Dynamic Mechanism of High-Speed Railway on Urban Social-Economic Development in Yangtze River Economic Zone

Minghao Zhu

***Abstract*—In this study, the author aims to investigate the inner law between high-speed railway (HSR) and economic development. Beijing-Shanghai High-speed Railway, as a case is simulated to find out how these relationships could be established, and the system dynamic is used to build a system model. The case results have revealed that the HSR has a strong influence on the development of the tertiary industry because of its passenger characteristics, and it has an overall positive effect on the GDP, especially secondary and tertiary industries. It has greatly contributed to the movement of the employed population from traditional agriculture to manufacturing and services industry.**

The findings of this study could not only serve as a reference for HSR planning, but also could guide employees moving to the more reasonable areas related to skill, knowledge and other information, which would subsequently improve urban economic.

***Index Terms*—High-speed railway, economic, industry, employee.**

I. Introduction

High-speed railway (HSR) has promoted harmonious development in different areas in EU and Japan [1]. HSR can reduce travel time, and have a positive effect on freight transport. It also has significantly reduced the commute time between interconnected cities. With the HSR network, it can free capacity of the low-speed tracks, and then absorb the freight railway traffic [2]. For the city of Zaragoza, the HSR has provided the city with an important opportunity to develop a very ambitious urban planning project, and it has generated a new spatial transformation [3]. Taking the new Kyushu Shinkansen route as an example, it has an influence on travel behavior when people use rail for commuting and tourism [4], that large-scale HSR infrastructure is needed for USA.

In China, the high-speed rail is made through a state-led planning process for stimulating economic growth. HSR construction projects have become the engine and booster, which are promoting the growth of Chinese economy. HSR construction improves regional resource integration, optimizes industrial structure, and realizes regional economic integration [5]. The new high-speed railway has enhanced the economic relationships between urban and rural areas [6]. HSR has drawn the inflow to the second tier cities inside the Shanghai-led HSR clique and strengthened the status of core cities [7]. From the view of a total-travel-time for studying spatial impacts, most of the HSR stations in China, poor public transport connectivity is a hurdle to improve the HSR accessibility and in improving the overall attractiveness of HSR as a component of integrated sustainable transport system [8]. HSR can promote the harmonious development in the unbalanced regions, and the hub-and-spoke patterns of the spatial traffic organization reconfiguration in unbalanced regions can realize the regional balance oriented by the high-speed railway [9]. The Beijing-Guangzhou HSR contributions to the growth of per capita GDP is 3.18% with a distinct U shape curve relation between years and economic effects [10]. The Wuhan-Guangzhou HSR effects regional economy though economic growth, industrial structure, spatial structure and regional cooperation. Besides, it could increase the gaps between big cities and small cities [11].

However, if we only consider the economic benefits of high-speed railway, fixed assets scale, mode of investment and financing, passenger capacity and the mode of transportation organization, organization and management are the main factors. A reasonable ticket price plays an important role in HSR benefit under regional economic conditions [12]. The Beijing-Shanghai high-speed railway has a heavy burden that the activity costs is 0.3619 yuan/person per kilometer, and the unit costs and capital costs are 0.4532 yuan/person per kilometer and 0.5244 yuan/person per kilometer, respectively [13].

Recently, United States has greatly interests in HSR, which has become a major theme in US transportation policy debates. HSR is not currently a commercial proposition, unless it more than proportionately enhances the economic efficiency of the nation's economy [14].

II. System Dynamics Modeling of Interaction between High — Speed Railway and Social Economy

A. Background Analysis

Beijing-Shanghai High-speed Railway connects the North China and East China, going through the Beijing-Tianjin-Hebei, the Yangtze River Delta and other major urban agglomerations. Along this railway, the areas it crosses are mainly plains, and it goes across four major river systems - the Haihe River, the Yellow River, the Huaihe River and the Yangtze River. The areas it crosses account for 6.5%

Manuscript received October 23, 2017; revised December 23, 2017. This work was supported in part by National Natural Science Foundation of China under Grant 61402427 and the Fundamental Research Funds for the Central Universities under Grant 2015RC073.

Minghao Zhu is with Beijing Jiaotong University, Beijing, 100044, China (e-mail: mhzhu@bjtu.edu.cn).

DOI: 10.7763/IJMO.2018.V8.615

of the country land, and the population accounts for 26.7%. It crosses 11 cities with more than 1 million people, with GDP accounting for 43.3%. It is the China's most active areas with the most potential in economic development and the China's busiest corridor in passenger, and cargo transport with the greatest potential for growth.

