce here. This discussion is furthered in Section 4 where the relevant economic implications are the main focus while those are supported by the parameter estimates. In Section 5 the test simulations and a case study are conducted. Finally in Section 6 concluding commments from the analysis are given.

2. GENERAL CONSIDERATIONS

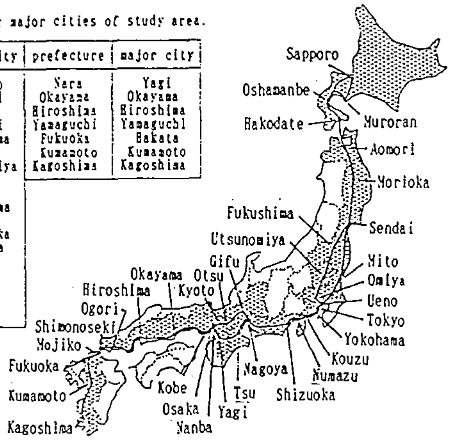
2.1 Basic features

(1) Spatial levels: The study area selected consists of 25 *prefectures§2* overlain by a national trunk line*§3* from Kagoshima to Sapporo, as in Figure 2.1. We consider the nation to consist of the study area of 25 prefectures and the *other area* of 22 prefectures as a whole.
(2) Classification of Activities: Activities are classified according to *major industry group* of *Population Census*. viz. primary, secondary, and tertiary industries constitute the three sectors

considered. Thus employments, products, productions, and final demands fall into these.

Prefectures and their major cities of study area.

prefecture	major city	prefecture	major city
Hokkaido	Sapporo	Nara	Yagi
Aomori	Aomori	Okayama	Okayama
Iwate	Iwate	Hiroshima	Hiroshima
Miyagi	Sendai	Yamaguchi	Yamaguchi
Fukushima	Fukushima	Fukuoka	Hakata
Ibaragi	Mito	Kumamoto	Kumamoto
Tochigi	Utsunomiya	Kagoshima	Kagoshima
Saitama	Omiya		
Tokyo	Tokyo		
Kanagawa	Yokohama		
Gifu	Gifu		
Shizuoka	Shizuoka		
Aichi	Nagoya		
Mie	Tsu		
Shiga	Otsu		
Kyoto	Kyoto		
Osaka	Osaka		
Hyogo	Kobe		



prefecture	abbreviation
Hokkaido	HKD
Aomori	AMR
Iwate	IWT
Miyagi	MYG
Fukushima	FKS
Ibaragi	IBG
Tochigi	TCG
Saitama	STM
Tokyo	TKY
Kanagawa	KNG
Gifu	GIF
Shizuoka	SHZ
Aichi	AIC
Mie	MIE
Shiga	SHG
Kyoto	KYT
Osaka	OSK
Hyogo	HYG
Nara	NAR
Okayama	OKY
Hiroshima	HRS
Yamaguchi	YMG
Fukuoka	FKO
Kumamoto	KMM
Kagoshima	KGS
other area	OTH

Fig 2.1 National trunk line based study area

(3) Dynamic Aspects: Concerning the period studied, the present needs of the study are confined to the formulation of a pilot model spanning the post-war period from 1950-85, while our ultimate goal is the extension of above to a *long-term historical review* from 1920. Here what we attempt to formulate is yet another operational model possessing dynamic aspects of recursive nature. For the compatibility with the years of population census our simulation cycles are spaced at 5 years. Thus there could be atmost 7 cycles, but second order lags in the models reduce this effect to 5.

2.2 Data Requirement and Compilation

Obviously any operational model requires a strong statistical backing which then depends on data resources, since one of the most important practical constraints is the scope of data that can be made available. Indeed, the model we introduce here is no exception to these limitations. Infact the lengthy period studied imposes the greatest restriction on data. Primary sources of data are available from *Population Census of Japan*, *Statistical Yearbook of Japan*, *Manufacturing Census*, *Prefectural Accounts*, *National Accounts*, and *National Input-Output Tables*. However, almost all above do not supply us with a detailed set of data to work with. In light of these considerations and qualifications it was necessary to compile the most appropriate set of data recursively focussing on *possible model structure,* and *data availability,* alternatively improving each other*§4*.

3. OUTLINE OF THE MODEL

As we have already outlined the basic features of the model now we proceed to the discussion of its overall formulation, as illustrated in procedure flow in Figure 3.1.

