The Effect of the Opening of High-Speed Railway on the Economic Growth of Heilongjiang

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Abstract. The positive and negative effects of high-speed railway in different regions have attracted close attention and have been highly valued against the background of population and factor mobility promoted by its fast development. This paper makes use of the DID difference-in-difference model in order to analyse the economic impacts bring by the high-speed railway on different areas in Heilongjiang province as well as on agricultural, manufacturing, and service industries between 2010 and 2020. This article aims to compare and demonstrate the different effects of the application of High-speed rail in numerous regions in Heilongjiang, the text also put forward the suggestion to Heilongjiang province high-speed railway economic development. Researches show that although the application of high-speed rail brought some positive impacts to the economy, there has been a significant negative effect on the overall economic growth of cities in Heilongjiang. The main problem lies in the obvious influence of siphonic effect and spill over effect on different tiered cities.

Keywords: High-speed railway · The tourism industry · Economy · Difference-in-differences model

1 Introduction

With China's vast land, geographical diversity and densely populated cities, the complexity of the topography restricts China's economic progress. The long span between regions and the long distance between cities limit the connection and trade with different places. Geographical location is one of the important reasons for the great difference in China's economic development.

Transportation construction is an important aspect of China's economic development. The development of high-speed rail (HSR) technology will become a milestone in the

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development of China's railway transportation. China's HSR will connect all provincial capitals and cities with a population of more than 500 000, covering more than 90% of the country's population, marking that China is about to enter the era of HSR. This implies that the factors of production such as labour flow, logistics and capital flows will be efficiently operated [1]. It is estimated that the correlation coefficient between railway mileage and GDP is about 0.959, the data confirmed that the two are highly positively correlated [2]. The rapid development of China's railway will drive the GDP and further promote the development of national economy.

However, there is no consensus on the influence of regional economic growth in academic field. Some academics believe that the rapid transportation of HSR promotes the adjustment of China's industrial structure to some extent, and integrate the development of areas along the rail for a better economic structure. Wang and Zhai analysed the related data onto Shanghai-Hangzhou HSR, and concluded that the increased elasticity of accessibility brought by HRS is conducive to the healthy and sustainable development of regions along [3]. Cui investigated on the impacts on regions in the Northeast China. By linking cities along the railway, there will be an increase in freight capacity by 50–60 million tons per year, greatly improving transportation capacity and efficiency [4]. Other believe that HSR will also lead to the outflow of production factors from second-tier and third-tier cities then gather in large cities with advanced economic development, resulting in a "Siphonic effect". Wang pointed out the adverse impacts on the Huai'an city, such as the siphonic effect, bypass effect, misallocation effect, and impact effect [5]. Zhang and Ou found that for the Pearl River Delta urban agglomeration, the opening of HSR in a city has spill over effect on other cities within a certain distance. The siphonic effect and spill over effect are largely caused by first-tier cities or key cities in the urban agglomeration [6]. Recently, some scholars delivered reports on the measures and suggestions of possible negative impacts bring by the HSR on the economy. Shi analysed some solutions to different aspects: constantly upgrade the regional industrial structure, make use of the governmental policies (relevant government departments need to formulate relevant policies according to regional economic development in different status of economy), and speed up the integration of HSR and the tourism industry [7].

Heilongjiang HSR is an important part of Beijing-Harbin passenger dedicated line network of "four length lines and four breadth lines" [8]. It is an HSR with the highest design and construction standard in the northernmost region of China. The Beijing-Harbin passenger dedicated line was completed, connecting Heilongjiang, Jilin, Liaoning, Hebei and Beijing by rail, greatly reducing the transportation cost between Beijing and Harbin. Passengers can realize the round-trip between Beijing and Harbin on the same day. It is more important significance appears in the traffic status of Heilongjiang. The speed of human flow and logistics between the three northeast east provinces and Beijing has been accelerated, which helps the development of higher quality and higher level in the region. Further optimize the layout of the national road network. The coal mine, grain and other resources in northeast China have also been delivered more efficiently. In addition, the economy of Heilongjiang Province has not developed for a long time. The reason for what affects its development is that most cities in Heilongjiang

province are heavy industrialized with traditional industries in the majority, the industrial structure is very unreasonable. To change the economic situation of Heilongjiang Province, it is inevitable to adjust the industrial structure [8].