Beijing-Shanghai High-speed Railway has been built in 2008, and it has officially been running from 2011. In 2014, the daily average of the passenger transport was nearly 300,000 passengers, which was its first profit. In 2015, the profit has reached 65 billion yuan. Its passenger transport has been over 450 million people in its fifth anniversary of the operation. Beijing-Shanghai high-speed rail is the busiest transport in China with the strongest transport capacity and best profits.

Passenger trains on Beijing-Shanghai High-speed Railway and inter-line passenger trains can be run in line to achieve the maximum network resources. The location, layout and scale of the stations are matched with the economy, passenger volume and urban planning of the cities along the route. The solar energy, wind energy, geothermal energy and other renewable energy are all fully used. With the design features of all-closed, full-interchange, it can achieve the aim of high speed, high density, and high security.

B. Causality Analysis

The interaction between railway (including the high-speed rail, the same below) and social economy involves many factors, such as GDP, investment, population, transportation capacity, passenger volume and freight volume and so on. There are complex relationships among variables, and the interaction, mutual evolution and mutual promotion of the systems have long-term dynamic causal feedback relations. The main state variables of the system are passenger capacity, transportation capacity, railway transport mileage, the primary industry GDP, the secondary industry GDP, the tertiary industry GDP and employment population, to describe the entire system changes. Through the analysis of the relationship between system elements and variables, the causal relationship is determined as shown in Fig. 1.

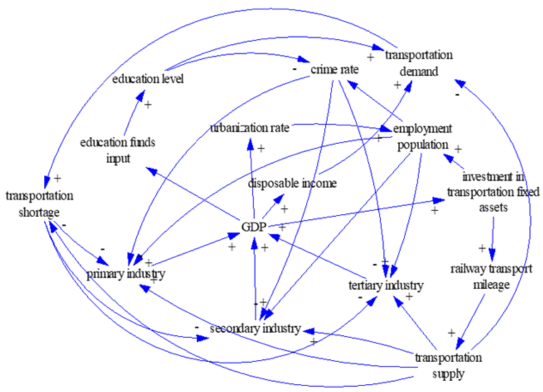


Fig. 1. A causality diagram of mutual relationship between railway and social.

1) GDP → investment in transportation fixed assets → railway transport mileage→ the primary industry (the secondary/tertiary industry) → GDP. The positive feedback loop indicates the increase in the transport capacity of railway lines through investment in transportation fixed assets, the improvement of transport supply levels, the optimization of traffic conditions, and the promotion of economic development
2) GDP → investment in transportation fixed assets → railway transport mileage→ transportation shortage→ the primary industry (the secondary/tertiary industry) → GDP. The positive feedback loop indicates an increase in transportation supply, reduction of the impact of transport shortages on economic growth, and ultimate promotion of economic development and greater railway investment.
3) GDP → investment in transportation fixed assets (urbanization rate) → employment population→ the primary industry (the secondary/tertiary industry) → GDP. The positive feedback loop indicates that the increase in investment in fixed assets will attract the working population to engage in investment and construction work, and then promote economic development. The GDP growth can promote the increase of urbanization rate, while it can also attract foreign population employment, and promote social & economic growth.
4) GDP→ education funds input→ education level→ transportation demand→ transportation shortage→ the primary industry (secondary/tertiary industry) → GDP. The negative feedback loop indicates that the increase of education investment can increase the education level of the city, promote the migrants to study in the city, produce the transportation demand, lead to the shortage of transportation capacity, and influence the social & economic development.
5) GDP → investment in transportation fixed assets (urbanization rate) → employment population→ crime rate → the primary industry (the secondary/tertiary industry) → GDP. The negative feedback loop indicates that the increase in the employment population can lead to an increase in the unemployment rate, and because of the dense population, the crime rate would increase and affect the socio-economic development.
6) GDP→ disposable income→ transportation demand→ transportation shortage → the primary industry (the secondary/tertiary industry) → GDP. The negative feedback loop indicates that the increase in disposable income makes people to have more funds to engage in various transport activities, which leads to the lack of transport capacity and affects economic development.

In terms of resources and environment, the main consumables of electrified railway are electric energy and water resources. The increase of railway transportation capacity can increase the consumption of electricity and water resources. By calculating the electricity consumption and water consumption per unit GDP, the proportion of the railway electricity and water consumption per year on GDP electricity consumption and water consumption can be analyzed to calculate the level of railway resource consumption.

