APPLICATION OF SYSTEM DYNAMICS SIMULATION METHOD IN EVALUATION OF TOTAL BENEFITS OF CHINA RAILWAY INVESTMENT[1]

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ABSTRACT

System dynamics adopts system simulation method on long-term dynamic simulation, which is not restrained by the higher order nonlinear describing equation and incomplete data. This method also provides friendly interface for man-machine interaction. This paper establishes a system dynamics model based on the combination of regional economy-traffic system with system dynamics theory, tests the validity of the proposed model, and proves the practicability and popularization value of applying the system dynamics method in the evaluation of the total benefits of railway investment.

Keywords: System dynamics, System simulation, Flow diagram, Regional economy-traffic system

1. INTRODUCTION

The total benefits of railway investment generally refers to the contribution the railway construction project has made to the regional economy through promoting the direct or indirect consumption in the region during the process of its construction and the potential positive effects on the regional society and economy during a certain period after the railway has been completed and put into use. According to the different diffusion paths of benefits and different periods of benefit production, the socioeconomic benefits of railway investment include the following five kinds: ①direct input benefits; ②output benefits; ③development benefits; ④deliver benefits; ⑤potential benefits. How to evaluate the total benefits produced in different periods has long been the focus of the study and discussion of railway investment.

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At present, the theoretical study on the evaluation of the total benefits of railway investment and its application in practice are still at the exploratory stage. The evaluation method used now is mainly qualitative analysis, while quantitative analysis is the supplementary method (and in quantitative analysis, static analysis is the most often used one). Although some quantitative dynamic models (such as input-output method, Multivariate statistical methods) have already been very perfect in evaluating the dynamics of the total benefits of railway investment, these models have high demands on the accuracy of data, which makes empirical study very difficult to carry out. System dynamics has its own advantage in analysing the long-term dynamic trend of the socioeconomic system. Its main characteristic is to carry out long-term dynamic simulation, restrained neither by higher order nonlinear describing equation nor by the time. In addition, it introduces constraints into the model and studies the behaviour mechanism of system under the stochastic disturbance. Furthermore, since its multi-feedback loop can weaken the system behaviour's sensitivity to most parameters, the accuracy of trend analysis will not be affected even if the data is not correct or incomplete, which increases its practicability and value of popularization.

2. SYSTEM DYNAMICS MODEL AND ITS CONSTRUCTION

The system dynamics (SD) is a method of studying the complex social system by applying computer simulation technology and based on the theory of system, the theory of control, and the theory of information. It believes that causal loop exists in any phenomena, and that any system has a certain structure, based on which the system can display certain functions and behaviours. Through dealing with different kinds of information flow in the system, it can describe the operation mechanism of a complicated system and build up a multiple and non-linear model to state the interaction between the elements within the system and environment elements. Furthermore, through the computerized simulation and strategy experiment, it can get a sequence that can achieve the future state of the system's development strategy and is cared by the model users.

The basic objective of the evaluation of the total benefits of railway investment is to analyse and evaluate the direct or indirect benefits of the project to the regional economy and the effects on the regional development after the completion of the project. The regional economic system is an open, dynamic and complex system and the regional traffic is one of its sub-systems. The construction of railway improves the function of regional traffic, promotes the development of other subsystems within the region, and finally accelerates the development of the regional economy. There are many complex and multi-loop feedback mechanisms existing in this process. In order to describe the active role of railway construction in the development of the regional economy, this paper builds a regional economy-traffic system dynamics model, summarizes the mechanism of the regional economy-transportation development through causal loop diagraph, simulates the development track of the regional economy with computer simulation technology, and compares the region's GDP with the railway construction project and the GDP without the project and then obtains the differences between them, which is the total benefits produced by railway investment and the ultimate goal of designing the model. Model construction includes four steps: ①causal loop analysis; ②flow diagram design of the model; ③construction equation of flow diagram; ④parametric estimation of the model.

2.1 Causal Loop Analysis

Causal loop analysis is to understand the structure mechanism and causation mechanism of the whole system, and to describe the dynamic behaviours of the system by highly abstract variables or indicators. Based on the mechanism of regional economy-transportation development, this paper designs causal loop diagraph (see Figure 1).