The Beijing-Harbin Railway has effectively promoted the development of the tertiary industry along the line, including Heilongjiang Province. It not only provides an efficient way of travel for the residents in northeast China, but also brings a further improvement to the tourism industry in Heilongjiang. Traveling in northeast China has become a favoured and popular way for more and more travel groups and individual travellers. In 2015, the first railway opened in Heilongjiang province—Harbin Qiqihaer HSR, which will also effectively connect all regions in Heilongjiang province with all stations in cities across the country [9].

The construction of HSR promotes the two-way circulation of regional factors of production in Heilongjiang Province. However, the application of HSR also leads to the transfer of people and property from second-tier and third-tier cities along the railway to big cities, resulting in "siphon effect". The opening of Harbin Mudanjiang HSR in 2018 resulted in a siphonic effect brought by the phenomenon of “spending exceeds income” to the high-speed economy. There was "confrontation" between each region, this fight shows through economic, factors of production, as well as the human flow, reflected in the railway connected cities. Compared with Mudanjiang, Harbin has a better developed economy, a prosperous market and a greater job opportunity. Attracting many consumers to Harbin for leisure and shopping, and attracting young people to Harbin for their career lives, resulting in a phenomenon of brain drain.

Although tourism brings to the Mudanjiang large gains, after the opening of the Harbin Mudanjiang HSR, tourists realize that they can take a round-trip in the same day, brought an increase in tourist traffic flow, but a decrease in tourists’ consumption. HSR’s contribution to the tourism and economic growth has not increased significantly, while the number of inhabitants in Mudanjiang city travelled to other cities significantly increased. It can be seen that the siphonic effect is greater than the spill over effect. Mudanjiang is not the only one suffered from these phenomena. Most of the cities along the line in Heilongjiang Province, especially the third and fourth tiers cities, are facing the same economic problems [10].

This paper makes use of the DID difference in difference model to study the influence and effect of the opening of high-speed railway on the economic growth of Heilongjiang Province, and simulate conclusion by selecting variable data from 2010 to 2020 from Heilongjiang Bureau of Statistics.

2 Methodology

2.1 Data Selection

The selected data include per capita GDP growth rate, the symbol is “Y”, and implication is (Current GDP per capita – GDP per capita of previous year) / GDP per capita of previous year; fixed asset investment, the symbol is “Fixed assets”, and implication is the regional fixed assets investment log; effective labour, the symbol is “work force”,

implication is Employed population / Total population; industrial structure, the symbol is "industrial", implication is Total output value of tertiary industry / Total output value of secondary industry; and fiscal expenditure, the symbol is "expenditure", implication is the regional real fiscal expenditure logarithm. Dummy variables were also selected. Including time factor, symbol is "period", which is 0 at the beginning (2010–2014) and 1 at the end of the period (2015–2020); regional factor, symbol is "connect", implication is "with high-speed speed railway" = 1, "without high-speed railway" = 0; and high-speed rail factor, symbol is "period * con", implication is Period * Connect. These variables are required by the DID model used in this study.

2.2 Data Description

Each variable's observed value is 143. The average GDP per capital growth rate is 7.512%. The maximum is 43.772% of Suihua, 2020. The minimum is -42.017% of Daqing, 2015. The average fixed assets investment log is 5.799. The maximum is 8.593 of Harbin, 2017–2020. The minimum is 2.795 of Daxinganling, 2011. Average effective workforce rate is 15.670%. The maximum is 77.234% of Daxinganling, 2010. The minimum is 4.745% of Suihua, 2010. The average ratio of tertiary industry to secondary industry (industrial structure) is 162.552%. The maximum is 448.030% of Daxinganling, 2016. The minimum is 17.505% of Daqing, 2011. Average real fiscal expenditure log is 14.372. The maximum is 16.269 of Harbin, 2020. The minimum is 12.830 of Daxinganling, 2010. Average regional factor is 0.462. Maximum is 1 of Jiamusi, Harbin, Daqing, Mudanjiang, Suijhua, and Qiqihaer, all time. Minimum is 0 of Qitaihe, Yichun, Shuangyashan, Daxinganling, Jixi, Hegang, and Heihe, all time. Average time factor is 0.546. The maximum is 1 of all regions, 2015–2020. The minimum is 0 of all regions, 2010–2014. Average high-speed railway factor is 0.252. The maximum is 1 of Jiamusi, Harbin, Daqing, Mudanjiang, Suihua, and Qiqihaer, 2015–2020. The minimum is 0 of Jiamusi, Harbin, Daqing, Mudanjiang, Suihua, and Qiqihaer, 2010–2014, and Qitaihe, Yichun, Shuangyashan, Daxinganling, Jixi, Hegang, and Heihe, all time.