C. System Flow Graph Analysis

According to the analysis of the causality diagram, the system dynamics model mainly includes four modules: railway subsystem, economic subsystem, social subsystem and resource subsystem.

1) Railway subsystem

The railway subsystem (the system flow diagram is shown in Fig. 2) includes railway transport capacity demand and transportation ability supply, and the difference is the railway transport capacity shortage. Railway transport capacity supply is mainly through fixed assets investment to construct new railways or extend the railways and to extend the railway mileage. The increase of GDP leads to the increase of employment population, the increase of per capita disposable income, the attraction of educational level, the attraction of tourism and other main factors which could increase the railway transport capacity demand. There are three state variables of the subsystem, which are passenger volume, freight volume and railway mileage. The corresponding rate variables are annual increase of passenger capacity, annual increase of freight volume and annual increase of railway mileage; and six table functions, which are the table function of primary industrial freight volume growth rate, the table function of secondary industry freight volume growth rate, the table function of tertiary industry freight volume growth rate, the table function of educational attraction, the table function of population and passenger growth rate, and the table function of per capita disposable income rate and passenger growth rate. Constants are tourism attraction, railway investment ratio. The rest are auxiliary variables.

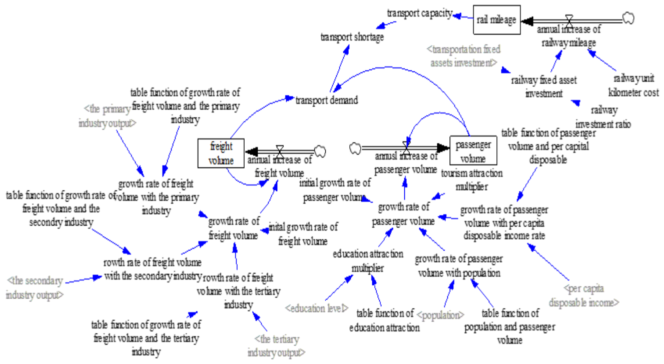


Fig. 2. System flow diagram of railway subsystem.

2) Economic subsystem

The economic system (shown in Fig. 3) involves many influencing factors. This paper assumes that the economic growth is mainly affected by the employment of the three industries, the volume of passenger and freight traffic, and the crime rate of social crimes. Employment population has a certain proportion with urbanization rate and investment in fixed assets. Economic growth presents with the increase of the three industries GDP. The subsystem sets the first industry GDP, the secondary industry GDP, and the tertiary industry GDP for the state variables. The corresponding rate variables are the annual increases of the primary industry GDP, the secondary industry GDP and the tertiary industry GDP, and 10 table functions, which are, respectively, the table function of the primary industry employment population and GDP growth rate, the table function of the secondary industry employment population and GDP growth rate, the table function of the tertiary industry employment population and GDP growth rate, the table function of the impact rate of crime rate on the primary industry GDP, the table function of the impact rate of crime rate on the secondary industry GDP, the table function of the impact rate of crime rate on the tertiary industry GDP, the table function of transport capacity and the primary industry GDP growth rate, the table function of transport capacity and the secondary industry GDP growth rate, the table function of transport capacity and the tertiary industry GDP growth rate, and the table function of population. The constants are the proportion of investment in total social fixed assets, the proportion of investment in transportation fixed assets, the proportion of investment in education funds, and the rest are auxiliary variables.

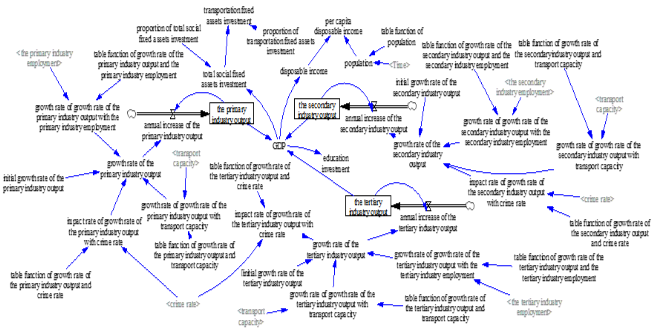


Fig. 3. System flow diagram of economic subsystem.