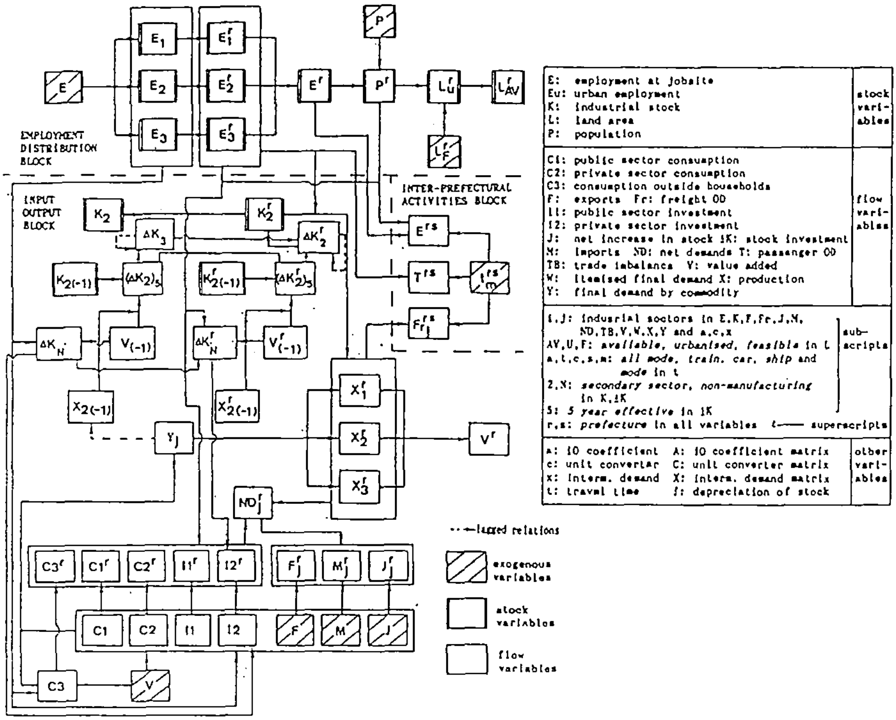


Figure 3.1 Procedure flow of the model and nomenclature

The variables used can be largely divided into stock and flow aspects. Spatially we have both national and prefectural entities, and the inter-prefectural ones as well. Again there are exogenous variables in all those categories at each spatial level, while exogenous coefficients belong to the national level. Major exogenous variables considered are national employment and population, GNP, total and feasible land areas, depreciation rate in secondary sector stock, IO coefficients and unit converters of IO table, and inter-prefectural travel times. In the text the variables without any ' superscript denote their national entities. The model is composed of 3 major blocks: *employment distribution*, *input output*, and *inter-prefectural activities*, and are linked to form a recursive dynamic model in its overall structure, while each of them is constructed to be sensitive to exogenous policy variables.

3.1 Employment distribution block

In this block mainly the stock aspects are distributed to sectors or the lower spatial level. Starting with the national employment, it is distributed to the 3 industrial sectors as indicated in the flowchart. These again are subject to spatial distributions according to the economic theories in choices of individuals. Allocation of exogenous national population to spatial units is also a process of such choices. Urban landuse activities are the last aspect in focus here, implicitly considered in urban land area at prefectural level, from which follows the identity relation of available land which is the difference between the feasible and urbanised lands. As employments and population could be considered as some basic measures of agglomeration, the present block is so formulated as it supplies us with such information on the evaluation of policies.

3.2 Input output block

Operating at both national and prefectural levels this block introduces a two level version of Leontief's balanced input-output (BIO) model, for a simplified but efficient spatial allocation of flow activities. Here the same input coefficients and final demand converters are assumed applicable at both spatial levels. To operate an IO model the final demand data are necessary, and are available from *Prefectural Accounts*. However since it does not provide the production data, we use the nominal IO table to compute them through commodity based inlflators as decribed in Ando[3] and distributing to prefectures. An IO table as applied here may be represented in Figure 3.2.

	$j=1 \sim n_1$ (3 sectors)		$j=1 \sim n_2$ (5 items)					
$i=1 \sim n_1$	inter-industry transactions x_{ij}	ID_i	net final demands Y_{ij}	ND_i	F_i	M_i	J_i	X_i
	values added V_j	0	0	0	0	0	0	GNP
	X_j productions	Σ	W_j	Σ	F	M	J	X

ID_i: intermediate demand by sector i
ND_i: final demand by commodity i
W_j: final demand by item j

Figure 3.2 Representation of an input-output table

In this block three categories of final demand items are considered; consumptions, investments and balancing items. First two items are the net final demands while the third constitutes exports F, imports M and net increase in stocks J, which fill the gap between demand and supply. It should be noted that all the variables in the block are in monetary terms of 1980 prices.

3.3 Inter-prefectural activities block

The overall model completes with the present one that analyses interaction between the zones. Here three models, viz. *commuting OD*, *passenger OD*, and *freight OD* are formulated. In a previous stage of the study[1] the time cost matrices for each cycle from 1950 have been computed. Among them are rail: 1950-85, car: 1965-85, all modes 1955-85, and ship 1950-85, according to the existence of each mode. For commuting to work mainly rail is used while passenger OD uses all modes among the prefectures. Freight OD in each primary and secondary sectors uses combined modes of rail, car, and ship for hauling.

4. MODEL CALIBRATION

4.1 Employment distribution block

(1) National employment distribution: Here we distribute national

employment to three sectors. For this we take into account their changes of trend, and deceleration effects that give rise to curtailment of employments. The first is the needs to achieve the same productivity growth given by the first term in each model in (4.1). Since employments are subject to saturation deceleration occurs with time, industry trying to cut down on wage payments as indicated by the negative parameter of the second term. We approximate the empolyment in sector i by function f_i having above logic, as given in Table 4.1.