The following (Fig. 1) is obtained by comparing the per capita GDP growth rate of regions with and without high-speed rail in Heilongjiang from 2010 to 2020. It shows that from 2010 to 2013, the average per capita GDP growth rate of regions with high-speed rail is higher than that of regions without high-speed rail. From 2014 to 2020, the average per capita GDP growth rate of regions with high-speed rail is lower than that of regions without high-speed rail. However, this comparison cannot be confirmed by the chart, because the error line of average per capita GDP growth rate in regions with high-speed rail and regions without high-speed rail coincides every year except in 2015. This is because the data are highly scattered from the mean value, in relative to difference between GDP per capita in regions with and without high-speed railway, and the per capita GDP growth rate varies greatly in different regions.

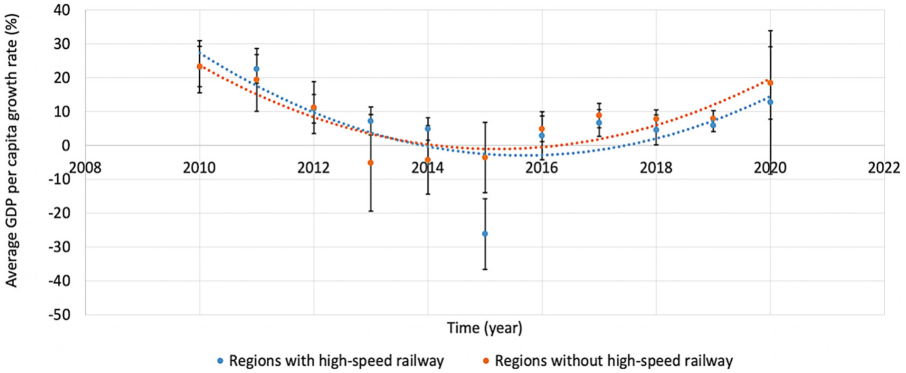

Fig. 1. Average GDP capita growth rate of regions with and without high-speed railways

2.3 Data Source and Operation

In order to study the impact of the opening of high-speed rail on per capita income, Heilongjiang Province from 2010 to 2020 is selected as the research object. During this period, Heilongjiang Province has regions with high-speed rail and regions without high-speed rail, which can make whether high-speed rail is opened as an independent variable to compare the difference in per capita income between regions with high-speed rail and regions without high-speed rail. The data of Qitaihe, Yichun, Jiamusi, Shuangyashan, Harbin, Daxinganling, Daqing, Mudanjiang, Suihua, Jixi, Hegang, Heihe and Qiqihar in Heilongjiang Province were selected for the study. According to the "four vertical and four horizontal" planning scheme of China's high-speed rail and the existing high-speed rail construction every year, the data on whether the high-speed rail is open or not are collected manually. Other data are from the statistical yearbook issued by Heilongjiang Provincial Bureau of statistics every year. In order to minimize the impact of price level changes on the data, the data from 2016 to 2020 are selected from the statistical yearbook issued in 2021, and the annual statistical yearbook includes the data of the previous five years. The data of 2015 is selected from the statistical yearbook of 2020, the data of 2014 is selected from the statistical yearbook of 2019, and so on. The data of 2010 is selected from the Statistical Yearbook published in 2015. Due to the lack of data for several years, the data of Suifenhe and Fuyuan are not included in the test. Finally, 143 observations from 12 prefecture level cities and Daxing'anling region in Heilongjiang Province from 2010 to 2020 are used for empirical analysis.

3 Results and Discission

3.1 Model Design

Difference-in differences method is an important measurement method, which is often used for quantitative evaluation of public policy or project implementation effect. The DID model controls to some extent the effects of some factors other than intervention factors by combining "differences before and after" and "differences have or no" effectively. In addition, it further controls some "noise" affecting elements in both the treatment group and the control group to make up for the flaw that the "natural experiment" cannot have a totally random sample distribution. This allows for a more accurate assessment of the treatment's effects. Therefore, this paper uses DID model to evaluate the impact of high-speed rail construction on regional economic development in Heilongjiang Province.