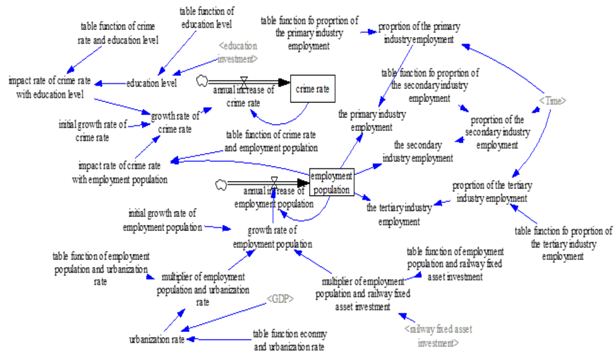


Fig. 4. System flow diagram of social subsystem.

3) Social subsystem

For the social subsystem (shown in Fig. 4), this paper studies the employment population, education level, urbanization rate and crime rate from the perspective of volume of the railway passenger and freight traffic. The increase of GDP can promote the development of urbanization process, provide a large number of jobs, improve the employment environment, promote rural economic development, increase farmer income, and increase employment in rural areas. The increase of the urban education can attract the immigrants to produce the population flow. On the other hand, investments in fixed assets require a lot of manpower and resources, so it would not only promote the increase in the employment population caused by the construction, but also affect other industries' demands on the working population. The system consists of two state variables: the employment population and the crime rate. The seven functions are as the following: the table function of the proportion of the primary, secondary and tertiary industry employment population, the table function of railway fixed assets investment and employment population, the table function of urbanization rate and employment population, the table function of economy and urbanization rate, the table function of education level, the table function of education level and crime rate influence, and the table function of employment population and crime rate influence. The initial employment population growth rate is a constant and the rest are auxiliary variables.

4) Resource subsystem

Considering that China has basically achieved electrified railway transformation, the social subsystem (shown in Fig. 5) mainly considers the relationship between railway's annual electricity consumption and GDP power consumption, and the relationship between railway's annual water consumption and GDP water consumption. The system constants are single train electricity consumption, single train water consumption, 100 million yuan GDP electricity consumption, and 100 million yuan GDP water consumption.

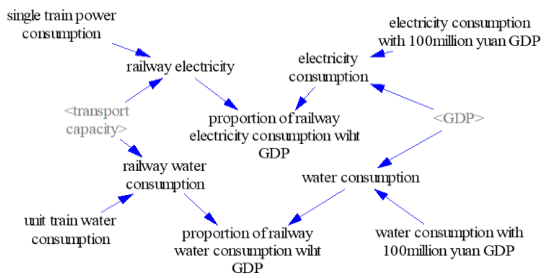


Fig. 5. System flow diagram of social subsystem.

5) Cyclic graph of key variables

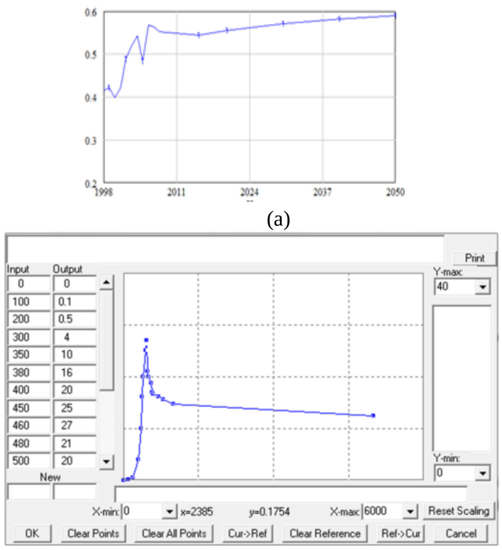
The analysis of one key variable in each simulation of the link in the whole system is conductive to the system process re-inspection and error investigation. The variable cycle graph takes the selected key variables as the starting point, analyzes each cycle path where the key variables are located, and shows the other variables and cycle steps involved in each loop path.

Taking the first industry GDP as a key variable, every cycle path experienced in the system simulation process can be presented. Based on the cycle result, it can be seen that the primary industry GDP has a total of seven circular paths, and the length of the loops are, respectively, 1, 10, 10, 10, 10, 12, 13, and 15. The variables include GDP, investment in total social fixed assets, investment in transportation fixed assets, investment in railway fixed assets, railway investment and the employment population multiplier, employment population growth rate, the annual increase of the employment population, employment population, employment population and crime rate influence value, crime rate growth rate, annual increase of the crime rate, crime rate, crime rate and the primary industry GDP influence rate, the primary industry GDP growth rate, and the annual increase of the primary industry GDP. Seen in the cycle graph, it is proved that the simulation correctly passes through every cycle path of the first industry GDP, and the simulation process does not show the situation of missing variables.

