DEVELOPMENT OF A CGE MODEL FOR POLICY EVALUATION ON LOGISTICS IN THE WESTERN REGION OF CHINA

Takaaki Okuda[a], Fuminori Tanekura[b], Takayuki Hatano[a] and Shuchang Qi[c]
[a] Graduate School of Environmental Studies, Nagoya University, Nagoya, Japan.
[b] Hokuriku Regional Development Bureau, Ministry of Land, Infrastructure and Transport, Kanazawa, Japan.
[c] National Bureau of Statistics of China, Beijing, China.
okuda@genv.nagoya-u.ac.jp; tanekura-f84n8@hrr.mlit.go.jp; thatano@urban.env.nagoya-u.ac.jp

Abstract

The Chinese economy has been drastically developing due to an increase of investment and improvement of productivity in those two decades. In spite of the fact, the development is being mainly focused in the coastal areas and the disparity between regions has become major concerns. For a balanced growth, Chinese government has launched to shape policies to improve the developing region. To evaluate effects of the policies in such region, it's important to take into account on the relationships of economic activities and infrastructure improvement. For the reason above, building a regional economic model should be needed to combine economic and transport evaluation. In the study, we propose a CGE model for evaluating the policies related to the development of the western region in China. The model consists of three sub-models as; 1) transportation, 2) economic activities, and 3) environmental impact.

From the results of two cases of the projects, increase of the regional utilities was observed by conducting the projects. It could be caused due to both a decrease in prices of goods and promotion of actual income outside of the project areas as well as in the evaluated site.

The results indicate that the model we propose can be suitable for evaluating the regional economic activities and the extent of the effect. And specific achievements on the cases we choose are as follows; 1) economic benefits caused by modal shift from road transport to railways, 2) regional spread of the economic benefits to the other regions far from the railways.

Keywords: Development of western regions in China; Logistics; Policy evaluation; CGE model
Topic Area: F1 Transport and Spatial Development

1. Transportation and economy in China

1.1. Regional disparities and the western large development in China

Chinese government has started plans to develop Shanghai as an international center for economic, finance and trade since the beginning of 1990. As the result of the projects, GDP in Pudon, where is famous as a newly developing area in Shanghai, grew 6 times and at 3 times in whole Shanghai during the last decade. It has made Shanghai be one of the world-class prominent economical centers.

Besides, China even has embraced about thirty million of the poor population, and most of them concentrate in the inner region of the country. According to the result of per capita income among 31 provinces in 1999, provinces in the eastern coastal region occupied nine in superior ten provinces. Income disparity between the highest Shanghai and the least Guizhou results in about twelve times. Such extreme income disparity has fueled the fires of social discontent and brought social disorder in the inner region, which was being left out of development.

It's well known that the social infrastructure improvement in the western region is quite late in comparison with the situation in the eastern area. Above all, delay in improvement of water facility and transportation has impeded the development of social economy in the region. In the western, water resource are seriously lacking in general. Due to the natural constraint, desertification and an outflow of land are advancing with difficulties on life and economic activities. On the other hand, the delay of traffic facility maintenance prevents movement of people and goods with other areas, and has become the restrictions factor of economic development. The necessity for transportation in the western region is higher than that in the eastern because of being located inland far from the coast and population dispersal. So it's suggested that it be important to build the arterial traffic connecting the inland with the coastal and overseas for trade.

In general, there are two major ways of transportation from the western region to the coastal; i.e. by shipping along the Yangtze River and by using the trans-continental railways. For instance, in 2000 the State Council demonstrated some international transportation routes in a letter. In the document, it was summarized the keys of development in the western region depended mainly on developing transportation systems such as Eurasian Land-bridge, shipping on the Yangtze, and some new railway.

1.2. Current conditions and issues on transportation in China

The traffic artery length in China surely increases, and the total extension has reached 68 thousand kilometers in 2000 year-end. About 6.1 thousand kilometers of extension had been recorded in the 9th five-year plan (1996-2000), which was the largest in the all five-year plans. Chinese Department of Railways has been strongly promoting speed-up, doubling of the tracks, and electrification of railways as well as modernization and increase of transportation. Due to going ahead with the plans, some improvement policies has been issued, including acceleration of construction of nation-wide railway network (Eight Length and Eight Width), construction of railway network in the western region, and so on. In the plan on the railway network in the western region, it is expected to complete New Eurasian Land-bridge. They will be the quickest routes connecting the Pacific and the Atlantic in comparison to Eurasian trans-continental railway, which is two thousand kilometers longer than the new one. Some vision on constructing land-bridge network has issued besides the New Eurasian; e.g. ERINA(Economic Research Institute for Northeast Asia) demonstrates seven transport corridors.

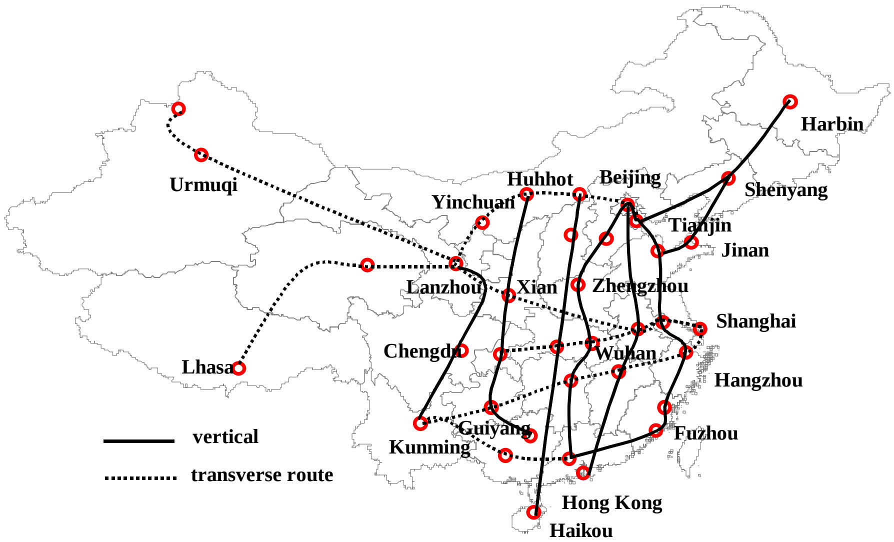


Fig.1 Railway Network in China (Eight Length and Eight Width)

Being improved transportation infrastructure, not only traffic conditions merely can be advanced but also can be spread several effects to many economic entities. The effects consist of reducing transportation costs, advantages on industries and household budget, activating local economy, etc. And more, these structural changes bring spillover effect to another industries and regions through inter-industrial relationship. In the western region, imperfection of inter-regional division of labor has been thought to be one of the most important factors against regional disparities. How will terms of trade be improved by measures on logistics? And how will new systems of division of labor be generated to the coastal region, inland and overseas? They should be important concerns on forecasting the prospects of the western in China.