Table 4.1 Parameter ostimatos of national cmployment distribution

$$\hat{E}_i = f_i; \quad E_i = \hat{E}_i / \Sigma_j \hat{E}_j; \quad i=1\sim3 \qquad (4.1)$$

$$f_i = \alpha_i \{E_{i(-1)}[V_{i(-1)}/V_{i(-2)}]\}^{\beta_i}\{[V_{i(-1)}/E_{i(-1)}]/[V_{i(-2)}/E_{i(-2)}]\}^{\gamma_i}; \quad i=1 \text{ and } 3$$

$$f_2 = \alpha_2 \{E_{2(-1)}[V_{2(-1)}/V_{2(-2)}]\}^{\beta_2}\{[K_{2(-1)}/K_{2(-2)}]\}^{\gamma_2}$$

α_1 11.406 (4.85)	β_1 0.848 (27.07)	γ_1 -0.892 (7.68)	R^2=0.9695	df=22 for all 3 models
α_2 2507.0 (8.03)	β_2 0.526 (8.70)	γ_2 -0.241 (5.16)	R^2=0.7754	
α_3 0.707 (3.00)	β_3 1.019 (51.33)	γ_3 -1.059 (16.4)	R^2=0.9878	(t values are given within parentheses)

(2) Prefectural distribution of sectorial employments and population: It is clear that the individual choices, in aggregative form, give rise to employment and population locations. Since we regard in our model that these two are vital indicators of spatial agglomeration, in order to make them possess a degree of sensitivity to transportation improvements we explicitly include the potential variables denoted by $\rho(.)$ in the respective models. Out of a number of candidate variables the selected potentials in the distributions and other variables used in conjunction with those are shown in Table 4.2. The parameter attached to the time cost variable in each potential is assigned values exogenously[4] as listed in Table 4.3.

Table 4.2 Variables used in employment and population distributions

population $\rho(P^r_{(-1)})$: $\Sigma_s P^s_{(-1)} EXP(-\beta_3 t^{rs}_{r(-1)})$	potential variables
urban employees $\rho(Eu^r_{(-1)})$: $\Sigma_s (E^s_{2(-1)}+E^s_{3(-1)}) EXP(-\beta_2 t^{rs}_{a(-1)})$	
stock of secendary secter $\rho(K^r_{2(-1)})$: $\Sigma_s K^s_{2(-1)} EXP(-\beta_1 t^{rs}_{r(-1)})$	
percentage of primary sector value added over mean VM_1: $[V^r_{1(-1)} - \bar{V}_{1(-1)}]/\bar{V}_{1(-1)}$	other vari-ables
percentage of secendary sector value added over mean VM_2: $[V^r_{2(-1)} - \bar{V}_{2(-1)}]/\bar{V}_{2(-1)}$	
percentage of total value added over mean VM: $[V^r_{(-1)} - \bar{V}_{(-1)}]/\bar{V}_{(-1)}$	
urban employment density over mean EuD: $Eu^r_{(-1)}/L^r_{F(-1)} - Eu_{(-1)}/L_{F(-1)}$	
share of available land over mean LAM: $L^r_{AV(-1)}/L^r_{F(-1)} - L_{AV(-1)}/L_{F(-1)}$	

Table 4.3 Parameters of time cest in potential variables

year	1950	1955	1960	1965
β_1	0.0154	0.0158	0.0160	0.0163
β_2	0.0216	0.0220	0.0221	0.0205
β_3	0.1230	0.1240	0.1280	0.1130
year	**1970**	**1975**	**1980**	**1985**
β_1	0.0161	0.0174	0.0170	0.0169
β_2	0.0325	0.0228	0.0216	0.0215
β_3	0.1420	0.1090	0.1320	0.1240

Variable selection considers sign requirement of each variable, as required by the economic theories applicable, together with the necessity to achieve the best explanatory power of the model. Logit type models are employed in these distributions, adopting Berkson's method[5] for the convenience in estimations, with the *reference* being the *other area§5*. In order to capture the effects due to zonal sizes in location chioces, each distribution carries *a priori* information*§6* given by a single period lag of variable being distributed. Thus the *location score* of prefecture r, given by ψ^r or ϕ^r, which is a linear combination of variables in Table 4.2 explains the change of location choices over the previous period. The parameter estimates appear in Table 4.4 for employments and population.

Table 4.4 Parameter estimates of employment and population distributions

$$E_i^r/E_i = \frac{E^r_{i(-1)}/E_{i(-1)}\,EXP(-E^r_{i(-1)}/E_{i(-1)}+\psi_i^r)}{\Sigma_s\, E^s_{i(-1)}/E_{i(-1)}\,EXP(-E^s_{i(-1)}/E_{i(-1)}+\psi_i^s)} \quad i=1\sim3 \qquad (4.2)$$

$$\underset{}{\psi_1^r} = \underset{(45.2)}{-0.37339}\underset{(2.97)}{-6.288E{-}10}[\rho(Eu^r_{(-1)})-\rho(Eu^r_{(-2)})]\underset{(3.71)}{+0.0613}VM_1\underset{(3.17)}{+1.65}LAM \quad R^2=0.9917\ df=146 \qquad (a)$$