Taking the railway as a key variable, based on the cycle result, it can be seen that it has 3 circular paths, and the length of the loops are, respectively, 10, 10, and 10. The variables include the transport capacity, the transport industry and the first industry GDP growth rate, the first industry GDP growth, the annual increase of the first industry GDP, the first industry GDP, GDP, the investment in total social fixed assets, investment in transport fixed assets, railway fixed asset investment, and the annual increase of railway mileage. Seen in the cycle graph, it is proved that the simulation correctly passes through every cycle path of railway mileage, and the simulation process does not show the situation of missing variables.

6) Table function and parameter estimation

This paper takes Jiangsu and Shanghai in the Yangtze economic belt as research areas. The main data come from China Statistical Yearbook, China Regional Economic Statistical Yearbook, China Tourism Yearbook, Jiangsu Statistical Yearbook, Shanghai Statistical Yearbook, which include GDP / gross regional product, fixed asset investment, population and labor, per capita disposable income, urbanization rate, education fund and undergraduate per 10,000 people, electricity consumption in major years and water consumption, public security cases investigated by public security bureau/ traffic accident, railway mileage, volume of passenger traffic cargo, and so on.



Input	Output
0	0
100	0.1
200	0.5
300	4
350	10
380	16
400	20
450	25
460	27
480	21
500	20

(b)

Fig. 6. (a) The table functions of tertiary industry employment population proportion; (b) the table function of tertiary industry employment population and GDP growth rate.

The model uses a number of table functions, and these table functions are divided into two types. The first type of the table function is only a function of time, as shown in Fig. 6(a). The value of the table function can generally be found in the public database. The second type is the function that represents the relationship between two variables, as shown in Fig. 6(b). The parameters of these table functions cannot be found in the public database, generally based on empirical values or estimated part of them during model debugging. The system model parameters are estimated in two ways: the coefficients in the equation that represents some rate-of-change relationships estimated by the least-squares method, and the historical data taken from the area under study; some other parameters estimated by system behavior method, which are only informative with no public data.

III. Model Test

A. Validity Test

By running the historical data to debug the model, the model parameters are determined to test and realize the consistency between compiling model and the actual historical trend. There are two reasons why this model takes GDP as the main historical value of the test indicators. Firstly, the core of the study is the relationship between the railway and socio-economic, and GDP is the main variable. The second reason is that GDP is the simulation process center in the system dynamics simulation process, according to the impact degree and circulation process of indicators, which is the repressor of the output value of the primary, secondary and tertiary industry, and also the external impact variable of the employment subsystem and railway subsystem.

Taking Shanghai as an example, regression analysis and data processing are carried out on the comprehensive data, and the system dynamics equation is established. The simulation results of GDP are as the following:

TABLE I: The Simulation Results and Initial Data of Shanghai GDP

Y	GDP（Simulation Value）	GDP（Real Value）	Error Degree
1998	3801.1	3801.1	0.00%
1999	4297.4	4188.7	2.60%
2000	4944.6	4771.2	3.63%
2001	5421.9	5210.1	4.07%
2002	6060.9	5741.0	5.57%
2003	7124.09	6694.2	6.42%
2004	8221.1	8072.8	1.84%
2005	9482.1	9147.1	3.66%
2006	10911.6	10572.2	3.21%
2007	12468.1	12494.0	-0.21%
2008	14406.2	14069.87	2.39%
2009	15744.5	15046.4	4.64%
2010	17470.1	17165.9	1.77%
2011	19470.1	19195.7	1.43%
2012	21581.7	20181.7	6.94%
2013	22894.7	21818.2	4.93%
2014	24571.1	23567.7	4.26%
2015	25894.7	25123.5	3.07%

Seen in Table I, the error degree between the simulation results and the true value is less than 6.5%, and the general statistical error of about 4% are acceptable error range. Since the statistical caliber of GDP has changed since 2004, there are two different GDP values in the China Statistical Yearbook. Considering the influence of the statistical data itself and the selection of composite indicator, the error range belongs to the acceptable error range. The model is tested by validity.