1.3. Necessity of policy evaluation and economic model

Formation of clear development strategies on constructing wide-area economy is getting more important policy issues for inland areas. In vast China, some problems arise on how

the goods should be transported by using railways, road traffic, and combination of them.
In those days the possibility of the selection has been expanded with advance of motorization as well as shift of distribution systems. Due to the reason, concerning on these sharing systems is necessary to resolve the wide-area logistical events.

However, it is indispensable to foster inter-regional comprehensive development strategies as these massive transportation routes extend across provinces. For instance, arrangement of the projects on comprehensive plans from state- to local-level is one of the issues. On such occasion, furthermore, tasks are also needed to explain the reason to carry out public works. For explaining the effectiveness of implementation of traffic policy to public, quantitative assay on regional relationships should be needed.

Some models on policy assay have been already proposed for evaluation of improvement of the large-scale transportation infrastructure. State Council of Development, for instance, issued a guideline for developing transportation policies in the western region in 1999. In the guideline, vision for improvement of transportation infrastructure is proposed with forecasting generated traffic volume in the future as well as with pointing out the current condition and the specificity of traffic in the western region. Transport demand forecasting based on economic growth, which uses regression analysis and elastic coefficient will be hopeful to evaluate the policies in detail. However, it is impossible to grasp the effects of improvement of traffic facilities on economics and the environment, and to select a project based on the evaluation.

The aim of this study consists of two items; 1. to establish a model that meets two conditions including "interval and mode of transportation" and "inter-industrial and spatial relationships". 2. to have discussion on traffic policies enabled by using the model.

2. An analytical model for policy evaluation

2.1. System of the model

To utilize an analytical model for policy discussion, it is necessary to objectify the current policies and to evaluate the outcome in numerical terms when each policy introduced. That is, constructing a model is required to describe a traffic improvement policy related to the development of the western region, and more to enable analysis of the outcome concretely. The traffic improvement policy, first of all, changes the regional traffic conditions. Following the changes, inter-regional traffic flow also changes. Those changes are expected to renew the structure of production and consumption in each region.
It has been well studied on traffic flow by applying to the traffic policies in the field of traffic engineering. As for studies on the change of the structure of production and consumption, it has been worked in the field of econometrics and so on. In this study, we integrate the models developed in the fields above mentioned with the object that better indices for traffic policies in China could be provided. With using the models, a new model

is built to analyze the effects of traffic policies on local community from a macroscopic viewpoint (Fig.2).

To describe traffic improvement policies in concrete form, it is needed to build a traffic network matching to the actual flow. The network enables to figure out the change of the traffic condition in each region following with the change of traffic policies. And then, the change of inter-regional traffic flow describes with a traffic model based on logit analysis. In the end, it will be able to quantify and to evaluate the effects of the traffic policies on local economical activities in China with the calculated costs of transport in the traffic model and a CGE model.

