Impact of High-speed Railways on Regional Economic Development: Based on Double Difference Model and Least Squares Linear Regression Model

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Abstract
Under the background of rapid development and sustainable development of China's high-speed railways, studying the impact of construction and operation of high-speed railways on regional economic development and its mechanism has both high theoretical attraction and practical significance. This paper selects Xi'an-Chengdu high-speed railway as a more important instance in Western China. High-speed railways are the research objects. The economic development along high-speed railways is studied using the double-difference and least-squares linear regression models. The following conclusions are drawn in this paper. In China's central and western regions, it is necessary to construct a high-speed railway to connect the two regional central cities. Such projects can bring more benefits to underdeveloped areas along high-speed railways." For objective economic growth. At the same time, this study proves the necessity and importance of building high-speed railways in such underdeveloped areas as western China. The results can be extended to other underdeveloped areas in China and even the world.

Keywords: *regional economic; high-speed railways; the double-difference and the least-square linear regression development*

1. INTRODUCTION

Since the Economic Reform and opening up, China's economic development has shown that the polarization between the eastern and western regions is becoming more serious. In order to reduce the income gap between the East and the West and achieve the goal of shared prosperity, western development was officially introduced in 2000. Because of the imbalance between the advantages of the vast region and rich resources in the western region and the infrastructure construction, strengthening the infrastructure construction in the western region, especially the transportation construction, has become the priority of the western development. As a network like rapid transit infrastructure, high-speed railway plays an excellent role in facilitating the interconnection and resource allocation of western cities and is more conducive to Western cities' economic concentration and talent absorption. Especially after the 2008 Wenchuan earthquake, although the disaster area has returned to normal economic development, there are still many problems to achieve further economic development. It is urgent to improve economic development through the construction of transportation facilities. As one of the leading "eight vertical and eight horizontal" high-speed railways, Xi'an-Chengdu high-speed railway not only connects Shanxi Province and Sichuan Province and crosses the natural barrier of Qinling Mountains, linking Chengdu, Xi'an, and Chongqing, but also connects the Silk Road and the Yangtze River Delta, forming a good situation that affects and drives the economic and social development of the West.

Under the background of the rapid development and sustainable development of the high-speed railway in China, the Research on the impact and mechanism of high-speed railway construction and operation on native economic development has high theoretical attraction and has real meaning. With the worldwide upsurge of high-speed railway construction since the 1990s, researchers domestic and international have carried out a

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lot of Research on this proposition from the perspectives of transportation, economics, urban planning, etc.

Our contribution is as follows. The first is to search for relevant data by searching the Yearbook of each region. The second is to sort out the data, carry out regression analysis, and test and analyze the results. Third, according to the results, it is concluded that the high-speed railways in western and mid-western China could learn from the experience.

The article is divided into five parts:(1) introduction the essential background of Xicheng high-speed railway's construction, (2) make a literature review, (3) use difference in difference model and OLS model to analyze, (4) summarize the case and analyze the result, (5) conclude the disfavor.