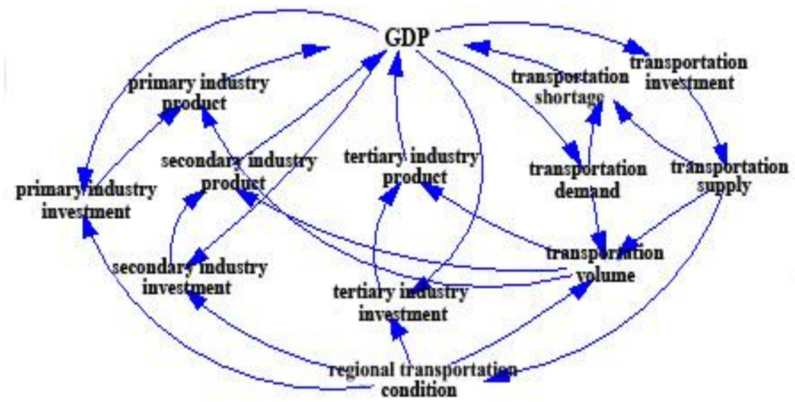

Figure 1 Causal Loop Diagraph of Regional Economy-Traffic System

This model sets four horizontal variables: regional GDP, regional primary industry product, regional secondary industry product, and regional tertiary industry product. Horizontal variables are the most important variables in SD, which play the role of accumulation in the system and reflect the changes of the scale of the whole system. Since regional GDP shows the development of the whole regional economy and the traffic system have different effects on different industries, we divide the industries into primary industry, secondary industry, and tertiary industry to study the traffic system's contribution to them respectively.

In the causal loop diagraph, several basic feedback loops are included hereunder as follows:

(1) Transportation supply → transportation volume → related industrial output value → GDP → transportation investment →transportation supply.

This positive feedback loop reflects that thanks to the market mechanism, the rise of transportation volume has been transferred to direct invest of relative industrial output value, and in turn promote the development of relative industry.

(2) Transportation supply → regional transportation condition → related industries investment → related industrial output value→ GDP → transportation investment →transportation supply.

This positive feedback loop reflects that the potential socioeconomic performance comes from regional traffic construction, in another word, the rising of transportation volume optimizes the regional condition of traffic and transportation, and improves regional environment for investment in turn, give a push to the regional economy.

(3) GDP → transportation investment → transportation supply → transportation shortage → GDP

This positive feedback loop demonstrates that the development of economy will give a rise on the transportation supply, and at the same time to release the pressure brought by transportation shortage, and finally to boost economic development. Railway needs government to put money in it, for it has the characteristics of public welfare and scale effect.

(4) GDP → transportation demand → transportation shortage → GDP

This negative feedback loop describes that the development of economy will increase the transportation demand, then to give rise to the shortage of transportation and finally to block the economic development.

It can be observed from the causal loop diagraph that regional transportation can affect social economic development by three ways:

Firstly, an indirect input and output benefit loop that triggered by direct transportation investment. This is showed in feedback loop 1. In this part, the money that was directly put into the construction of regional transportation has transferred to the indirect investment going to the relative industry, and stimulates the development of regional relative industries.

Secondly, output benefit loop. The feedback loop 3 reflects the benefit that brought by the construction of regional transportation. It calculates contribution to efficiency of the growth of net output in all relevant sectors caused by the increase amount of the regional passengers and freight, via simulating on the alternation of the regional transportation volume.

Thirdly, other benefit loops. The feedback loop 2 reflects that the development benefit and potential benefit rooted in the construction of regional transportation project.

2.2 Flow Graph Design of the Model

Through analysing the regional economy-transportation system and dividing each factor into horizontal variables, sub-variables and constant according to the principle of system dynamics, we make the system dynamics interactive flow graph of regional economy-transportation development based on Figure 1 (see Figure 2).