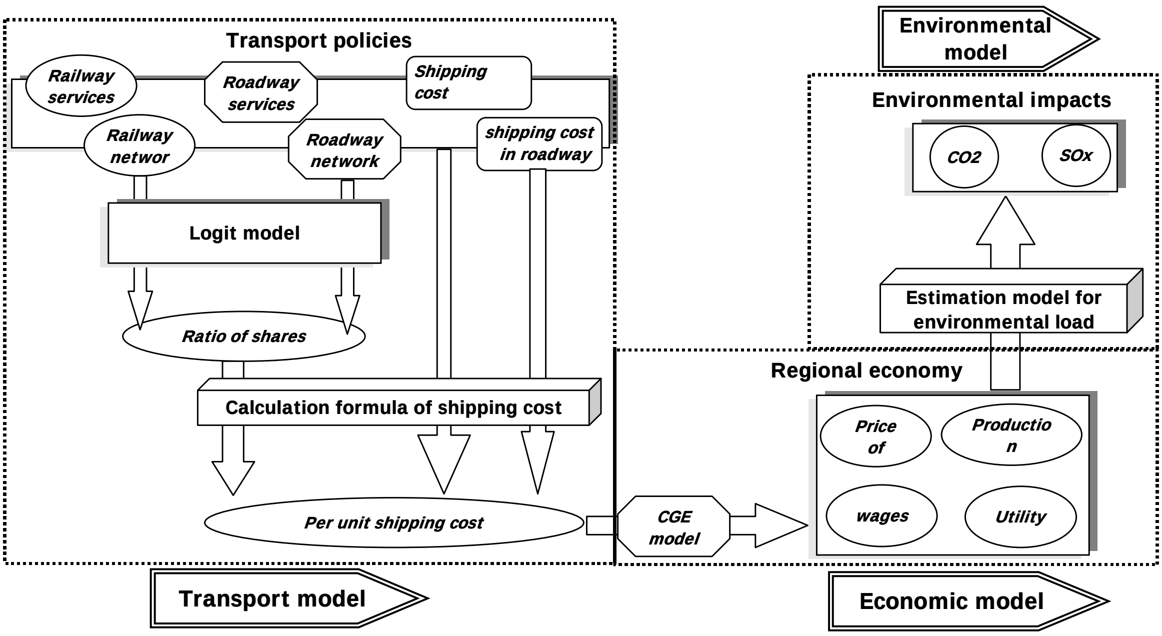


Fig. 2 Genaral Scheme of the Analytical Model

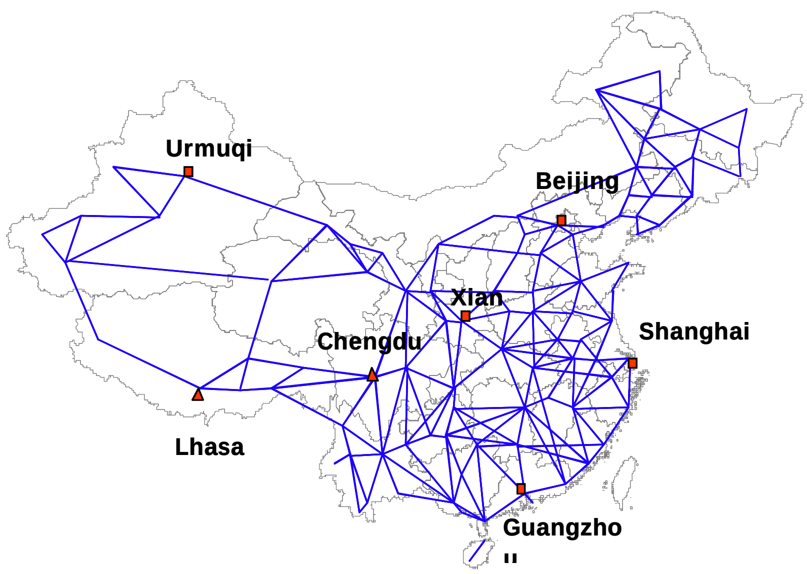


Fig. 3 Inter-city Railway Network in China

2.2. Traffic model

In this study, effects of traffic policies on the traffic flow are discussed with the traffic model. The model calculates per unit cost of transport when done traffic policies. The estimated output is then recognized as an input variable in an economic model.

Costs of transport are calculated with a cost function, which results in the integration of a cost in each sector (Formula 1). Per unit cost of transport with letter i between r and s regions (Ci^{rs}) is defined as a function with costs of each sector (C^{rs}_{rail}, C^{rs}_{auto}) and share of sectors (y^{rs}_{rail}, y^{rs}_{auto}).

In formula 1, α indicates a correction factor relating to differences among goods. Rates of transport share are defined as a logit model like formula 2 and 3, respectively. Formula 4 and 5 indicate utility functions with the variables of service and time-scale. When an inter-regional traffic condition changes, average costs and rates of transport share would be varied following the change of transit time through the functions. Moreover, costs of transport in each sector can also be varied with several policies.

$$C_i^{rs} = \alpha_i \left(C_{rail}^{rs} y_{rail}^{rs} + C_{auto}^{rs} y_{auto}^{rs} \right) \qquad (1)$$

$$y_{rail}^{rs} = \frac{\exp U_{rail}^{rs}}{\exp U_{rail}^{rs} + \exp U_{auto}^{rs}} \qquad (2)$$

$$y_{auto}^{rs} = \frac{\exp U_{auto}^{rs}}{\exp U_{rail}^{rs} + \exp U_{auto}^{rs}} \qquad (3)$$

$$U_{rail}^{rs} = \alpha_{rail} \ln t_{rail}^{rs} \qquad (4)$$

$$U_{auto}^{rs} = \alpha_{auto} \ln t_{auto}^{rs} + \alpha_r + \alpha_0 \qquad (5)$$

$$t_{rail}^{rs} = \text{(Driving time)} + \text{(Standing time)} + \text{(Unloading time)} \qquad (6)$$

$$t_{auto}^{rs} = \text{(Driving time)} + \text{(Unloading time)} \qquad (7)$$

Table 1 Result of estimation of parameters

Variables			**Factors (t-value)**
Transit time by railway	min	α_1	3.42 (2.16)
Transit time by road	min	α_2	-16.1 (-11.1)
Constants by departure plac	—	β_r	see Fig.4
Constant	—	β_0	107.6 (36.2)
Correlation coefficient	—	R	0.950
Coefficient of determination	—	R^2	0.900

Accuracy of parameters and indices in the model is shown in Table 1 and Fig. 4, respectively. The parameters were estimated using a regression analysis with published rates of share and inter-regional transit time. Correlation coefficient in the model marks at 0.950, which relatively seems higher. In Fig. 4, regions in deeper color tend to depend on the automobile transportation, provided that transport conditions are same. It indicates that the values are higher in the western region including Xinjiang, Gansu, Sichuan and Yunnan, and lower in the northeast with Beijin, Tianjin and Shanxi.

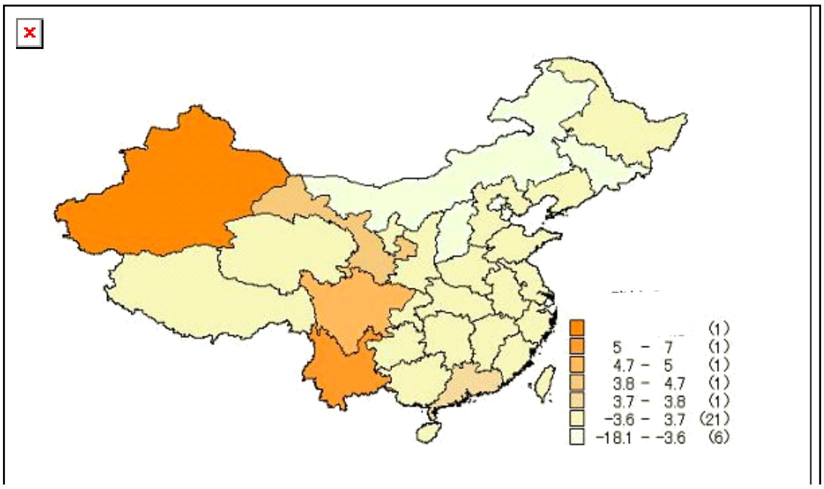


Fig. 4 Result of estimation on the dummy constants in departure places

Table 2 Structure of Inter-Regional Input-Output table

		sector					
		production	transport	private consumption	government consumption	capital formation	export
sector	scale	RxN	RxRxN	R	R	R	1
production	RxN						
transport	RxRxN						
import	N						
wages	R						
other	1						

R:number of region (29)
N:number of industry (7)

2.3. Economic model

The economic model we establish provides quantitative assessment on an economic society through the variation of both policies and the cost of transport. In this study we use a computable general equilibrium model (hereinafter called CGE model) as the economic model.