2. LITERATURE REVIEW

Ning Yan and Xu Peng [1] studied the interaction between real estate investment, fixed asset investment, and GDP based on the VAR model. They found that real estate investment and fixed asset investment greatly contribute to GDP growth, which also affects real estate investment and fixed asset investment. However, because fixed asset investment can easily cause economic overheating, GDP growth cannot be excessively dependent on fixed-asset investment, especially real estate investment. Sun Tianqi and Yuan Jingwen [2] believe that from an international perspective, countries worldwide have experienced a stage of high dependence on investment in economic development, and the investment rate presents certain Pro cyclical characteristics. With regard to the excessive dependence of China's GDP on investment, especially in the central and western regions, we will strive to promote the transformation of the model of economic growth and prevent the government from transferring large amounts of investment and subsidies, but did not induce industries to attract employees, and did not promote the improvement of the per capita income level in the region. Song Lizhi [3] conducted an empirical study on the relationship between China's fixed-asset investment and economic growth using the time series data from 1980 to 2010. It is found that cointegration analysis shows a long-term relationship between them, and simulation test shows that there is a two-way Granger causality between fixed asset investment and economic growth. There is a mutually promoting relationship between China's fixed-asset investment and economic growth. Compared with the traditional asymptotic theory, the conclusion obtained by this method is more robust. Liu Jinquan and Yin Zhong [4] analyzed the dynamic relationship between fixed asset investment and economic growth in the process of China's economic development, impulse response function, and analysis of variance by using the quarterly data of fixed asset investment growth rate and real GDP growth rate from the first quarter of 1993 to the fourth quarter of 2010 and Granger causality test. Wu Jinshun [5] believed that the large-scale development of high-speed rail had brought unprecedented contraction in time and space, improved the circulation speed of economic factors such as labor force, and significantly impacted China's economic and social development. He empirically studied the impact of high-speed rail on regional economic growth. The results show that the high-speed railway has a significant positive impact on urban GDP growth. Liu Liwen and Zhang Ming [6] believe that, on the one hand, high-speed rail improves the overall level of national accessibility, especially in the West and small and medium-sized cities.

On the other hand, high-speed rail produces a "corridor effect" due to its technical characteristics. Cities with high-speed rail and along the corridor benefit much more than cities without high-speed rail, increasing spatial and regional development imbalance. Li Jianlong [7] used the panel data of 29 provinces and cities in China from 2011 to 2017 to analyze the mechanism of expressway mileage on the level of regional economic development by using the benchmark regression method and found that expressway mileage plays a significant role in promoting regional economic development. Ren Xiaohong, Wang Yu, and Dan ting [8] found that the opening of high-speed rail negatively impacts the per capita GDP growth rate of county-level and prefecture-level small and medium-sized cities in a relatively short period none of them is significant. However, in the long run, although the opening of high-speed rail has no significant impact on the per capita GDP growth rate of county-level small and medium-sized cities, However, it shows a significant positive role in promoting small and medium-sized cities at the prefecture-level. Sun Na, Zhang Meiqing, and Tao Ketao [9] further discussed the impact of high-speed rail on urban economic growth and its internal mechanism and compared cities of different sizes. The results show that the impact of high-speed rail on urban economic benefits is mainly indirect, and different action paths explain the differences in the impact of high-speed rail on cities of different sizes. Liu Mengyu and Shen Lizhen [10] found that the impact of high-speed rail on different types of cities has obvious heterogeneity. Cities with short time distance, high degree of policy guidance cooperation, significant differences in GDP, and small innovation ability differences are more likely to benefit from the development of high-speed rail.

3. MODELING PROCESS

The Differences-in-Differences model is usually applied to an extensive range of public policy research[11,12]. By constructing individual and temporal dummy variables, the difference between the experimental and control groups is carried out to evaluate

policy effects effectively. This model can avoid the endogeneity problems of the model to a certain extent and effectively separate the policy effects, which is one of the methods commonly used by scholars to evaluate the policy effects. This article regards the opening of the Xian-Chengdu high-speed rail as a quasi-natural experiment. The cities that opened the Xian-Chengdu high-speed railway were used as the treatment group, and the cities that did not open the high-speed rail were used as the control group. The city's GDP is used as the dependent variable, and some explanatory variables are selected. Least squares regression and Differences-in-Differences model are used to study the impact of the opening of high-speed rail on the economy of the regions along the line. [13].The results of the parallel trend test show that before the implementation of the policy, the economy of the treatment group and the control group roughly maintain the same growth trend, so it meets the preconditions of the parallel trend hypothesis.