$$\psi_2^r = \underset{(8.36)}{-0.18501}\underset{(2.02)}{+0.01297}[\rho(K^r_{2(-1)})-\rho(K^r_{2(-2)})]\underset{(3.13)}{+0.0519}VM_2\underset{(2.23)}{-0.0038}EuD \quad R^2=0.9906\ df=146 \qquad (b)$$

$$\psi_3^r = \underset{(36.86)}{-0.2025}\underset{(3.89)}{+5.713E{-}8}[\rho(P^r_{(-1)})-\rho(P^r_{(-2)})]\underset{(6.22)}{+0.0356}VM \quad R^2=0.9998\ df=147 \qquad (c)$$

$$P^r/P = \frac{P^r_{(-1)}/P_{(-1)}\,EXP(-P^r_{(-1)}/P_{(-1)}+\phi^r)}{\Sigma_s\, P^s_{(-1)}/P_{(-1)}\,EXP(-P^s_{(-1)}/P_{(-1)}+\phi^s)} \qquad (4.3)$$

$$\phi^r = \underset{(2.7)}{-0.1828}\underset{(7.31)}{+5.592E{-}8}[\rho(Eu^r)-\rho(Eu^r_{(-1)})]\underset{(2.28)}{+0.0442}VM\underset{(2.71)}{+0.086}LAM \quad R^2=0.9979\ df=171 \qquad (d)$$

In primary sector it is intrinsic to choose the locations where high profits can be achieved and also land is available for agriculture, as indicated by second and third terms in (a). However the urbanisation process triggers switching of jobs from primary to other two sectors given by the negativity of the first term. For secondary sector (b), the choices vary positively with the increase in stock turn over from the previous period and high profits, while the deceleration takes place when capacity of the location is reached, indicated by urban employment density. In the tertiary sector (c), change in population location as well as zones with high production profits become the attributes of the location process.

A similar argument may be extended for population too (d), that it is quite natural that residential locations are chosen at proximity to jobsites in urban areas. Also high wage areas may be expected to attract choices, while opposite effects by capacity limitations could be probable depending on the existence of available land.

(3) Urbanised land area: Data on landuse activities at prefectural level are available on land ledgers which actually are those only taxable, excluding public land. In describing the landuse activities in his model, Ando[3] adopts a methodological approach in compliling the data on urban activities, re-classifying the 41 residential and industrial activities into 5 categories using CALUTAS data[6], and 1978 Housing Survey data. Unfortunately for a long-term time series analysis like ours, it is almost impossible to obtain reliable data right throughout. Hence we ulitise only one urban landuse category given by *urbanised land* L_U, which includes residential and industrial activities. However we adopt two assumptions from his approach on urban landuse: (a) urban land doesn't exceed the inhabitable land, ie. $L_U \leqq L_F$. (b) the available land is the difference between the above two, $L_{AV}=L_F-L_U$. Also we assume that (c) urbanisation is an irreversible process, $\Delta L_U \geqq 0$, and (d) inhabitable land existed in 1980, from World Census on Agriculture and Forestry, would have been there from

1950. Based on these assumptions we have compiled L_U from 1950-85.[7]
Here we express the share of urbanised land in terms of stock increases[3] by a bi-nomial logit model as in (4.4) of Table 4.5. The amount of available land from the previous period is thus converted to either urban land, depending on the change of urban landuse activities of population and urban employment, or remains as it is.The residual of the latter after urbanisation becomes the identity given by (4.5).

Table 4.5 Parameter estimates of urbanised land area

$$\Delta L_U^r/L_{AV(-1)}^r = 1/[1+\underset{(11.1)}{47.77}EXP(-\underset{(3.38)}{0.4167}\Delta P^r/L_F^r - \underset{(3.07)}{0.346}\Delta Eu^r/L_F^r] \quad R^2=0.9909 \;\; df=179 \qquad (4.4)$$

$$\text{where } L_{AV}^r = L_F^r - L_U^r \qquad (4.5)$$

4.2 Input output block

Here we formulate a model block to analyse the spatial allocations of flow variables excepting one stock variable, K_2, included here to preserve clarity and simplicity in the entire analysis. The main framework of the block is clearly provided by the BIO model which operates at two levels, national and prefectural. In this respect it is first necessary to formulate the itemised final demands and convert them to commodity based ones to compute sectorial productions. However, we first look at the flow models independent of IO computations.