Table 3 Classification of industri

classification	
1	agriculture
2	base materials
3	daily lives
4	processing and assembly
5	infrastructure
6	wide-area services
7	local-area services

In order to determine parameters of production and utility functions, we estimate inter-regional input-output (IRIO) tables based on the published regional input-output (RIO) tables among twenty nine provinces. RIO table is a table of non-competing-import type expressed at producer price based on new SNA systems in 1997. It consists of 38 endogenous sectors, 4 for value-added, and 6 for final demand, respectively. To analyze it easily, we put the table together to 7 for endogenous, 2 for value-added, and 4 for final demand. As far as the segmentation of regions, we cover twenty nine provinces except for Hong Kong, Macau, Tibet and Hainan.

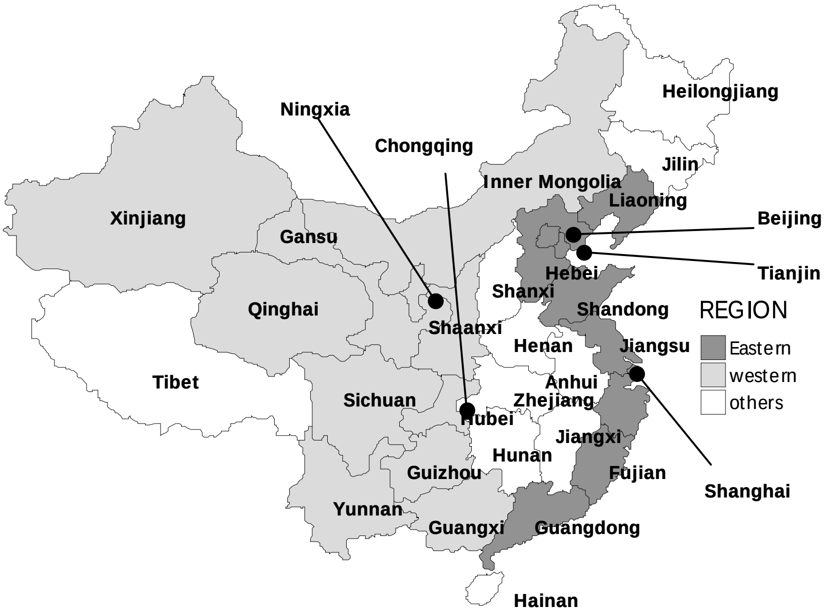


Fig. 5 Illustration of division of the regions

The CGE model expresses domestic economic activities in various regions using a mathematical model. In addition, the model can analyze the relationships between improvement of traffic infrastructure and economic activities. In the model, we assume the conditions in the way prescribed as; 1) only two economic entities exist in each region; 2) budget constrains for both producers and household; 3) producers should be categorized into several classes as they introduce various kinds of goods to the market.

According to Armington's hypothesis, goods that are produced in each region should be recognized as the different ones. Households hold all production factors consisted of labor and capital, earn income by supplying the factors to the market, and do paying. Only a capital market is established in a country and labor markets done in each region.

3. Analysis for policy evaluation

3.1. Analysis of effects on improvement of China Land-bridge (Lanzhou-Baoji)

Improvement of some transport network, which could be the key axis, has been planned in China. Above all, the two lines that connect northwest-to-coastal and southwest-to-coastal have received attention. Some projects have been also taken up in the western large development plan and the 10th five-year plan.

Double-tracking a railway between Lanzhou (Gansu) and Baoji (Shanxi), which belongs to China Land-bridge (CLB), is one of the prominent projects. The railway connecting between the cities runs 487 kilometers total and is now being double-tracked with one ten billion yuans (equivalent to $US 1.2 billion) of public investment. The interval is the last that has not been completed double-tracking along the total line due to the topographical complexity. After completion of the construction most parts of CLB will be upgraded with double-tracking lines and electrification, and more expansion of the trade between regions will be expected.