3.1.The Differences-in-Differences model

In general, Differences-in-Differences model the basic Differences-in-Differences model is as (1):

$$Y_{it} = \alpha_0 + \alpha_1 du + \alpha_2 dt + \alpha_3 du \cdot dt + \varepsilon_{it} \quad (1)$$

"du" is a grouped dummy variable. If individual i is affected by the implementation of the policy, individual i belongs to the treatment group, and its "du" value is 1; If individual i is not affected by the implementation of the policy, individual i belongs to the control group and its "du" value is 0. "dt" is a dummy variable for policy implementation. "dt" is 0 before policy implementation and 1 after policy implementation. "du dt" is the interaction term between grouped dummy variable and policy implementation dummy variable. Its coefficient reflects the net effect of policy implementation, which is reflected in Table 1.

TABLE 1. THE DIFFERENCES-IN-DIFFERENCES MODEL

	Before policy	After policy	Diffrerence
Treatment group	$\alpha_0 + \alpha_1$	$\alpha_0 + \alpha_1 + \alpha_2 + \alpha_3$	$\alpha_2 + \alpha_3$
Control group	α_0	$\alpha_0 + \alpha_2$	α_2
Difference	α_1	$\alpha_1 + \alpha_3$	α_3

Taking urban GDP as a dependent variable, the Differences-in-Differences model adopted in this paper is as (2):

$$gdp_{it} = \alpha_0 + \alpha_1 treat + \alpha_2 time + \alpha_3 did + \varepsilon_{it} \quad (2)$$

Among them, "treat" is a grouping dummy variable. If city i is connected to Xian-Chengdu high-speed rail, the treat value is 1. If it is not connected, the value of treat is 0; "time" is a dummy variable for high-speed rail connectivity. "time" takes the value of 0 before the high-speed rail is connected and takes the value of 1 after the high-speed rail is connected. "did" is the interaction term between the grouping dummy variable and the high-speed rail connecting dummy variable. When city i is connected to the high-speed rail at t, its value is 1. Otherwise, it is 0.

3.2. Least squares linear regression model

The basic OLS model is as (3):

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \beta_3 x_{i3} + \cdots + \beta_p x_{ip} + \varepsilon_i \quad (3)$$

x_{ij} is the observation data of group i of the j explanatory variable, ε_i is the random error term of the data of group i, and it satisfies:

$E(\varepsilon_i) = 0, \mathrm{var}(\varepsilon_i) = \sigma^2 I$, each ε_i is independent.

In order to intuitively explore the impact of the opening of the Xian-Chengdu high-speed rail on the economic growth of cities along the line, this paper selects the dependent variable GDP as the primary indicator to measure the economic status of the city. The regression model is as (4):

$$gdp_{it} = \beta_0 + \beta_1 treat + \beta_2 time + \beta_3 did + \beta_4 x1_{i,t} + \beta_5 x2_{i,t} + \beta_6 x3_{i,t} + \beta_7 x4_{i,t} + \varepsilon_{it} \quad (4)$$

The control variables are:

Consumer Price Index (CPI):

CPI is a macroeconomic indicator reflecting the changes in the price level of consumer goods and services generally purchased by households, denoted as $x1_{i,t}$.

Fixed asset investment growth rate:

The growth rate of fixed assets investment refers to the ratio of the original value of fixed assets increased to the original amount of fixed assets in a certain period. The growth rate of fixed-asset investment is the measurement index of fixed investment growth, denoted as $x2_{i,t}$.

The ratio of the added value of the tertiary industry to the added value of secondary industry:

The proportion of the modern service industry in the industrial structure is increased, which is an important measure of the advanced industrial structure. This paper

measured the industrial structure by the ratio of the added value of the tertiary industry to the added value of the secondary industry, denoted as $x3_{i,t}$.

The following is abbreviated as the ratio of t s.

The ratio of fiscal expenditure to the gross regional product in the general public budget:

Government size (also known as "government economic influence" with Chinese characteristics) is an important variable in the economic growth model of cities in western China. Government size is measured by the ratio of fiscal expenditure in the general public budget to GDP, denoted as $x4_{i,t}$. The following is abbreviated as the ratio of f b.