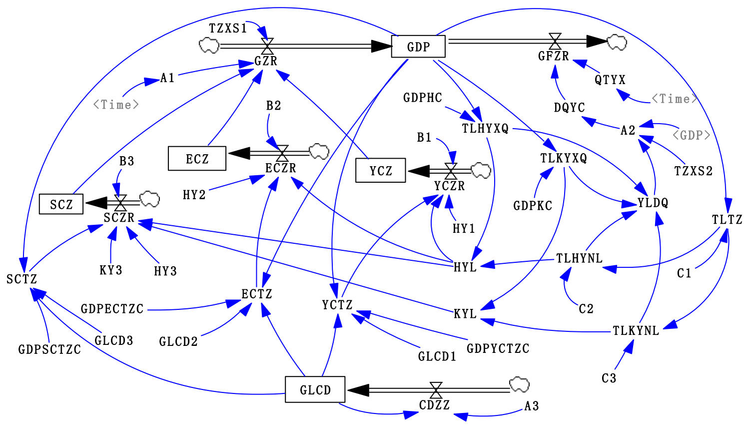

Figure 2 Flow Graph of Regional Economy-Transportation Development

Where:

GDP: regional product;

YCZ: regional primary industry product;

ECZ: regional secondary industry product;

SCZ: regional tertiary industry product;

YCTZ: regional primary industry investment;

ECTZ: regional secondary industry investment;

SCTZ: regional tertiary industry investment;

YLDQ: regional transportation volume shortage;

TLHYXQ: regional railway demand of freight;

TLKYXQ: regional railway demand of passenger transport;

TLHYNL: regional railway capacity of freight;
TLKYNL: regional railway capacity of passenger transport;
GLCD: regional railway miles;
KY3: regional tertiary industry product elasticity of passenger transport growth;
GZR: regional GDP growth rate;
GFZR: regional GDP negative growth rate;
A1: regional product intrinsic growth rate;
A2: regional railway capacity influence coefficient;
A3: regional railway miles intrinsic growth rate;
TLTZ: railway transportation industry investment;
CDZZ: regional railway miles annual growth;
HYL, KYL: regional objective freight and passenger transport respectively;
QTYX: regional other transportation means influence coefficient;
B1, B2, B3: regional primary industry, secondary industry, and tertiary industry investment growth coefficient respectively;
GDPHC, GDPKC: regional economic demand coefficient of freight and passenger transport respectively;
YCZR, ECZR, SCZR: regional primary industry, secondary industry, and tertiary industry annual growth respectively;
HY1, HY2, HY3: regional primary industry, secondary industry, and tertiary industry elasticity of freight growth respectively;
GDPYCTZC, GDPECTZC, GDPSCTZC: regional primary industry, secondary industry, and tertiary industry input coefficient respectively;
GLCD1, GLCD2, GLCD3: regional primary industry, secondary industry, and tertiary industry coefficient of traffic improvement respectively;
C1: regional GDP influence coefficient of railway transportation investment;
C2: railway freight capacity influence coefficient of regional railway transportation industry;
C3: railway passenger transport influence coefficient of regional railway transportation industry.

2.3 Construction Equation of Flow Graph

After we build the flow graph, with the help of the Vensim's formula editor, quantification system simulation model can be established and the system dynamics equation can be drawn according to the relevant data of the regional economy. Some of the main formulas are as follows:

(1)ECTZ=GDP*GDPECTZC+GLCD*GLCD2	Units: hundred million Yuan
(2)ECZ=INTEG(ECZR,ECZ0)	Units: hundred million Yuan
(3)ECZR=B2*ECTZ+HY2*HYL	Units: hundred million Yuan/Year
(4)GDP=INTEG(GZR-GFZR,GDP0)	Units: hundred million Yuan
(5)GFZR=QTYX*DQYC	Units: hundred million Yuan/Year
(6)GLCD=INTEG(CDZZ,GLCD0)	Units: kilometre
(7)GZR= (ECZ+SCZ+YCZ)*A1*TZCS1	Units: hundred million Yuan/Year
(8)HYL=MIN(TLHYNL,TLHYXQ)	Units: ten thousand ton kilometre
(9)KYL=MIN(TLKYNL,TLKYXQ)	Units: ten thousand ton kilometre