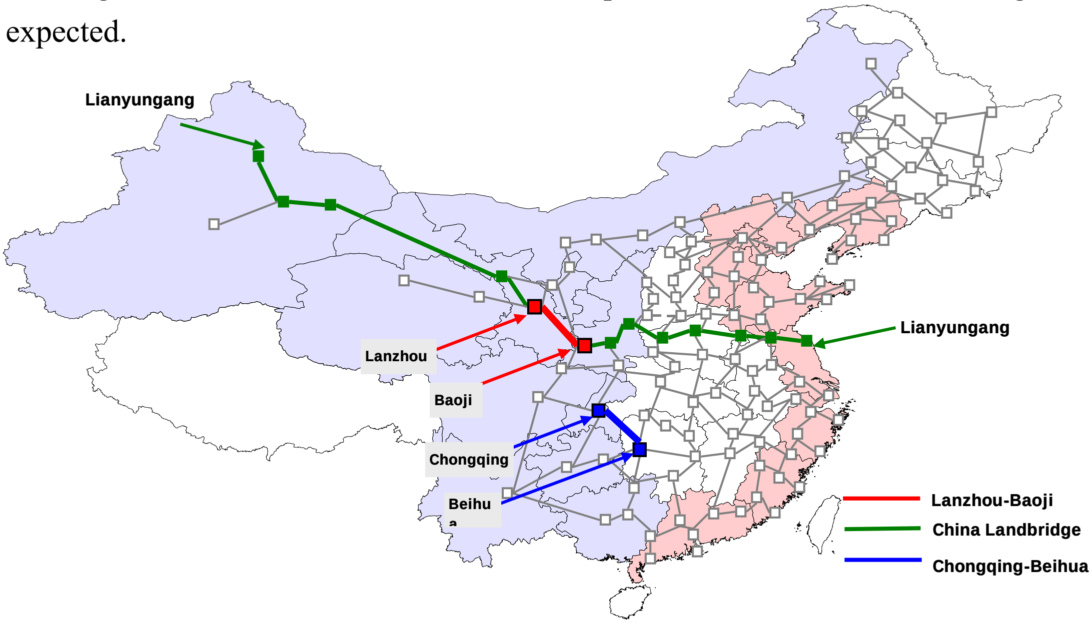


Fig. 6 Main projects on enhancing railways in China

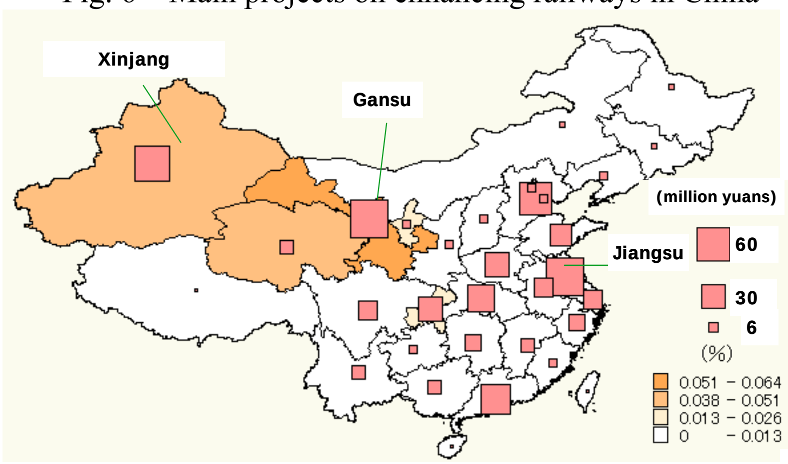


Fig.7 Changes of EV (Lanzhou-Boaji)

In order to make an objective appraisal of increase of social welfare with social capital improvement, it is needed to replace welfare changes with the monetary value in some way. In economics, if evaluated welfare changes with the monetary value, income change that is equivalent to that of individual utility level could be looked on as the measure of money. As typical examples for the money measurement, variations of consumer surplus (MD), compensation variations (CV) and equivalent variations (EV) have been proposed. In general it is thought that increase of social welfare results in aggregation of individual MD, CV or EV. In fact, EV can be obtained with monotonic transformation of the utility, and is dominant to CV.

From the result of the evaluation, about 490 million yuans ($US 60million) of EV could be increased in whole China when double-tracked between Lanzhou and Baoji. In Fig.7, the changes of EV in each province by the double-tracking project are demonstrated. It indicates that remarkable increases of EV may be expected in Gansu, Xinjiang and Jiangsu.

Changes of average cost of transport per goods to regions are also illustrated in Fig. 8. In the figure it shows that the deeper is a region colored, the larger reduces the cost of transport. Extensive renovations of traffic conditions are observed in the northwest region (Gansu, Xinjiang, Qinghai etc.), five provinces in the central, Sichuan and Chongqing.These changes induce to decrease the prices and to increase actual income ongoingly. In Fig. 9, we illustrate changes of the local prices in industries related to the daily lives, and the result indicates larger decreases of the prices in the northwest region, where the traffic conditions would be improved. In terms of wages, larger increases are observed in Gansu, Qinghai, and in Jiangsu where is at the east end of CLB (Fig. 10). And it can also be recognized from a result that changes of wage depend on those of production in each province.

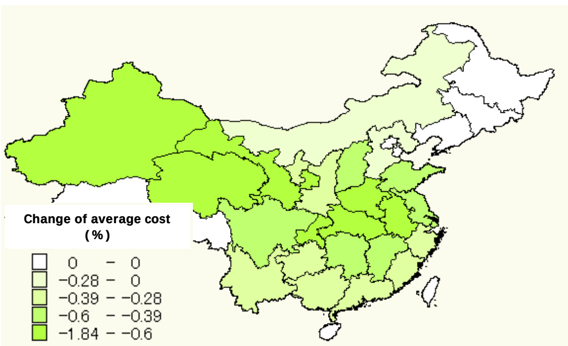


Fig. 8 Change of average cost

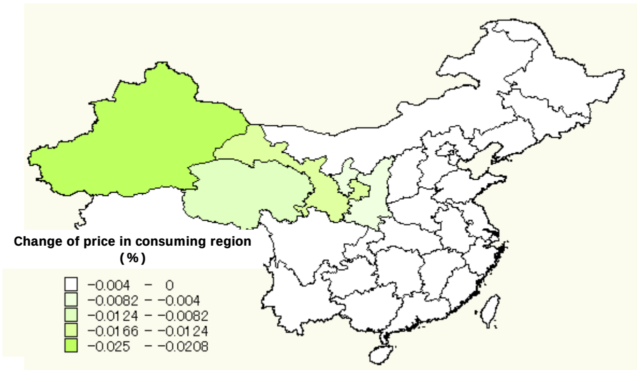


Fig. 9 Change of price in daily lives

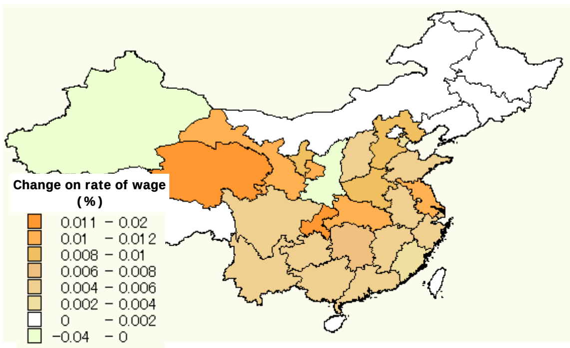
It is important to survey the change of production in each goods for recognizing how the renewal railway project in Lanzhou has impacts on structures of industries and division of labor. In nationwide changes of production, due to improvement of the traffic condition increases of production can be observed in the secondary sector, including base materials, daily lives, processing and assembly, and social infrastructure (Fig.12).

Among them the largest increase is obtained in the base material industry that provides materials to all industries. On the other hand, it also indicates that traffic reformation causes production decrease in the sector of both local and wide-area services, and of agro-industry.