4. RESULT ANALYSIS

4.1.Data and overview of Xian-Chengdu high-speed rail

The Xian-Chengdu high-speed railway connects Shanxi and Sichuan provinces and many cities. According to the actual situation of the railway, the railway map drawn in this article is as follows：

FIGURE 1. The picture of Xian-Chengdu high-speed railway

The Xicheng high-speed railway is divided into the new Xian-Chengdu high-speed railway from Xi'an to Jiangyou section (built-in Shaanxi and Sichuan sections) and the existing Chengdu-Mianle intercity railway from Jiangyou to Chengdu. As of January 2018, there are 22 stations on the entire Xian-Chengdu high-speed railway line, namely: Xi'an North Station, Afanggong Station, Huyi Station, Foping Station, Yangxian West Station, Chengdu North Station, Hanzhong Station, Ningqiang Station South Station, Chaotian Station, Guangyuan Station, Jianmenguan Station, Qingchuan Station, Jiangyou North Station, Jiangyou Station, Qinglian Station, Mianyang Station, Luojiang East Station, Deyang Station, Guanghan North Station, Qingbaijiang East Station, Xindu East Station, and Chengdu East Railway Station.

This paper preprocesses the collected data of explanatory variables and explains variables of each city, and some of the statistical properties of the data obtained are shown in the following table.

TABLE 2. STATISTICAL NATURE OF THE DATA

Variable	Obs	Mean	Std. Dev.	Min	Max
gdp	80	2943.37	3728.78	296.71	17013
x1	80	102.54	1.23	101	105.7
x2	80	11.53	11.18	-19.6	33.6
x3	80	0.89	1.36	-7.02	5.65
x4	80	0.22	0.10	0.11	0.70

4.2. Result and result analysis

4.2.1.The Differences-in-Differences model result analysis

Through the Hausman test, the model used in this paper is determined to be a fixed utility model. The Differences-in-Differences model results are as follows:

TABLE 3. THE DIFFERENCES-IN-DIFFERENCES RESULT

Outcome var.	GDP	S. Err.	|t|	P>|t|
Before	—	—	—	—
Control	806.659	—	—	—
Treated	2986.774	—	—	—
Diff (T-C)	2180.116	1078.475	2.02	0.047**
After	—	—	—	—
Control	1085.500	—	—	—
Treated	5123.251	—	—	—
Diff (T-C)	4037.751	1647.398	2.45	0.017**
Diff-in-Diff	1857.636	1969.018	0.94	0.348

The data results show that before the opening of the railway, the GDP of the control group was 80.65 billion yuan, and the GDP of the treatment group was 298.677.4 billion yuan. The gap between them was approximately 218 billion yuan. The test p-value of this gap is 0.047, which is very significant. After the opening of the railway, the GDP of the control group was 108.55 billion yuan, and that of the treatment group was 512.325.1 billion yuan. The gap between them reached more than 403.7 billion yuan, and the test p-value of the gap was 0.017, which is also very significant. The results are converted into the following table:

TABLE 4. CONVERSION OF THE DIFFERENCES-IN-DIFFERENCES MODEL RESULTS

	Before policy	After policy	Diffrerence
Treatment group	2986.774	5123.251	2136.477
Control group	806.659	1085.500	278.841
Diffrerence	2180.116	4037.751	1857.635

The data results are shown that the average annual GDP of the cities in the treatment group before the opening of the Xian-Chengdu high-speed railway was about 298.6774 billion yuan, and after the opening of the high-speed railway, the annual average GDP of these cities increased to 512.3251 billion yuan; the average annual GDP of the control group after the opening of the Xian-Chengdu high-speed railway increased from 806.659 to 512.3251 billion yuan. 1085.5. The situation of the control group and the treatment group tells us that without opening the Xian-Chengdu high-speed railway, the urban GDP only increased by less than 30 billion yuan, but with the intervention of the high-speed railway, the average annual GDP increased by more than 200 billion yuan. Therefore, we can conclude that the opening of the Xian-Chengdu high-speed railway has promoted the economic growth of the cities along the line, and the average annual GDP has increased by an average of 185.7635 billion yuan. Through the Differences-in-Differences model, we can intuitively see the difference between the control group and the treatment group before the opening of the high-speed rail and the change of their gap after the opening, thus concluding that the opening of the Xian-Chengdu high-speed rail will promote the economic growth of the cities along the line.