(10)SCTZ=GDP*GDPSCTZC+GLCD*GLCD3	Units: hundred million Yuan
(11)SCZ=INTEG(SCZR,SCZ0)	Units: hundred million Yuan
(12)SCZR=B3*SCTZ+HY3*HYL+KY3*KYL	Units: hundred million Yuan/Year
(13)YCTZ=GDP*GDPYCTZC+GLCD*GLCD1	Units: hundred million Yuan
(14)YCZ=INTEG(YCZR,YCZ0)	Units: hundred million Yuan
(15)YCZR=B1*YCTZ+HY1*HYL	Units: hundred million Yuan/Year
(16)YLDQ=TLHYXQ-TLHYNL+TLKYXQ-TLKYNL	Units: ten thousand ton kilometre
(17)A1=WITH LOOKUP (Time)	Units: Dmnl
(18)A2=WITHLOOKUP (YLDQ*TZCS2/GDP)	Units: Dmnl
(19)DQYC=DELAY3 (A2, 2)	Units: Dmnl
(20)QTYX=WITH LOOKUP (Time)	Units: hundred million Yuan/Year

2.4 Parameter Estimation of the Model

(1) KY3: regional tertiary industry product elasticity of passenger transport growth; HY1, HY2, HY3: regional primary industry, secondary industry, and tertiary industry elasticity of freight growth respectively; the estimation to parameters (take KY3 as an example):
logKYL=a+blogSCZ……①
In this equation, b is elastic coefficient, which means that 1% growth of SCZ will lead to b% growth of LYL, namely b is KY3; likewise we can get HY1, HY2, HY3.
(2) The estimation of parameters, such as GDPYCTZC, GDPECTZC, GDPSCTZC, GDPHC, GDPKC, GLCD1, GLCD2, GLCD3, C1, C2, C3, B1, B2, B3, is similar to formula① taking linear regression after math log. And b is the estimated parameter.
(3) The estimation of parameter A3: logGLCD=a+bt (t=1, 2, 3……n), and b is A3.
(4) The Estimation of parameter A2 can be achieved by expert evaluating method, which means that the experts analyse the shortage influence of the approach in study and give the influence coefficient.

3. AN EMPIRICAL ANALYSIS-TOTAL BENEFITS OF BEIJING-KOWLOON RAILWAY

Beijing-Kowloon railway is a railway in the People's Republic of China connecting Beijing West Station in Beijing to Shenzhen Station in Shenzhen, Guangdong Province. It then follows the rail-link between Shenzhen to the special administrative region of Hong Kong to Hung Hom Station (Kowloon Station) in Kowloon.
It is a dual-track railway. Construction began in February 1993. It was opened in 1996, connecting Beijing and Kowloon through Bazhou, Suning, Hengshui, Liaocheng, Heze, Shangqiu, Fuyang, Macheng, Jiujiang, Nanchang, Xiangtang, Ganzhou, Longchuan, Chang Ping, in the Changping integration with the Guangzhou-Shenzhen Railway, through Shenzhen to Kowloon, with a length of 2397 kilometres (see Figure 3). Across Beijing, Hebei, Shandong, Henan, Anhui, Hubei, Jiangxi, Guangdong and Hong Kong, 9 provinces, municipalities and special administrative regions. Land area is 226,000 square kilometres, accounting for 2.4% of the total land area of China. The gross value of industrial and agricultural output is accounted for 40% of China’s.

Figure 3 Schematic diagram of the Beijing-Kowloon railway

By collecting information, we get the following data. Some of the data are obtained from the 15 chief cities (Langfang, Hengshui, Cangzhou, Liaocheng, Heze, Puyang, Shangqiu, Xinyang, Fuyang, Huanggang, Jiujiang, Ji'an, Ganzhou, Heyuan, and Huizhou) the Beijing-Kowloon railway passes by. However, the statistics these cities do not have, including A3, GLCD1, GLCD2, GLCD3, can only be obtained from the provinces (Hebei, Shandong, Henan, Anhui, Hubei, Jiangxi, Guangdong) the Beijing-Kowloon railway passes by. Other data, such as C1, C2, C3, are obtained by the estimation based on national data. The main raw data are shown in Table 1.