B. Sensitivity Analysis

The essence of sensitivity analysis is to explain the rules and the key index changes influenced by these factors, with changing the value of relevant variables one by one. In this paper, the third industry GDP is used to analyze the sensitivity of transportation demand stimulus. Taking Shanghai Province as an example, the curve of Current1 adjusts the proportion of railway fixed assets investment to change the railway transportation capacity on the basis of Current, in order to study the change degree of each industry GDP, and analyze the change of transportation demand.

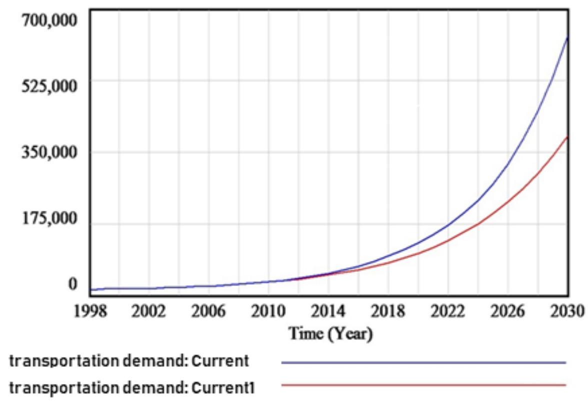


Fig. 7. Sensitivity analysis on the transportation demand.

As seen in Fig. 7, when the current railway investment ratio in fixed assets is increased from 0.0819 (current1) to 0.1 (current2), the transport capacity plays a positive role in promoting the secondary industry and tertiary industry stimulus coefficient, and also can promote the transport demands. In general, it is found that in the sensitivity analysis, the secondary industry and the tertiary industry GDP and the GDP comprehensive index are positively sensitive to the stimulation coefficient of freight demand and passenger traffic demand, and the transport capacity is positively sensitive to the stimulation coefficient of GDP. The greater the stimulation coefficient, the greater the increases in the corresponding variable are. Because the primary industry on the railway is less dependent on railway, it has a negative effect on the primary industry. The model has been tested by sensitivity.

IV. Conclusion

In order to meet the requirements of the system dynamics simulation for the time zone, the simulation time interval is set from 1998 to 2030.

The HSR has an overall positive effect on the GDP of Jiangsu Province. As seen in Fig. 8, Jiangsu has been ranked among the top provinces in the country, and has a number of large and medium-sized cities and adequate socio-economic development. The social economy is well developed, the economic growth rate goes beyond the GDP growth rate in a long term, and the development is relatively stable. Fig. 9 shows that the railway has a positive effect on Shanghai's GDP composite indicator. On one hand, railway construction improves the capacity of railway transport, and directly promotes economic development; on the other hand, the increase in employment population promotes the increase of population engaged in various industries, and contributes to GDP growth.

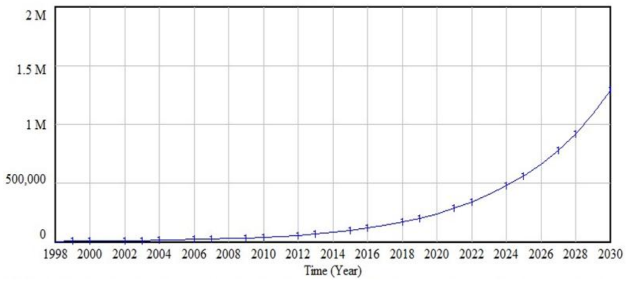


Fig. 8. Simulation trend graph of GDP.

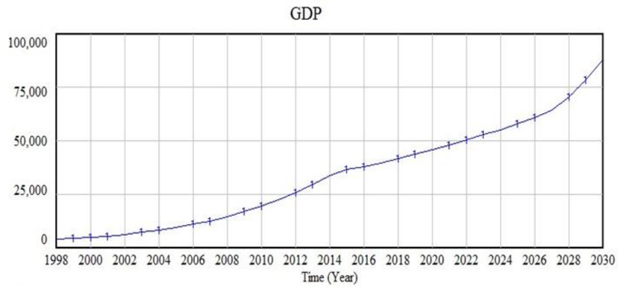


Fig. 9. Simulation trend graph of GDP.