The DID model is mainly to follow the natural science experiment in some experimental objects to implement some 'treatment' approach, through the results before and after the experiment to evaluate the effect of this treatment. A new policy or the establishment of public facilities will affect some people in the region, while others may be unaffected or slightly affected. The exogenous events that make these social groups change is called natural experiments or quasi-experiments. The areas affected by the opening of high-speed rail are referred to in this paper as the "treatment group," whereas the areas that were unaffected before and after the opening are referred to as the "control group."

Based on this, the DID baseline model takes the following form:

$$Y_{it} = \beta_0 + \beta_1 time_{it} + \beta_2 connect_{it} + \beta_3 time_{it} \times connect_{it} + X_{it} + \alpha_i + \varepsilon_{it} \quad (1)$$

3.2 The Meaning of Each Variable in the Model

Y_{it} Is the growth rate of per capita GDP of j city at time t. $time_{it}$ is a time virtual variable with 0 in the early stage and 1 in the later stage. The coefficient β_1 represents the change of the per capita GDP growth rate of the studied city from the beginning to the end, namely the time effect. $connect_{it}$ is a virtual variable. If the city does not have high-speed rail, it is 0. If the city has high-speed rail, it is 1. The geographical impact unrelated to the start of high-speed rail is represented by the coefficient β_2. The product of two virtual variables represents the estimated value of the double difference. The coefficient β_3 represents the impact of the opening of high-speed rail on the economic growth of cities in Heilongjiang Province. X_{it} Are other control variables, including other factors affecting per capita GDP growth rate. α_i Represents the urban fixed effect, which is the difference that cities do not change with time. Considering that there may be difference among cities, it is reasonable to introduce α_i. ε_{it} is a random error term.

Table 1. Descriptive statistics of variables

Variable name	Minimum	Maximum	Median	Average	Standard deviation
Y: GDP per capita growth rate (%)	– 42.017	43.772	7.715	7.512	13.295
Fixed Assets: Fixed assets investment	2.795	8.593	5.670	5.799	1.209
Work Force: Effective workforce (%)	4.745	77.234	15.547	15.670	7.683
Industrial: Industrial structure (%)	17.505	448.030	146.721	162.552	94.272
Expenditure: Fiscal expenditure	12.830	16.269	14.348	14.372	0.738
Connect: Regional factor	0.000	1.000	0.000	0.462	0.500
Period: Time factor	0.000	1.000	1.000	0.546	0.500
Period * Con: High-speed rail factor	0.000	1.000	0.000	0.252	0.436

Table 2. The meaning of each variable in the model

Variable	Meaning	Illustration
Y_{it}	Policy effect	t represents time, i represents city
$time_{it}$	Time virtual variable	$t<2015$, $time_{it} = 0$; $t>2015$, $time_{it} = 1$
$connect_{it}$	Individual virtual variable	–
$time_{it} \times connect_{it}$	Policy virtual variable	If $time_{it}$=1, and $connect_{it}$=1, $time_{it} \times connect_{it}$=1. If not, $time_{it} \times connect_{it}$=0
β_0	Constant term	–
$\beta_1, \beta_2, \beta_3$	Coefficients for each	–
α_i	Urban fixed effect	–
ε_{it}	Random error term	–
Fixed assets	Fixed assets investment	Logarithm of actual fixed assets
Work force	Effective labor force (%)	Employees/total urban population
Industrial	Industrial structure (%)	Gross output value of tertiary industry/second industry
Expenditure	Fiscal expenditure	Logarithm of actual fiscal expenditure

Through the first-order difference of the equation using panel data, the following results can be obtained (Tables 1, 2 and 3):

Table 3. DID model difference results

	Before the opening of high-speed railway (time = 0)	After the opening of high-speed railway (time = 1)	DID
Treatment group(gt = 1)	$\beta_0 + \beta_1$	$\beta_0 + \beta_1 + \beta_2 + \beta_3$	$\Delta y1 = \beta_2 + \beta_3$
Control group(gt = 0)	β_0	$\beta_0 + \beta_2$	$\Delta y1 = \beta_2$
DID	β_1	$\beta_1 + \beta_3$	β_3