Table 4.6 Parameter estimates of investments and consumptions

$$(\Delta K_2)_5 = \underset{(4.99)}{1118675.9} + \underset{(1.84)}{0.0449}V_{(-1)} + \underset{(2.66)}{0.4257}K_{2(-1)}X_{2(-1)}/X_{2(-2)} - \underset{(2.21)}{0.854}K_{2(-1)} \quad R^2=0.6688 \;\; df=22 \qquad (4.7)$$

$$\text{we obtain } \Delta K_2 \text{ from } (\Delta K_2)_5 = \Sigma_{n=1,4}[\Delta K_{2(-1)} + n(\Delta K_2 - \Delta K_{2(-1)})/5](1-\delta)^{5-n} + \Delta K_2 \qquad (4.8)$$

$$(\Delta \hat{K}_2^r)_5 = \underset{(4.77)}{19976.6} + \underset{(3.82)}{0.0264}V_{(-1)}^r + \underset{(8.08)}{0.4261}K_{2(-1)}^r X_{2(-1)}^r/X_{2(-2)}^r - \underset{(2.83)}{0.326}K_{2(-1)}^r + \underset{(3.62)}{1352363}Dm1 \quad R^2=0.8772 \;\; df=151 \qquad (4.9)$$

$$\text{similarly } (\Delta K_2^r)_5 = \Sigma_{n=1,4}[\Delta K_{2(-1)}^r + n(\Delta \hat{K}_2^r - \Delta K_{2(-1)}^r)/5](1-\delta^r)^{5-n} + \Delta \hat{K}_2^r \qquad (4.10)$$

$$\text{with adjustments } (\Delta K_2^r)_5 = (\Delta \hat{K}_2^r)_5/\Sigma_r(\Delta \hat{K}_2^r)_5; \text{ and } \Delta K_2^r = \Delta \hat{K}_2^r/\Sigma_r \Delta \hat{K}_2^r$$

$$K_2^r = K_{2(-1)}^r(1-\delta^r)^5 + \Sigma_{n=1,4}[\Delta K_{2(-1)}^r + n(\Delta K_2^r - \Delta K_{2(-1)}^r)/5](1-\delta^r)^{5-n} + \Delta K_2^r \qquad (4.11)$$

$$\text{and } K_2 = \Sigma_r K_2^r \qquad (4.12)$$

$$\Delta K_N = -\underset{(10.18)}{6669526.4} + \underset{(2.03)}{0.0681}V_{(-1)} + \underset{(6.17)}{5.119}E_3(E_{3(-1)}/E_{3(-2)}) - \underset{(6.17)}{3.315}E_{3(-1)} \quad R^2=0.9872 \;\; df=22 \qquad (4.13)$$

$$\Delta \hat{K}_N^r = \underset{(1.65)}{6046.3} + \underset{(11.52)}{0.202}V_{(-1)}^r + \underset{(2.69)}{0.285}E_3^r(E_{3(-1)}^r/E_{3(-2)}^r) - \underset{(2.52)}{0.516}E_{3(-1)}^r + \underset{(4.89)}{1482471}Dm1 \quad R^2=0.9649 \;\; df=151; \quad \Delta K_N^r = \frac{\Delta \hat{K}_N^r}{\Sigma_r \Delta \hat{K}_N^r} \qquad (4.14)$$

$$C1^r/P^r = \underset{(7.58)}{0.01616} + \underset{(35.09)}{0.9979}C1_{(-1)}^r/P^r + \underset{(3.94)}{0.00746}V^r/P^r \quad R^2=0.9563 \;\; df=179 \qquad (4.15)$$

$$C2^r/P^r = \underset{(11.37)}{0.11036} + \underset{(12.89)}{0.4953}C2_{(-2)}^r/P^r + \underset{(14.12)}{0.247}(V^r + V[P^r/P - E^r/E])1/P^r \quad R^2=0.9707 \;\; df=179 \qquad (4.16)$$

$$C3^r/E^r = \underset{(9.98)}{0.03699} + \underset{(12.02)}{0.6934}C3_{(-1)}^r/E^r + \underset{(6.86)}{0.0097}(V^r + V[E_3^r/E_3 - E^r/E])1/E^r \quad R^2=0.8486 \;\; df=179 \qquad (4.17)$$

$$I1^r/P^r = \underset{(7.54)}{0.02795} + \underset{(31.4)}{0.97154}V_{(-1)}^r/P^r + \underset{(2.04)}{0.03772}\Delta P^r/P^r \quad R^2=0.8449 \;\; df=179 \qquad (4.18)$$

$$I2^r = \Delta K_2^r + \Delta K_N^r \qquad (4.19)$$

(1) Investment of secondary sector: This is assumed equal to the manufacturing investment as investment data on mining and construction are not available. First we formulate the *effective investment* over the 5 year period at national level as in (4.7), following the acceleration principle[8], as the investment is considered the difference between the optimal and existing stocks. The first term is proportional to the

operating surplus while the second gives the expected investment due to expansion of production, and the last is the existing stock after depreciation. Then the present investment is given by (4.8) assuming a uniform annual increase over 5 years. Similarly corresponding values at prefectural level are given by (4.10) and (4.11) which are adjusted for their national amounts. Here Dm1 is a dummy for the *other area*.

(2) Secondary sector stock: Stock at prefectural level becomes an identity (4.11) with a similar assumption of uniform increase of investment, and is summed to get the national stock (4.12).

(3) Non-manufacturing investment: Following a similar approach of acceleration principle as in (4.7), we formulate national value through (4.13) and that at prefectural level by (4.14).