Table 1 The Main Raw Data Needed in the Model [2]

Year	GDP (hundred million Yuan)	Total Investment (hundred million Yuan)	Rotation Volume of Passenger transport (ten thousand passenger kilometre)	Rotation Volume of Freight Transport (ten thousand ton kilometre)	Operation Mileage (kilometre)	National Railway Investment (hundred million Yuan)
1988	175.83	48.7	685276	787644	12221.8	149.53
1989	221.83	53	354811	569842	12437.1	131.64
1990	290.62	54.51	329725	553900	12573.7	147.17
1991	389.24	67.1	331800	720760	12605	167.76
1992	457.32	64.51	802008	1788805	12788.5	228
1993	702.39	103.6	387279	1511895	12996.9	449
1994	949.23	193.2	502365	824208	13119.4	565.7
1995	1190.6	234.82	579255	1319976	12123.7	540.4
1996	2268.2	390.33	598688	1643836	15021.2	615.1
1997	2991.33	813.74	1140096	2624930	15080.6	655.5
1998	3780.47	757.48	718173	1344406	15090.8	831.62
1999	3875.7	1069.6	989548	1165824	15135.3	819.49
2000	4064.66	1210.4	1268433	2549965	15106.7	788.4
2001	4374.17	1323.87	1422720	1832208	15071.7	808.68

Notes: The data in Table 1, except the data of national railway investment, are directly related with the Beijing-Kowloon Railway.

3.1 The Estimation of Related Data

Using the above parameters estimation method (see 2.4), the estimated value of the related data can be obtained with the SPSS software.
Estimation of A3 (take A3 as an example):

Table 2 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.866(a)	0.750	0.733	0.020924574

a Predictors: (Constant), T

Table 3 ANOVA (b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	0.020	1	0.020	44.923	0.000(a)
	Residual	0.007	15	0.000		
	Total	0.026	16			

a Predictors: (Constant), T;
b Dependent Variable: GLCD

Table 4 Coefficients (a)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.064	0.011		382.862	.000
	T	0.007	0.001	0.866	6.702	.000

a Dependent Variable: GLCD

A3's estimation is 0.007, correlation coefficient r=0.866. F shows that there is significance linear correlation.
Likewise, we can get the following parameters:
A3=0.0069 Units: 1/year;

[2]Source of Information：China Statistical Yearbook（1997-2003）, China City Statistical Yearbook（1989-2002）, China Beijing-Kowloon Railway Development Yearbook（1997-19980）, Economic Statistical Yearbook of Jiujiang(1998-2003), Statistical Yearbook of The Chinese Investment in Fixed Assets(1990-2003), Statistical Yearbook of the Provinces along the Beijing-Kowloon Railway (1989-2003).

B1=0.57	Units: 1/year;
B2=1.02	Units: 1/year;
B3=0.76	Units: 1/year;
GDPECTZC=0.85	Units: Dmnl;
GDPSCTZC=1.22	Units: Dmnl;
GDPYCTZC=1.26	Units: Dmnl;
GDPHC=0.37	Units: ten thousand ton kilometre/hundred million Yuan;
GDPKC=0.325	Units: ten thousand ton kilometre/hundred million Yuan;
GLCD1=11.94	Units: hundred million Yuan/kilometre;
GLCD2=6.46	Units: hundred million Yuan/kilometre;
GLCD3=10.36	Units: hundred million Yuan/kilometre;
HY1=1.82	Units: hundred million Yuan/(ten thousand ton kilometre*Year);
HY2=1.84	Units: hundred million Yuan/(ten thousand ton kilometre*Year);
HY3=1.91	Units: hundred million Yuan/(ten thousand ton kilometre*Year);
KY3=2.38	Units: hundred million Yuan/(ten thousand ton kilometre*Year);
C1=0.967	Units: Dmnl;
C2=0.189	Units: ten thousand ton kilometre/hundred million Yuan;
C3=0.164	Units: ten thousand ton kilometre/hundred million Yuan;
GDP0=175.83	Units: hundred million Yuan;
YCZ0=55	Units: hundred million Yuan;
ECZ0=72.51	Units: hundred million Yuan;
SCZ0=48.23	Units: hundred million Yuan;
GLCD0=12223.2	Units: kilometre.