The HSR development in Jiangsu Province has promoted the secondary and the tertiary industry. As shown in Fig. 10, the output value of the first industry has been increasing from 2006 to 2024; the level of mechanization of agricultural production in Jiangsu Province is relatively high; the development of railway is conducive to the circulation of agricultural products, and promote the logistics and distribution between the southern and northern cities of Jiangsu Province, with the industrial layout balanced. After 2024, due to the level of urban industrialization, the population of the first industry have more profound influences on primary industry GDP, making the first industrial output declined. The main railway development of Jiangsu Province mainly improves the city's second industry. Its increase of the railway transportation capacity enhances the development quality of manufacturing, and then enhances the industrial competitiveness of Jiangsu Province. The secondary industry of Jiangsu Province has maintained a rapid growth. Before 2017, the secondary industry as its leading industry, leads Jiangsu Province to have a rapid social and economic development.

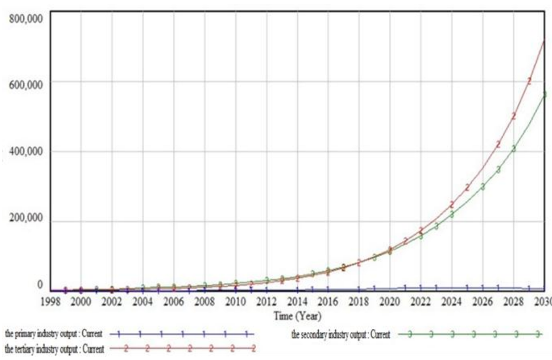


Fig. 10. Simulation trend graph of three industries output.

The HSR can increase employment in secondary and tertiary industry. As shown in Fig. 11, the employment population and the industrial population simulation trends show that the employment population is relatively stable, with the secondary industry and the tertiary industry population growth accelerated. The first industry gradually shrinks, mainly due to the greater HSR's influence on the city's passenger volume. Secondary and tertiary industries, especially the high-tech industries, have higher requirements on high-level talents, and with the development of Jiangsu Province, the industry can provide more and more jobs, making its second tertiary industry develop rapidly. In Fig. 12, according to the three industries, the output value of the primary industry, the output value of the secondary industry and the tertiary industry in Shanghai vary. Among them, the output value of the primary industry continues to grow by 2025, and the growth rate remains at around 6%. After 2025, it could begin to decline; the output value of the secondary industry would have a rapid growth with more than 15%, and it could promote the output value of the secondary industry obviously. The growth of the second industry GDP is restrained from 2013 to 2027. After 2027, it would regain its growth. The output value of the tertiary industry has been promoted since 1998, and maintains a relatively stable growth rate. From the changes of industrial GDP, the promotion of the development of the railway to the tertiary industry is very obvious, the promotion to the secondary industry is less, and the impact on the primary industry is very small.

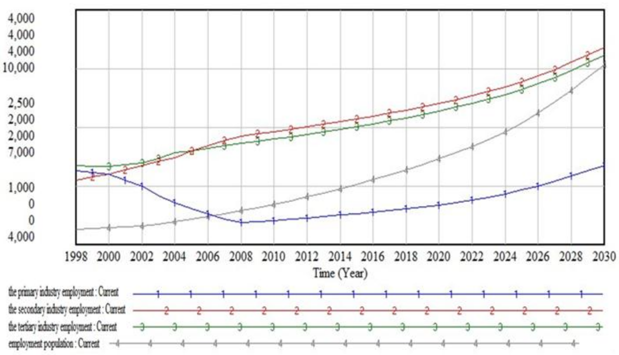


Fig. 11. Simulation trend graph of the employment population and the population in industries.

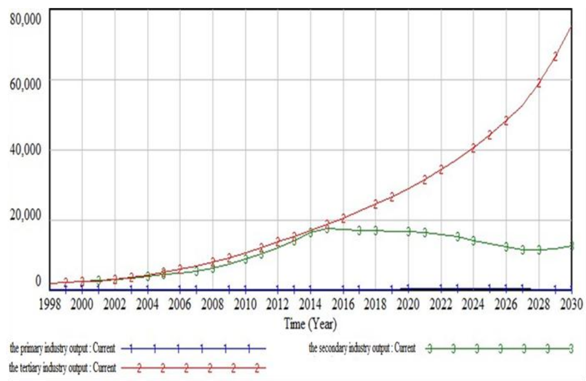


Fig. 12. Simulation trend graph on the three industries output.