4.2.2. The regression result analysis

Through the least-squares linear regression model, it is easy to find the linear relationship between GDP and each explanatory variable, distinguish the variables that have a positive and negative impact on GDP, and observe each variable's degree of influence on GDP. Then, it is carried out the growth of GDP analysis.

The regression results are as follows:

TABLE 5. THE REFRESSION RESULITS OF ALL VARIABLES

GDP	Coef.	Std. Err.	t	P>|t|
time	-1403.96	843.06	-1.67	0.100
treat	1121.38	582.88	1.92	1.92
treated	2610.41	1459.37	1.79	0.078
cpi	-297.24	250.95	-1.18	0.240
Fixed asset	-30.12	24.88	-1.21	0.230
the ratio of t s	538.59	266.08	2.02	0.047
the ratio of f b	-14727.05	4092.95	-3.60	0.001
_cons	35494.66	25906.74	1.37	0.175

Coef is the estimated value of the coefficient of each variable. A positive coefficient indicates that the variable has a positive effect on the growth of GDP, and a negative value has a negative effect. Std. Err. represents the estimated standard error of the coefficient of the variable. "t" is the value of the t statistic of the regression coefficient test of the variable; P>|t| represents the p-value obtained by the significance test of the regression parameter estimated by the variable. When p is less than or equal to 0.05, we consider the regression coefficient very significant. When p is greater than 0.05 and less than 0.1, it is considered significant, and when p is greater than 0.1, it is considered insignificant.

The regression equation obtained from the results is as (5):

$$gdp_{it} = -1403.96 \cdot time + 1121.382 \cdot treat + 2610.405 \cdot did - 297.2411 \cdot x1_{i,t} - 30.11539 \cdot x2_{i,t} + 538.5904 \cdot x3_{i,t} - 14727.05 \cdot x4_{i,t} + 35494.66 \quad (5)$$

Among them, the p-value of the coefficient significance test of the interaction item did of the grouped virtual variable, and the high-speed railway connection virtual variable is 0.078, which is lower than

the significance level of 0.1, indicating that the interaction item did significantly. The p-value of the whole regression equation is 0.0004, less than the significance level of 0.05, which is also significant. Therefore, it is considered that the regression equation passes the significance test.

4.2.3. result analysis

The Xicheng high-speed railway traverses the Qinling Mountains, starting from Xi'an, crossing Hanzhong, Guangyuan, Jiangyou, Chengmian, and finally into Chengdu. It is one of the main corridors of the eight vertical and eight horizontal high-speed railways, with a total length of 658 kilometers. The opening of the Xicheng-Chengdu high-speed rail has brought great convenience and advantages to the Shanxi and Sichuan provinces:

4.2.3.1. Realize the networking of Hapcheon and national passenger transportation

Before opening the Xian-Chengdu high-speed rail, the railway transportation quality in the Sichuan-Chongqing area was low, and the passage was not smooth. After the opening of the Xicheng Railway, the situation of tight transportation capacity in the Sichuan-Chongqing area has been greatly improved. The main passage of high-standard passenger transportation has greatly shortened the time and space distance. It can be reached within four hours from Chengdu and Chongqing to Xi'an and within eight hours from Chengdu and Chongqing to the Beijing-Tianjin-Hebei region. The Sichuan-Chongqing region and the national express passenger network are fully implemented.