3.2 Model Simulated and Data Set Analysed

3.2.1 Dynamic Analysis

After setting up the model, we can carry out model simulation and data set analysis (here we only make an analysis of GDP) with Vensim. Generally, the data set analysis is completed with the operation of control window. However, Vensim has provided a more powerful function of output control, which makes the analysis more convenient and much deeper, and makes the output more perfect. Figure 4 depicts the GDP changes of the cities along the Beijing-Kowloon railway after the railway has been completed.

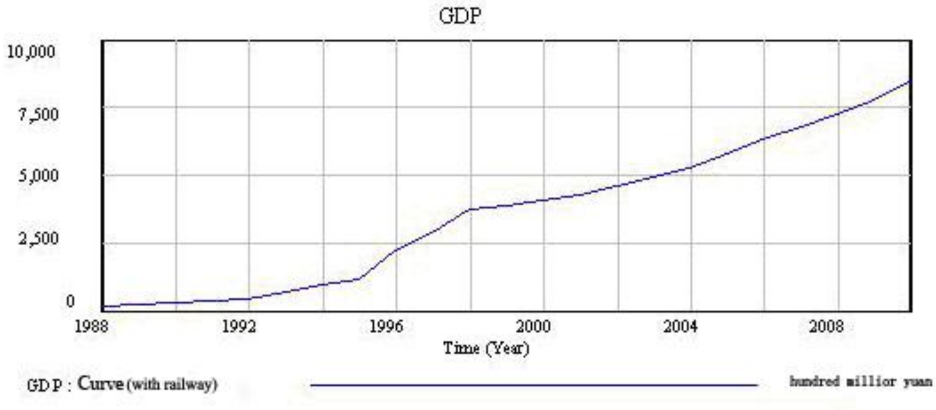

Figure 4 GDP Changes of Cities along Beijing-Kowloon Railway

In order to see the GDP changes after the railway has been completed, the data in Figure 4 can be shown in tabular form (see Table 5).

Table 5 GDP Data of Cities along Beijing-Kowloon Railway

Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
GDP (hundred million Yuan)	175.83	226.81	301.65	409.85	437.47	686.75	961.54	1143.62	2234.55	2876.15	3734.40	3883.97

（Continued）

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
GDP (hundred million Yuan)	4068.95	4306.02	4567.72	4904.44	5291.49	5762.22	6314.27	6783.67	7247.28	7812.35	8506.84

3.2.2 Test of Historical Data of GDP variables in Regional Economy-Transportation Development Interactive System Dynamics Model

In the regional economy-traffic system model, historical test should be made on the main variables, and the validity of the model should be tested by comparing the simulation value of the variables with their historical data. The historical test of the main variable -GDP is listed in Table 6.

Table 6 Test of Historical Data of GDP in the Beijing-Kowloon Railway System Dynamics Model

Variable / Year	GDP(hundred million Yuan)		
	simulation value	actual value	error%
1988	175.83	175.83	0
1989	226.81	221.83	2.24
1990	301.65	290.62	3.8
1991	409.85	389.24	5.29
1992	437.47	457.32	-4.34
1993	686.75	702.39	-2.23
1994	961.54	949.23	1.3
1995	1143.62	1190.6	-3.95
1996	2234.55	2268.2	-1.48
1997	2876.15	2991.33	-3.85
1998	3734.4	3780.47	-1.22
1999	3883.97	3875.7	0.21
2000	4068.95	4064.66	0.11
2001	4306.02	4374.17	-1.56
2002	4567.72	4627.6	-1.29

The error between the actual value and simulation value of GDP is shown in Figure 5:

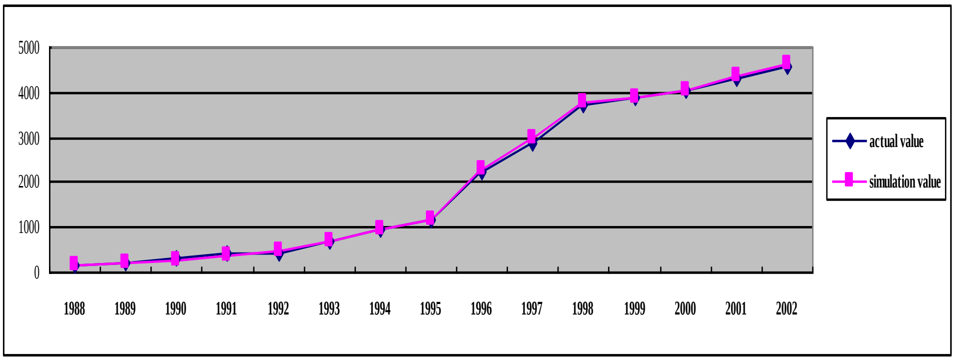

Figure 5 Comparison between Actual Value and Simulation Value of GDP

It can be seen that all the errors in Figure 5 are less than 6%, which means that the model stands the historical test.

3.2.3 Comparison of the GDP "with/without" Beijing-Kowloon Railway

With the help of "with/without method", this paper estimates the total benefits of the Beijing-Kowloon railway by getting the difference between the GDP with railway construction and the GDP without railway construction. Based on the above parameters of the system dynamics model, this paper gets the changes of the GDP without the Beijing-Kowloon railway by reducing the influence of these parameters (see Figure 6)[3].

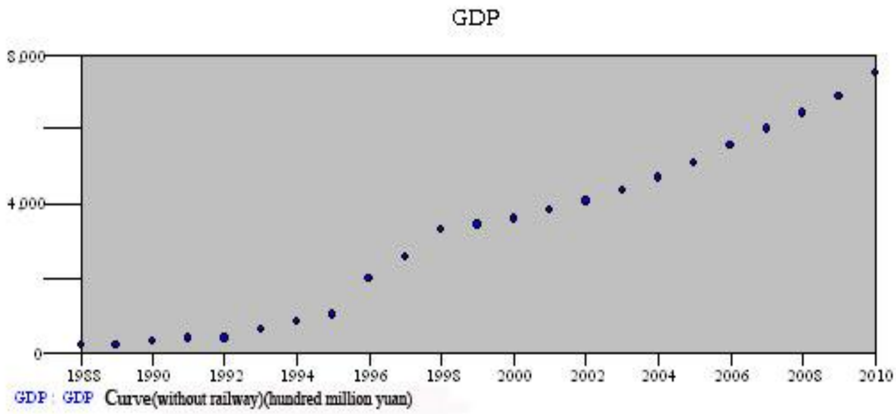

Figure 6 Simulated GDP Changes without Beijing-Kowloon Railway

We select data set with the help of Vensim and draw Figure 7 by comparing Figure 4 with Figure 6. Hence we can get the total benefits of the Beijing-Kowloon railway.

[3]We can get the curve under case of without railway by a small processing to the parameters, reducing the influence of them, which is the curve under the case with railway; without railway is just a hypothetical, there is no actual data.

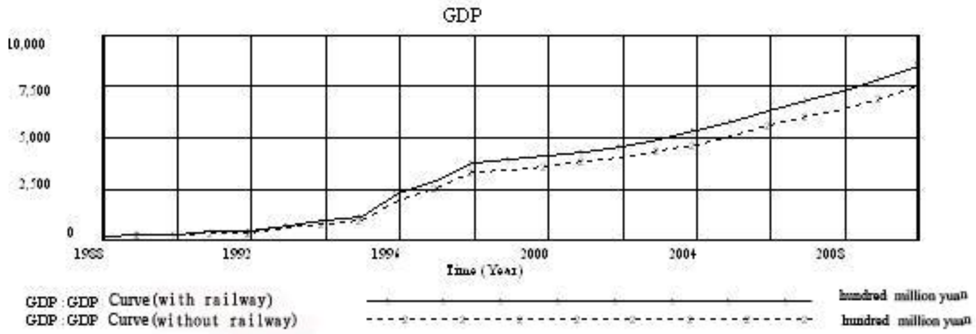

Figure 7 Comparison of GDP Changes of Cities with/without Beijing-Kowloon Railway

Figure 7 shows the total benefits of the Beijing-Kowloon railway, while Table 7 displays more specific figures.