(4) Consumption items: Three consumptions are considered. Although simulation moves from national level to prefectural in distributions, the parameters are estimated at the lower level, so as to improve the degree of freedom from the pooled data. Therefore we introduce the models of latter level first. Anticipated consumption of the public sector depends on the previous records and borne by the present gross prefectural product which comes from IO computations of productions which we explain later. The scale effects due to zonal sizes are removed by estimating the per capita values as in (4.15). Similarly, the consumption expenditures of households model uses a simple Keneysian approach, that the present expenditures are largely decided by those of the period before and the disposable income considering transfers from jobsite to residential site as in (4.16). Coming to the last item of consumption expenditures incurred by firms as the social and welfare expenses of employees may be assumed proportional to the number of them. Here in (4.17) too transfers are accounted for, from the production site to that of main offices.

(5) Prefectural investments: With a non-profit oriented outlook, the public sector investment in (4.18) constitutes a share of the lagged total product, and the new demand due to increased population.

All 4 final demand models so far incorporate distributions that follow the first order Taylor expansions. Finally, the public sector investment is directly available from the identity in (4.19).

Table 4.7 National final demand models

$C1=0.01616P+0.9979C1_{(-1)}+0.00746V$ (4.20)	$C2=0.11036P+0.4953C2_{(-1)}+0.247V$ (4.21)
$C3=0.03699E+0.6934C3_{(-1)}+0.0097V$ (4.22)	$I1=0.02795P+0.9715V_{(-1)}+0.03772\Delta P$ (4.23) $I2=\Delta K_2+\Delta K_N$ (4.24)

(6) National final demands: With the transferred parameters from the lower level the models (4.20) through (4.23) are directly computed along with the identity (4.24) in Table 4.7.

(7) National productions: Exports F, imports M and the net increase in stocks J are the three balancing items, which are assumed exogenously given at national level due to the fluctuating nature of each, and estimation restrictions stemming from the data limitations. Therefore now we have the net final demand $W = C1+C2+C3+I1+I2$, from which we get the commodity based net final demand ND=CW, and denoting TB=F+M+J the commodity based total final demand in compact form becomes Y=C[W TB]. Thus from the balancing equation X=AX+Y,

we get the national sectorial productions as: $X=(I-A)^{-1}Y$ (4.25)

(8) Prefectural productions: National values are distributed to the lower level. For primary sector labour is considered the sole input of

production while the secondary sector employs labour and capital as primary inputs in a translog type function with insignificant variables dropped. In the tertiary sector apart from the labour, productivity per urban employee is assumed to accelerate with agglomeration of productions.

Table 4.8 Parameter estimates of prefectural productions

$\hat{X}_1^r=1432.05E_1^{r\,0.43369}Dm2^{1.6113}$ (12.5) (9.17) (7.36)	$R^2=0.6484$ df=204	(4.25)	$X_1^r=\dfrac{\hat{X}_1^r}{\Sigma_r \hat{X}_1^r}$ $l=1,\ldots,3$
$\ln\hat{X}_2^r=4.228+0.5369\ln E_2^r+0.02235(\ln K_2^r)^2-0.429\ln Dm2$ (9.55) (11.3) (19.5) (3.62)	$R^2=0.9538$ df=203	(4.26)	
$\hat{X}_3^r=0.9384E_3^{r\,1.0596}(Y^r_{(-1)}/Eu^r_{(-1)})^{0.8604}Dm2^{-0.141}$ (7.02) (104.7) (41.8) (9.65)	$R^2=0.9939$ df=178	(4.27)	

The approximations are given by (4.25) to (4.27) and entail dummy Dm2 for the *other area*. Once the three productions are available, from IO computations prefectural values added are directly obtained.

Table 4.9 Prefectural exports, imports and net increase in stocks

$F_j^r=(X_j^r/X_j)F_j$ (4.28) $M_j^r=(D_j^r/D_j)M_j$ (4.29) where $D_j^r=\Sigma_i\, a_{ji}X_i^r+\Sigma_k\, c_{jk}W_k^r$; $i,j=1\sim3$; $k=1\sim5$

Hence the residual for commodity j: $J_j^r=X_j^r-(D_j^r+F_j^r+M_j^r)$ $j=1\sim3$ (4.30)

(6) Prefectural balancing items: The prefectural commodity based exports and imports are distributed in accordance with productions and demands as in (4.28) and (4.29) in Table 4.9. However the net increase in stocks (4.30) is considered a residual of demand and supply.

4.3 Inter-prefectural activities block

We employ unconstrained gravity models to describe *commuting*, *passenger OD*, and *freight OD*. Commuting trips (4.31) are mostly diagonal, while passenger trips (4.32) are more dispersed and generated due to business contacts of urban employees. Both indicate increasing effects with agglomeration. We incorporate dummy Dum1 to account for the intra-prefectural trips which are quite significant.