Table 4. Results of regression

	Model 1	Model 2	Model 3	Model 4	Model 5
	Y	Y	Y	Y	Y
Treated	4.855	6.56	6.818*	6.403	5.299
	(1.54)	(1.62)	(1.67)	(1.59)	(1.24)
Time	– 1.502	– 1.855	– 1.835	– 4.564	– 6.74
	(–0.52)	(-0.63)	(–0.62)	(–1.45)	(–1.60)
Treated*Time	– 11.153**	-10.518**	– 10.725**	-10.384**	– 9.282**
	(–2.61)	(–2.40)	(–2.43)	(-2.39)	(–2.03)
Fixed assets	–	– 1.043	– 0.943	– 0.537	– 2.289
	–	(–0.67)	(–0.60)	(–0.35)	(-0.84)
Work force	–	–	0.096	0.123	0.146
	–	–	(–0.67)	(–0.86)	(1.00)
Industrial	–	–	–	0.029**	0.027**
	–	–	–	(–2.29)	(2.04)
Expenditure	–	–	–	–	3.571
	–	–	–	–	(0.78)
cons	8.898***	14.192*	12.03	6.079	– 33.627
	(4.15)	(1.74)	(1.37)	(0.67)	(–0.65)
N	143	143	143	143	143
R-sq	0.108	0.111	0.114	0.147	0.151

4 Results and Analysis

In order to estimate the influence of the construction of the high-speed railway to the cities in Heilongjiang Province, there are five models were regressed. The result is shown in the following (Table 4).

From the Table 4, there are some obvious conclusions. Firstly, the regression model without control variable shows that the construction of high-speed railway has a negative impact on urban economic growth rate, which is significant at the level of 5%. The specific impact is that the growth rate of per GDP decreased about 11% because of the high-speed railway. And then, one control variable, "Fixed assets" were attended in the model 2, the influence of the construction of the high-speed railway is also significant at the level of 5%. In the model 3, there are two control variables, "Fixed assets" and "Work Force", the significance of the influence of the construction of high-speed railway in is also at the 5% level. In the model 4, there are three control variables, "Fixed assets", "Work Force" and "Industrial", the negative influence of the opening of high-speed railway in this model is also significant at the 5% level. In the model 5, the growth rate of per GDP decreased about 9.282% because the construction of the high-speed railway.

The main reason for the negative influence of the construction of high-speed railway is the "Siphon" phenomenon. As for the cities in Heilongjiang Province, these cities are economically underdeveloped. So, when the high-speed railway constructed in these cities, it is easier for labor, capital and other production factors to move to the economic development center. These production factors can promote local economic development. So, the result is that the construction of the high-speed railway has a negative influence on local economic growth.

As for other variables, firstly, time variable always has negative effect to growth of economic, but it is not significant in these five models. This illustrates that the per GDP growth rate of cities has a downward trend in Heilongjiang, which is similar to the economic growth trend of China in the same period. Secondly, the regional effect is always positive and it is significant at the 5% level in model 3. The main reason is that the high-speed railway is constructed in the cities, which is developed better than other cities in Heilongjiang. Thirdly, as for other control variables, the fixed assets had the negative effect to the economic growth rate but not significant. And the work force had insignificant positive influence in the growth rate of per GDP. It is remarkable that industrial had the positive effect to the growth rate of per GDP and it is significant at the level of 5% in the model 4 and model 5.

5 Conclusion

Firstly, the construction of high-speed rail had a significant influence on the economic growth of Heilongjiang cities, with a negative trend. We cannot deny that after the construction of high-speed railway in Heilongjiang Province, the impact on economic development is complex. First of all, many enterprises are easier to expand to some more remote areas in Heilongjiang, which can promote the development of economy. But at the same time, many talents and capital will transfer from these regions to some economic central areas, where there are more opportunities for them. Then as for the Heilongjiang province, most cities there are large-scale industry cities, the economic growth is mainly from traditional industry. The construction of the high-speed railway has brought several changes to the industry structure, which means the tourism has been developed. However, because people can go there and back on the same day, so the consume of the visitors just contribute a little to the GDP.

Secondly, Regional influence has a significant positive effect on economic growth. The main reason is that although the areas where high-speed railway is set up are remote areas in China, they are also economically developed cities in Heilongjiang.

Finally, industrial (the ratio of the tertiary industry and the secondary industry) can promote the economic growth at the level of 5%. It shows that Heilongjiang's economy is still dominated by traditional industries.

There are also some shortcomings in our research, because the limitation of the number of cities, the total amount of observed objects is relatively small. Only concern about the high-speed railway opened in 2015, and there is no comparison between the earlier high-speed railway or the recently opened high-speed railway.

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