Table 7 Tabular Form of Data in Figure 7

Year	GDP(with railway) (hundred million Yuan)	GDP(without railway) (hundred million Yuan)	total benefits (hundred million Yuan)
1988	175.83	175.83	0
1989	226.81	226.81	0
1990	301.65	284.74	16.92
1991	409.85	349.39	60.46
1992	437.47	332.26	105.22
1993	686.75	530.96	155.79
1994	961.54	752.42	209.12
1995	1143.62	879.34	264.28
1996	2234.55	1795.3	439.25
1997	2876.15	2333.33	542.82
1998	3734.4	3060.41	673.99
1999	3883.97	3175.93	708.04
2000	4068.95	3319.69	749.26
2001	4306.02	3507.07	798.95
2002	4567.72	3714.28	853.44
2003	4904.44	3984.13	920.31
2004	5291.49	4296.06	995.43
2005	5762.22	4678.96	1083.26
2006	6314.27	5131.09	1183.18
2007	6783.67	5512.17	1271.5
2008	7247.28	5888.34	1358.94
2009	7812.35	6351.1	1461.25
2010	8506.84	6924.27	1582.57

From Table 7, we can see that the total benefits of Beijing-Kowloon railway are rather considerable. In 1990, when it had been put into use for its third year, the Beijing-Kowloon railway achieved 1,692 billion Yuan as the total profits of its investment. In 1991, it achieved 6,046 billion Yuan, and afterwards its profits kept increasing year by year. In 2004, its profits increased to 99,543 billion Yuan and are expected to increase to 158,257 billion Yuan in 2010.

4. CONCLUSION

4.1 The Strengths of System Dynamics Model

The methodology and feature of system dynamic make it more qualified to study the relationship between regional transport construction and development regional economic, for a general econometric model can not solve the problems on non-linear, control threshold and

feedback loop. Therefore, it needs to take system dynamic approach to study the evaluation of the total benefits of railway investment.
System dynamic model emphasizes the dynamic characteristic relationship between system structure and system behaviour. So compared with other study approaches, it has the hereunder advantages:
(1) It can be easily used to describe systems with large scale and build feedback structure. Also, it can be easily operated by computer. It has unique superiority in the simulation of dynamic behaviours of social economic system.
(2) It can process problems directly and pictorially. It can be easily used to imitate man-machine interaction with the help of causal loop diagram, system flow diagram, computer graph, and tabular technology.
(3) It does not require absolutely precise data and the precision of its trend analysis is not affected by the incompleteness of data. The lack of data, reference and relation is a frequent problem that in the research of social economics. While, when people are encountered of the above mentioned problem, the model of system dynamics still can do the research, for its model structure is the base of the feed-back.
(4) It is good at dealing with cyclical problem and long-term cyclical problem. System dynamic model is a rational model of cause and effect mechanism, which emphasizes the behaviour of the system is mainly determined by the mechanism within the system, and as a result it has a relative long simulation time.
(5) It is good at dealing at complex problems of high-end, nonlinear, and time-varying. Regional economic system is complex, so it will need to be described by equations of high degree, non-linear and time-varying rather than general method of mathematics. While to use other ways, such as linear approximation approach, is want of liable. Conclusively, simulation technique is more effective.
This paper applies system dynamics model in the empirical analysis of the total benefits of Beijing-Kowloon railway investment and tests its validity through historical data examination, which shows that the error is small (less than 6%). Hence, it can be concluded that system dynamics model has practicability and value of popularization.

4.2 The Weaknesses of System Dynamics Model

The structure of the model is mechanical. It cannot adapt to the changes of the environment and upgrade its lower structure to higher structure by itself8. When building up the model, we should collect not only the data that can reflect the phenomenon outside the system, but also the data about the system itself. In order to get the model that can reflect the essence of the system, we should go deeper into the system to observe the immeasurable causal loop and connect the dynamic changes of the system and its feedback structure.

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