3.2. Comparison among the projects

Though Sichuan and Chongqing are the main development blocks in the southwest region, the areas don't have enough railways connecting to the coastal region. To improve the situation, Chinese government has been going ahead with constructing a new railway between Chongqing and Beihua (Fig. 6).

In this chapter, we compare effects of two projects; the new railway between Chongqing and Beihua and the double-tracking in Lanzhou, and then consider the aspects taken.
Changes in EV are illustrated in Fig. 14, indicating that effects of construction converge into four provinces (Chongqing, Sichuan, Hunan and Guangdong).



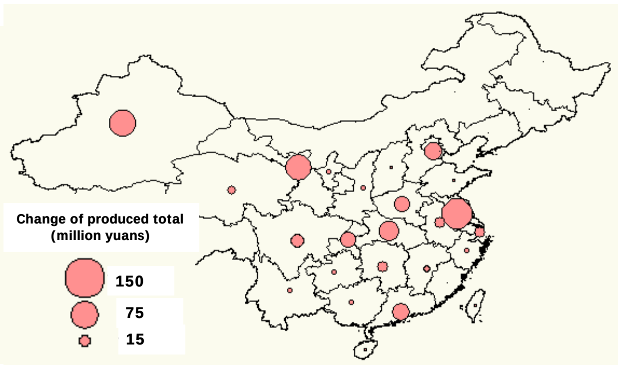
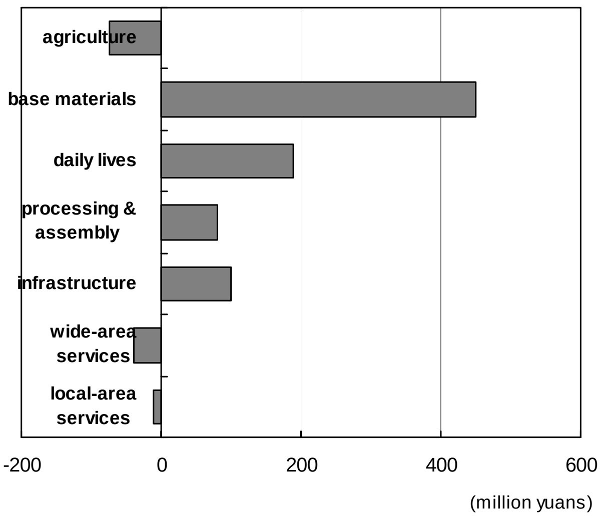


Fig. 10 Change of rate of wage

Fig. 11 Change of produced total



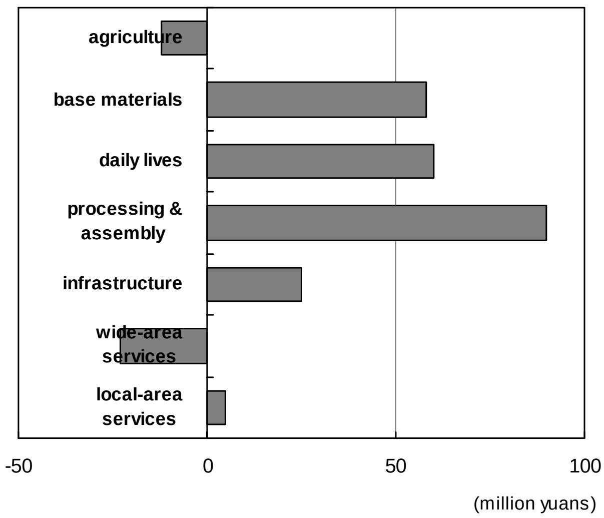


Fig. 12 Change of production (Lanzhou-Boaji)

Fig. 13 Change of production (Chongqing-Beihua)

Project in Lanzhou, extent of the impact of the new railway is quite limited. And changes of production seem to be the same. The reasons of the situation might be considered as follows;

1. The four provinces already have enough industrial bases and manage their economies in their own area.
2. South China economic zone including Guangdong comes to get a tighter relationship to the western region by the new railway installation. But the economic zone of South China can manage their activities almost in the territory, so less improvement of the trade between the both regions might arise.

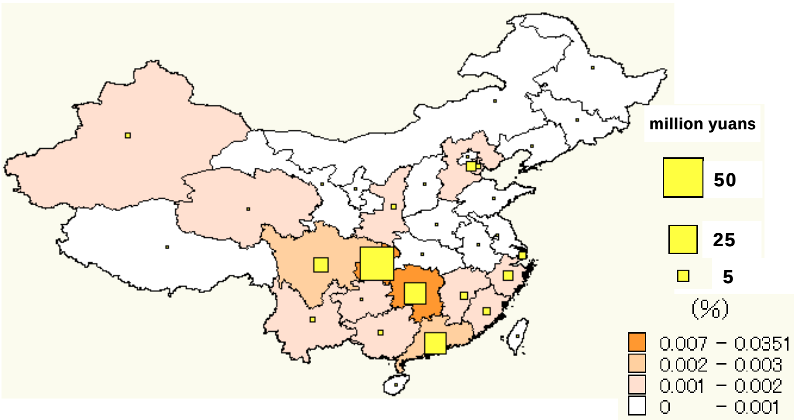


Fig.14 Change of EV (Chongqing-Beihua)

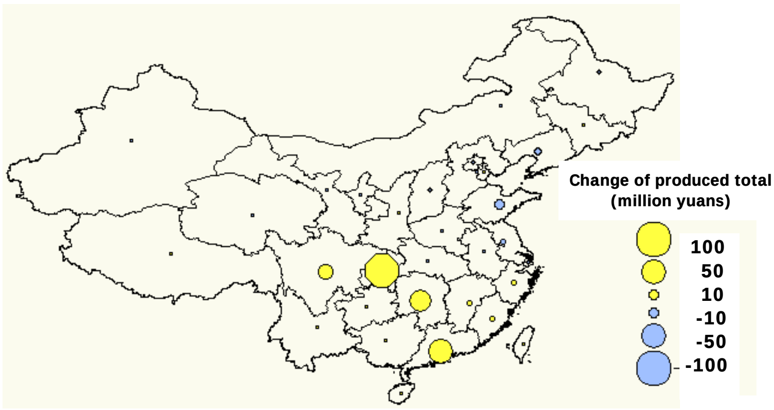


Fig.15 Change of producted total (Chongqing-Beihua)

Patterns of the changes of production are quite the same as the case of the double-tracking project. Suffice it to say, production in daily lives and field of processing and assembly is increased in comparison with Lanzhou project.