Table 4.10 Inter-prefectural models

$E^{rs}=1.29P^{r\,0.475}E^{s\,0.482}EXP(-0.124t^{rs}_r-0.00076Yr)$ $R^2=0.9910$ df=3228 (26.8) (70.0) (106.7) (73.3) (4.19)		(4.31)
$T^{rs}=2.74(E_2^r+E_3^r)^{0.653}(E_2^s+E_3^s)^{0.639}EXP(-0.026t_a^{rs}-1.91Dum1-0.006Yr)$ $R^2=0.9550$ df=4981 (9.31) (15.9) (15.5) (10.4) (25.2) (16.0)		(4.32)
$Fr_1^{rs}=12.0X_1^{r\,0.017}ND_1^{s\,0.015}EXP(-0.431Yr-0.001tt^{rs}+5.85Dum1+1.56Dum2)$ (26.6) (18.0) (21.9) (26.2) (21.8) (29.8) (15.2)	$R^2=0.4786$ df=2926	(4.33)
$Fr_2^{rs}=18.5X_2^{r\,0.0012}ND_2^{s\,0.0019}EXP(-0.527Yr-0.00103tt^{rs}+5.15Dum1)$ (51.3) (27.9) (34.7) (40.2) (29.5) (33.7)	$R^2=0.6425$ df=3119	(4.34)
here Yr is year: eg. 1955 as *55*; and $tt=Vr*t_r+Vc*t_c+Vs*t_s$		

Freight tonnage hauled by commodity is aggregated into 2 sectors, primary and secondary using (4.33) and (4.34) respectively, assuming it to be proportional to productions at the origin and demands at destination. As the cost variable we adopt a *composite cost* tt which is regarded a weighted combined cost of rail, car and ship. The weights for the respective modes are the eigen vectors Vr, Vc and Vs obtained from the first component[9] from the principal component analysis. Further in (4.35) we incorporate the disproportionate primary sector products using an agglomeration dummy Dum2 to identify the prefectures Tokyo, Kanagawa, Aichi, Osaka and Hyogo.

5. TEST SIMULATION

(1) Total test: As mentioned in Section 2 the effective simulation spans 5 cycles from 1960 to 1985. For this period we have conducted the total test on the entire model and partial results are illustrated in this section. Figures 5.1 and 5.2 are the population and employment distributions respectively along the study area in 1960 and 1985, indicating both actual and computed values.

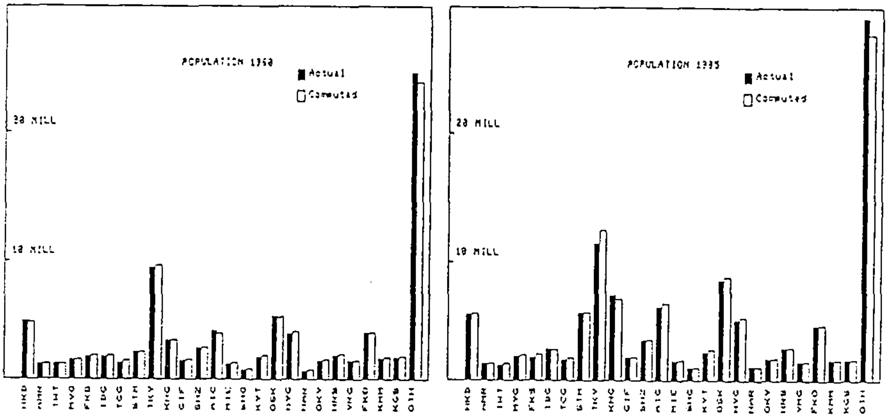


Figure 5.1 Population distribution along study area and *other area*

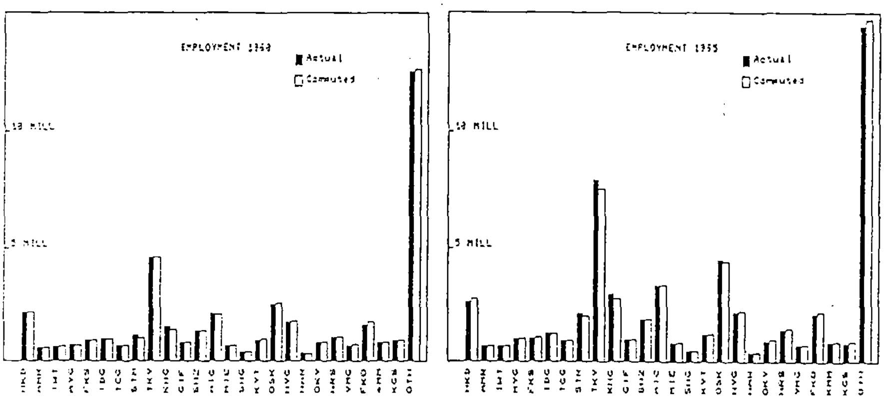


Figure 5.2 Employment distribution along study area and *other area*

It is seen that errors in agglomerated prefectures and the *other area* are comparatively larger than those in other prefectures. However, Mean Absolute Percentage Errors (MAPE) of all stock and flow variables except inter-prefectural ones were found below 10%, and sample results of MAPE for population, employment, production and commuting OD are listed here in Table 5.1, for 1960, 1975 and 1985.