V. Discussion

On the basis of system dynamics, the system dynamic model of the interaction between high - speed railway and social economy is established. By analyzing the background of high - speed rail construction, a causal graph and a system flow graph are established, and the cycle graph of key variables is described. By simulating the railway and socio-economic development data of Jiangsu Province and Shanghai, it is found that the railway has promoted the overall economic development of Jiangsu Province and Shanghai. The overall output value of the second industry and the tertiary industry in Jiangsu Province has been promoted. For the first industry, the railway promotes it in the early development, while later begins to inhibit. The promotion of tertiary industry in Shanghai is very obvious, the promotion of the secondary industry is less, and the impact of the primary industry is very small. The population growth of the secondary industry and the tertiary industry in Jiangsu Province accelerates, with the first industry gradually shrinking. The promotion to the employment in Shanghai is very obvious, and substantial increase in employment of the tertiary industry makes up the employment decline of the first industry. Therefore, it conducts the rapid growth of the total employment population.

ACKNOWLEDGMENT

This work was supported by "National Natural Science Foundation of China" (61402427) and "the Fundamental Research Funds for the Central Universities" (2015RC073).

REFERENCES

[1] H. Y. Yin, "Research on urban agglomerations' spatial reconfiguration oriented by high-speed railway," *Innovation and Sustainability of Modern Railway*, 2012, pp. 236-239.

[2] S. Gil-Pareja, R. Llorca-Vivero, and J. Paniagua, "Does high-speed passenger railway increase foreign trade? An empirical analysis," *International Journal of Transport Economics*, 2015, vol. 42, no. 3, pp. 357-376.

[3] M. P. A. Logrono and C. B. Sanfeliu, "The high speed train and the urban project: A new railway for the Zaragoza of the third millennium," *Scripta Nova-Revista Electronica De Geografia Y Ciencias Sociales*, 2009, vol. 13, no. 281.

[4] Y. Tanaka and M. Monji, "Application of postassessment of kyushy shinkansen network to proposed US high-speed railway project," *Transportation Research Record*, 2010, pp. 1-8.

[5] H. F. Zhou and Y. P. Xu, "Studies on construction of high-speed railway promoting harmonious development of regional economy," *Innovation and Sustainability of Modern Railway*, 2012, pp. 925-933.

[6] Y. Zhao, X. M. Li, and X. Y. Li, "The economic impact analysis of the high-speed railway on urban-rural inequality," *Biotechnology, Agriculture, Environment and Energy*, 2015, pp. 77-81.

[7] X. J. Li, B. Huang, R. R. Li, and Y. P. Zhang, "Exploring the impact of high speed railways on the spatial redistribution of economic Activities — Yangtze river delta urban agglomeration as a case study," *Journal of Transport Geography*, 2016, vol. 57, pp. 194-206.

[8] J. J. Wang, J. Xu, and J. F. He, "Spatial impacts of high-speed railways in China: A total-travel-time approach, "Environment and planning a," 2013, vol. 45, no. 9, pp. 2261-2280.

[9] H. Y. Yin, "Study of traffic accessibility in Poyang lake economic zone oriented by high-speed railway," *Applied Mechanics and Materials*, 2012, pp. 178-181.

[10] X. Peng, "The economic effect of high-speed railway in beijing-guangzhou railway: A difference-in-differences estimation," in *Proc. 2016 ICMIBI International Conference on Humanity, Education and Social Science*, 2016, vol. 62, pp. 162-167.

[11] M. Zhang, Q. Wu, D. Wu, L. Zhao, and X. Liu, "Analysis of the influence on regional economic development of high-speed railway," *Journal of Chemical & Pharmaceutical Research*, 2014, vol. 6, no. 8, pp. 243-254.

[12] X. D. Du and N. Ren, "High-speed railway PFV prediction model research under regional economic conditions," *Advanced Materials Design and Mechanics*, 2012, vol. 569, pp. 246-250.

[13] Z. Z. Yang and J. Q. Gou, "Research on the economic benefits of high-speed railway enterprise based on activity based costing method," in *Proc. ICMETM 2015 - International Conference On Modern Economic Technology and Management*, 2015, vol. 17, pp. 1-7.

[14] K. Button, "Is there any economic justification for high-speed railways in the United States?" *Journal of Transport Geography*, 2012, pp. 300-302.

Minghao Zhu was born in Anhui, China, on July 16, 1984. He has received the doctorate degree in management science at Beijing Jiaotong University in October 2012 in China. His major field of study is decision analysis

At present, he is employed at School of Economics and Management, Beijing Jiaotong University. His interests are social and economic effects of transportation and information management.

Dr. Zhu won science and technology progress award by China Railway Association.