4. Conclusion

4.1. Achievement of the study

In the western region of China, delay of improvement on traffic facilities is the major limitation to develop their economies. Despite the government has issued and done several policies related to the traffic affairs, the results seem not to be effective now. In this study, we proposed a set of regional analysis models for measuring effects of the policies quantitatively.

In developing models, it was needed to meet two conditions like "interval and means of transportation" and "inter-industrial and spatial relationship".

Under the restriction above, we developed a new regional economic model with integration of traffic and CGE model. And using the model, we evaluated two promising railways projects in the western region in the 10th five-year plan.

The contents of evaluation obtained are as follows;

1 Changes of utilities and production along railway areas in shifting road to railway transport.

2 Repercussions of inter-industrial and of inter-regional relationship on regions except along railways.

The results of analysis indicated that there are large differences in areas and regions with lines improved. In case of the line between the northwest and the coastal area, effects of improvement on the railway could be obtained broadly. On the other hand, in case of the line between the southwest and the coastal area, economical effects seemed to be little to other regions.

4.2. Issues for the future

To make the model complete, we have to consider two aspects of the problem on (1)data and (2)theory. As far as item 1, data sets issued in China have been improved recently, but to do precise analysis we will have to obtain more refined ones. On item 2, to carry out CGE analysis some assumptions are required. In fact Chinese market system consists with fusion of socialist economy and market economy.

The system is somehow different from those in other nations, so there are inexplicable factors under the framework of market economy. Due to the reason, it must be considered to take into account the factors on creation of a model.

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Appendix Structure of CGE model

(1) Suffixes

i : industry i (output)

j : industry j (input)

r : region r (output)

s : region s (input)

(2) Variables on price

$PM(i)$: price of the imported goods

$W(s)$: rate of wage

R : rental price of the fixed capital stock

<Production Sector>

$PX(i,r)$: home goods price at production

$PF_A(j,s)$: composite goods price with labor and fixed capital stock

<Distribution Sector>

$PZ(i,s)$:home goods price at consumption

$PD_B(i,s)$: composite goods price with home goods at consumption

$PQ_B(i,r,s)$: composite goods price with home goods and transport services

<Transport Sector>

PT : price of transport services

$PF_C(s)$: composite goods price with labor and capital

(3) Variables

$\bar{L}(s)$: supply of labor

$\bar{K}(s)$: supply of fixed capital stock

<Industrial sector>

$X(j,s)$: quantity of output

$Z_A(i,j,s)$: input of composite goods

$F_A(j,s)$: primary input

$L_A(j,s)$: input of labor

$K_A(j,s)$: input of fixed capital stock

<Distribution Sector>

$Z(i,s)$: output of composite goods

$D_B(i,s)$: input of home goods

$M_B(i,s)$: input of the imported goods

$Q_B(i,r,s)$: input of home goods at the place of consumption

$X_B(i,r,s)$: input of home goods at the place of production

$T_B(i,r,s)$: input of transport services

<Transport Sector>

T : quantity of output

$Z_C(i,s)$: input of composite goods

$F_C(s)$: primary input

$L_C(s)$: input of labor

$K_C(s)$: input of fixed capital stock

<Private consumption>

$Z_H(i,s)$: consumption of composite goods

<Government consumption>

$Z_G(i,s)$: consumption of composite goods

<Fixed capital formation>

$Z_I(i,s)$: input of composite goods

<Export>

$X_E(i,r)$: amount of export of home goods at the place of production

(4) Proportional variables

$\mu_H(s)$: savings rate in private sector

μ_G : savings rate in government sector

$\tau(s)$: income tax rate

(5) Variables in amount

$Y_H(s)$: income in private sector

Y_G : income in government sector

S : total national savings

I : fixed capital formation

E : export

(6) Function values

<Elasticity of substitution>

$\sigma_D(i)$:elasticity of substitution for home goods

$\sigma_M(i)$: elasticity of substitution with home and exported goods

$\sigma_F(j,s)$:elasticity of substitution with labor and fixed capital stock

<Industrial sector>

$\beta_A^Z(i,j,s)$: input coefficient

$\beta_A^F(j,s)$: value-added coefficient

$\beta_A^L(j,s)$: scale parameter of composite function for primary input on labor

$\beta_A^K(j,s)$: scale parameter of composite function for primary input on fixed capital stock

<Distribution Sector>

$\beta_B^D(i,s)$: scale parameter of composite function for home and imported goods on home ones

$\beta_B^M(i,s)$: scale parameter of composite function for home and imported goods on the imported

$\beta_B^Q(i,r,s)$: scale parameter of composite function for home goods at the place of production

$\beta_B^X(i,r,s)$:input coefficient of home goods at the place of production

$\beta_B^T(i,r,s)$: input cofficient for transport services

<Transport sector>

$\beta_C^Z(i,s)$: input cofficient

$\beta_C^F(s)$: value-added coefficient

$\beta_C^L(s)$: scale parameter of composite function for primary input on labor

$\beta_C^K(s)$: scale parameter of composite function for primary input on capital