Table 5.1 Sample results of MAPE

	1960	1975	1985
population	3.85	4.95	3.65
employment	2.95	2.58	2.82
production	2.83	2.29	1.30
commuting OD	25.35	43.23	38.76

MAPE for variable x is defined as:

$$\frac{1}{26} \Sigma_{r=1,26} \frac{| x^r - \hat{x}^r |}{x^r} 100\%;$$

where x^r and $\hat{x}^r$ are actual and computed values of prefecture r respectively.

The high errors in inter-prefectural models are quite likely due to the fluctuating nature of movements of people and commodities.

(2) Case study evaluation: *Shinkansen* facilities on the trunk line have been operative since 1964 from Tokyo to Osaka, since 1972 from Osaka to Okayama, since 1975 from Okayama to Fukuoka, since 1982 from Saitama to Iwate and since 1985 form Tokyo to Saitama. The first, *Tokaido line*, is what we subject to transformation, by delaying its operation by 10 years. Re-computing the travel times after the transformation a case study is conducted and the results are as follows:

Table 5.2 Changes due to policy transformation

	population(0000s)			employment(0000s)		
	1970	1975	1985	1970	1975	1985
Tokyo	1078	1079	1081	648	662	713
	-5.5	*-7.5*	*-8.6*	*-3.9*	*-5.8*	*-9.4*
Aichi	521	568	596	279	282	309
	-3.2	*-4.1*	*-7.6*	*-2.7*	*-3.5*	*-6.6*
Osaka	745	806	820	393	394	421
	-2.2	*-2.7*	*-5.3*	*-1.9*	*-2.8*	*-4.7*
Fukuoka	394	417	446	185	187	198
	-2.2	*-2.7*	*-5.3*	*-1.8*	*-2.8*	*-4.6*
Other area	2829	3228	3735	1386	1431	1604
	+7.8	*+12.6*	*+20.8*	*+4.3*	*+6.6*	*+11.2*

Table 5.3 Comparison of population in Kanto and Kansai in 1985 due to policy transformation

		before	after
Kanto	population (0000s)	2512	2022
	national share (%)	20.8	16.7
Kansai	population (0000s)	1784	1709
	national share (%)	14.7	14.1

Generally population and employment in central prefectures decrease but *vice versa* in the *other area* as indicated in *italics* in Table 5.2. Also, Kanto region shrinks in 1985 where a fifth of national population declines to 16.7%, which is nearly the same of Kansai having shown a stable national share even after policy transformation.

6. CONCLUSION

Here in this article we have introduced an operational model for describing spatial agglomeration due to transportation improvements in Japan during the period 1950-85. It serves as a pilot model for the intended long-term analysis from 1920-85, dating as far as when both Tokyo and Osaka had almost similar shares of population. We have just completed the first version of the model presented here, on calibration of parameters and conducting the total test. Also we have conducted a policy simulation on delaying the *shinkansen* facilities on trunk line railroads by a decade. The results indicate a substantial decrease of agglomeration particularly in *Kanto* as well as other sub-peaks like Osaka, Nagoya and Fukuoka. On the other hand the *other area* grows, meaning a reduced out-migration to centres. However these results have yet to be supported by the final test as our next task needed attention. In overall configuration the scope of data is quite restricted that we are compelled to work within those limits. In *fine tuning* the model on final test, it may perhaps be limited to improving each model function in an efficient way. Hence we must continue our efforts towards a more complete model which would certainly provide useful guidelines in policy evaluations also in developing nations.

FOOT NOTES

(1) Here Kanto refers to the region consisting of Tokyo, Kanagawa and Saitama, while Kansai refers to Kyoto, Osaka, Nara, and Hyogo.

(2) The Japanese governing system consists of 3 local hierarchical levels out of which the highest in rank is the *prefectural* government, 47 of such administrative districts forming the entire nation.

(3) The study area may be considered linear. This stems from the necessity of compatibility for a single-dimensional theoretical analysis at a subsequent stage of the study. On the other hand the geographical shape of Japan itself could safely be assumed linear.

(4) A detailed account of data availability is given in Daluwatte[1] while the same on data compilation procedures appear in Uetsuhara[9].

(5) Assuming the *other area* to be the reservational zone which plays no active role, we set reference ψ or ϕ to zero.

(6) It is possible to use known or *a priori* information to improve our forecasts since it reflects the size of the forecast to some extent. For explanation we consider a singly constrained gravity model as illustrated in Table F1:

Table F1 Use of *a priori* information in a single-constrained gravity model

Max. $-\Sigma_j P_j \ln(P_j/q_j)$	where q and c are *a priori information* and cost variable respectively. From Lagrangian maximation we end up with the the solution:
s.t. $\Sigma_j P_j = 1$	
$\Sigma_j P_j c_j = \bar{c}$	$P_j = q_j EXP(-q_j - \lambda - \gamma c_j)$
$\Sigma_j q_j = 1$	where λ and γ are Lagrange multipliers.
Transforming this to a ratio of probability we get:	$\frac{P_j}{\Sigma_j P_j} = \frac{q_j EXP(-q_j - \gamma c_j)}{\Sigma_j q_j EXP(-q_j - \gamma c_j)}$; from this result we interpret the cost function c as ψ or ϕ in our models and q as the lagged *a priori* variable.

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