4.2.3.2.Promote the development of regional tourism

The Xian-Chengdu high-speed railway runs through the Qinba Mountains, connecting the Guanzhong Plain, the Hanzhong Basin, and the Chengdu Plain, passing through Deyang, Mianyang, Guangyuan in Sichuan Province and Hanzhong City in Shaanxi Province. Xi'an and Chengdu are planned as megacities, and Mianyang, Deyang, Guangyuan, and Hanzhong are Second-level central cities. There are many world-class and national-level scenic spots along the route. Local tourist spots are dotted. Zhou, Qin, Han, and Tang cultures, Qinling natural scenic spots, the history and culture of the Han and Three Kingdoms, Zhuying and other national first-class, protected rare animal ecological inspection tourist attractions, swords Menshu Road cultural tourism, and the Queen's hometown ecological leisure vacation tourism, "two bombs and one-star" science and technology city, Sanxingdui tourism, Qingcheng Mountain and Dujiangyan scenic spot, etc,. After the project opened to traffic, it has greatly met the travel needs of intercity passenger flow and tourist flow along the line and played an essential role in strengthening the integration of urban and rural areas, promoting tourism along the line, and driving the development of regional economy and related industries. Taking Xi'an city as an example, from January to November in 2017, the number of tourists at home and abroad was 174.5061 million, with an increased rate of 20.5%.

Meanwhile, the total income of tourism was 153.052 billion yuan, with an increased rate of 34.2%. In 2018, the number of tourists received at home and abroad was 241,837,500, with a growth rate of 38.6%. The total income of tourism was 241,455 billion yuan, with a growth rate of 57.8%. It can be seen that the opening of the Xian-Chengdu high-speed railway has a great promotion and positive effect on Xi'an's tourism.

4.2.3.3.Strengthen the exchange of information with the outside world to promote economic development

The Xian-Chengdu high-speed railway connects the two provincial capital cities of Chengdu and Xi'an and communicates with Chongqing through the southern section of the Lanyu Railway. After the project is opened to traffic, it can effectively gather the advantages of the workforce, information, resources, technology, and other aspects of the two major economic zones of Guantian and Chengdu, form a new strategic platform for the coordinated development of the regional economy, inject strong acceleration into regional social and economic development, strengthen economic and social communication, interaction, integration and development between regions, and form a development pattern that undertakes linkage and jointly connects the Bohai Sea Rim and the Yangtze River Delta Economic Zone. It makes the flow of people, logistics, and information more convenient and significantly stimulates regional economic development [14].

5. CONCLUSIONS

The construction of high-speed railways has great social benefits, but due to the high construction costs and uncertain economic benefits of high-speed railways, there is no consensus on the value of the investment in high-speed railways. In recent years, with the acceleration of the networking process of high-speed railways in China, the analysis of regional economic benefits brought by the construction of high-speed railways has become one of the research hotspots. The impact of high-speed railways on regional economic development is one of its external effects. Its nature and scale are determined by the importance of high-speed railways in the economy and the transport characteristics of transportation infrastructure, which are generally divided into positive and negative externalities. The impact of high-speed railway construction on regional

economic development mainly focuses on three aspects: the impact on the total or increment of urban economy, the impact on urban population clustering and employment opportunities, and the impact on regional economic equity is different.

High-speed railways can promote regional economic growth by improving local accessibility and stimulating subsequent fixed investment. However, the heterogeneity of high-speed railways will lead to the difference between their local economic promotion and the economic growth of surrounding cities caused by the spatial spillover effect.

This paper verifies the important impact of the Xi'an-Chengdu high-speed railway on regional economic development along the line. Similarly, it can guide transportation infrastructure construction in underdeveloped areas such as Northwest China and northeast China. However, this paper also has some inadequate considerations, such as the impact of road transport facilities on the regional economy. The impact of these multimodal forms of transportation on regional economic development is one of the possible tasks in the future.

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