<Private consumption>

$\beta_H^Z(i,s)$: share parameter of consumption function

<Government consumption>

$\beta_G^Z(i,s)$: share parameter of consumption function

<Fixed capital formation>

$\beta_I^Z(i,s)$: share parameter of investment function

<Export>

$\beta_E^X(i,r)$: share parameter of export function

$C(i,r,s)$: cost of transport after infrastructure improvement

$\overline{C}(i,r,s)$: cost of transport before infrastructure improvement

Demand in industrial sector

$$Z_A(i,j,s) = \beta_A^Z(i,j,s) \cdot X(j,s) \quad \textbf{(1)}$$

$$F_A(j,s) = \beta_A^F(j,s) \cdot X(j,s) \quad \textbf{(2)}$$

$$L_A(j,s) = \beta_A^L(j,s) \cdot \left(\frac{PF_A(j,s)}{W(s)} \right)^{\sigma_F(j)} \cdot F_A(j,s) \quad \textbf{(3)}$$

$$K_A(j,s) = \beta_A^K(j,s) \cdot \left(\frac{PF_A(j,s)}{R} \right)^{\sigma_F(j)} \cdot F_A(j,s) \quad \textbf{(4)}$$

$$PX(j,s) \cdot X(j,s) = \sum_i PZ(i,s) \cdot Z_A(i,j,s) + PF(j,s) \cdot F_A(j,s) \quad \textbf{(5)}$$

$$PF_A(j,s) \cdot F_A(j,s) = W(s) \cdot L_A(j,s) + R \cdot K_A(j,s) \quad \textbf{(6)}$$

Demand in distribution sector

$$D_B(i,s) = \beta_B^D(i,s) \cdot \left(\frac{PZ(i,s)}{PD_B(i,s)} \right)^{\sigma_M(i)} \cdot Z(i,s) \quad \textbf{(7)}$$

$$M_B(i,s) = \beta_B^M(i,s) \cdot \left(\frac{PZ(i,s)}{PM(i)} \right)^{\sigma_M(i)} \cdot Z(i,s) \quad \textbf{(8)}$$

$$Q_B(i,r,s) = \beta_B^Q(i,r,s) \cdot \left(\frac{PD_B(i,s)}{PQ_B(i,r,s)} \right)^{\sigma_D(i)} \cdot D_B(i,s) \quad \textbf{(9)}$$

$$X_B(i,r,s) = \beta_B^X(i,r,s) \cdot Q_B(i,r,s) \quad \textbf{(10)}$$

$$T_B(i,r,s) = \beta_B^T(i,r,s) \cdot Q_B(i,r,s) \quad \textbf{(11)}$$

$$PZ(i,s) \cdot Z(i,s) = PD_B(i,s) \cdot D_B(i,s) + PM(i) \cdot M_B(i,s) \quad \textbf{(12)}$$

$$PD_B(i,s) \cdot D_B(i,s) = \sum_r PQ_B(i,r,s) \cdot Q_B(i,r,s) \quad \textbf{(13)}$$

$$PQ_B(i,r,s) \cdot Q_B(i,r,s) = PX(i,r) \cdot X_B(i,r,s) + PT \cdot \frac{C(i,r,s)}{\overline{C}(i,r,s)} \cdot T_B(i,r,s) \quad \textbf{(14)}$$

Demand in Transport sector

$$Z_C(i,s) = \beta_C^Z(i,s) \cdot T \quad \textbf{(15)}$$

$$F_C(s) = \beta_C^F(s) \cdot T \quad \textbf{(16)}$$

$$L_C(s) = \beta_C^L(s) \cdot \left(\frac{PF_C(s)}{W(s)} \right)^{\sigma_{FT}} \cdot F_C(s) \quad \textbf{(17)}$$

$$K_C(s) = \beta_C^K(s) \cdot \left(\frac{PF_C(s)}{R} \right)^{\sigma_{FT}} \cdot F_C(s) \quad \textbf{(18)}$$

$$PT \cdot T = \sum_i \sum_s PZ(i,s) \cdot Z_C(i,s) + \sum_i PF_C(s) \cdot F_C(s) \quad \textbf{(19)}$$

$$PF_C(s) \cdot F_C(s) = W(s) \cdot L_C(s) + R \cdot K_C(s) \quad \textbf{(20)}$$

Private consumption

$$Z_H(i,s) = \beta_H^Z(i,s) \cdot \frac{(1-\mu_H(s)) \cdot Y_H(s)}{PZ(i,s)} \tag{21}$$

Government consumption

$$Z_G(i,s) = \beta_G^Z(i,s) \cdot \frac{(1-\mu_G) \cdot Y_G}{PZ(i,s)} \tag{22}$$

Fixed capital formation

$$Z_I(i,s) = \beta_I^Z(i,s) \cdot \frac{I}{PZ(i,s)} \tag{23}$$

Export

$$X_E(i,r) = \beta_E^X(i,r) \cdot \frac{E}{PX(i,r)} \tag{24}$$

Supply-demand balance in home goods market (consumption place)

$$Z(i,s) = \sum_s Z_A(i,j,s) + Z_C(i,s) + Z_H(i,s) + Z_G(i,s) + Z_I(i,s) \tag{25}$$

Supply-demand balance in home goods market (production place)

$$X(i,r) = \sum_s X_B(i,r,s) + X_E(i,r) \tag{26}$$

Supply-demand balance in transport services market

$$T = \sum_i \sum_r \sum_s \frac{C(i,r,s)}{\overline{C}(i,r,s)} \cdot T_B(i,r,s) \tag{27}$$

Supply-demand balance in labor market

$$\overline{L}(s) = \sum_j L_A(j,s) + L_C(s) \tag{28}$$

Supply-demand balance in fixed capital formation market

$$\sum_s \overline{K}(s) = \sum_j \sum_s K_A(j,s) + \sum_s K_C(s) \tag{29}$$

Distributive income and savings

$$Y_H(s) = (1-\tau(s)) \cdot \left(W(s) \cdot \overline{L}(s) + R \cdot \overline{K}(s)\right) \tag{30}$$

$$Y_G = \sum_s \tau(s) \cdot \left(W(s) \cdot \overline{L}(s) + R \cdot \overline{K}(s)\right) \tag{31}$$

$$S = \sum_s \mu_H(s) \cdot Y_H(s) + \mu_G \cdot Y_G \tag{32}$$

Balance of investment and savings

$$I = S \quad \textbf{(33)}$$

Balance of export and import

$$E = \sum_i \sum_s M_B(i,s) \quad \textbf{(34)}$$

Utility

$$U_H(s) = \prod_i Z_H(i,s)^{\beta_H^Z(i,s)} \quad \textbf{(35)}$$