High-speed Rail and China's Economic Growth

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Abstract. In recent years, with the continuous improvement and deepening of China's high-speed rail construction, the impact of high-speed rail construction on economic development has become more and more significant. In order to measure the economic benefits of high-speed rail construction, we built an difference in difference (DID) model to explored the relationship between the construction of high-speed rail and the GDP of cities along the route using the data of 300 prefecture-level cities in China from 2005 to 2018. The research results show that: the construction of high-speed rail can significantly promote the growth of GDP in cities along the line. In addition, influence mechanism shows that the opening of high-speed rail can stimulate the growth of the number of people in the scientific research comprehensive service industry in cities along the line, drive the increase in real estate development investment and foreign direct investment, and further deepen the impact of high-speed rail construction on urban GDP.

Keywords-high-speed rail construction, economic development, DID method

1. INTRODUCTION

In general, basic transportation construction can have an obvious positive effect on economic development, that is, the construction of high-speed rail and other infrastructure can promote the GDP growth of cities along the route (Banerjee, Duflo, & Qian, 2020)[1]. For small and medium-sized cities and even counties, high-speed rail access will allow them to gain the positive spillover effect brought by big cities and accelerate the development of industries, especially heavy industries (Xu & Nakajima, 2017)[2]. With the process of urbanization, the opening of high-speed rail in central cities will attract more talents, but peripheral cities will experience rapid industrialization (Baum-Snow, Brandt, Henderson, Turner, & Zhang, 2017)[3]. In addition to increasing the travel rate of passengers, the opening of high-speed rail can also unleash the ability of traditional railway infrastructure to support regional multimodal transportation, and promote the further development of China's transportation industry and the further improvement of the transportation network (He, Wei, Yu, Yuan, & Chen, 2021)[4]. After the opening of the high-speed rail, the underdeveloped central and western regions will attract more tourists than the eastern regions, and cities with unique tourism resources will therefore earn more income (Gao, Su, & Wang, 2019)[5].

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The improvement of infrastructure can not only have a positive impact on the development of enterprises, but also promote the increase of labor force, thereby providing abundant human capital for enterprise construction(Duranton & Turner, 2011)[6]. High-speed rail can strengthen the dissemination of knowledge and technology, and can reduce the development cost of enterprises, strengthen investment and trade between cities while enhancing cross-regional connections, thereby promoting regional technological innovation and driving the growth of urban GDP (Fassio, Montobbio, & Venturini, 2019)[7].

Research on the Shinkansen in Japan also shows that the Shinkansen will accelerate the growth of the service industry in the central area and the decline in the periphery (Li & Xu, 2018)[8]. Research on the French high-speed rail found that the high-speed rail reduces the communication costs of enterprises, thereby improving the work efficiency and production professionalism of enterprises (Charnoz, Lelarge, & Trevien, 2018)[9]. Another example is a study in Spain that shows that the opening of the high-speed rail can effectively increase the number of tourists to high-profile attractions and promote the development of local tourism (Varela & Navarro, 2020)[10].

The mainstream view of research on the effect of high-speed rail is that the positive effect of the construction of high-speed rail and other transportation infrastructure on economic development cannot be ignored, and the regional economic gap will be reduced due to the opening of high-speed rail, which promotes the integration of regional economies (Chen & Haynes, 2017)[11]. However, there are still scholars who have reached the contradictory conclusion-investment in transportation infrastructure will lead to negative spillover effects in the region (Moreno & López-Bazo, 2007)[12].

The impact of the opening of high-speed rail on economic development is obvious, but due to factors such as differences in urban scale and resource factors, the opening of high-speed rail has two effects on the urban economy. This article mainly focuses on the impact of the opening of high-speed rail on urban GDP and its impact mechanism.

2. MODEL AND DATA

This paper uses the difference in difference method (DID) method to study the impact of the opening of high-speed rail on the GDP of cities along the route. The two-way fixed effect model is set as follows:

$$GDP_{it}=\alpha+\beta D_{it}+\theta X_{it}+A_i+B_t+\varepsilon_{it} \quad (1)$$

In the equation, the explained variable GDP is the regional GDP of city i in year t; D represents the dummy variable for the opening of the high-speed rail, the year before the opening of the high-speed rail is set to 0, and the year after the opening of the high-speed rail is set to 1. X represents other control variables that affect the city's economic development. A_i, B_t, and ε_{it} represent city fixed effect, time fixed effect, and random error, respectively. Our control variables include science and technology expenditures, employees in the tertiary industry, urban

employees and employees in R & D. The time span of each variable is 2005-2018. All data are from the "China City Statistical Yearbook" over the years.

We have listed the descriptive statistics of the main variables in Table 1. It can be seen from the table that the standard deviation of each variable is relatively large, especially the standard deviation of urban GDP, which shows that there is a very large gap in the economic strength of China's cities.

TABLE I. DESCRIPTIVE STATISTICS OF MAIN VARIABLES

variable	mean	sd	obs
GDP (billion CNY)	175.4	272.1	4032
Science and technology expenditure (billion CNY)	4.221	6.682	4033
Real estate investment (billion CNY)	22.02	43.62	4003
FDI (million USD)	807.2	2077	3525
Employees in the tertiary industry (thousand)	13.42	30.98	3946
Employees in R & D industry (thousand)	11.07	36.40	3740
Urban employees(thousand)	510.8	765.1	4038

3. EMPIRICAL RESULTS

3.1 Baseline results

Table 2 shows the results of the benchmark regression, that is, the estimated impact of the opening time of the high-speed rail on the city's GDP. In the years from 2005 to 2018, the dummy variable is 1 after the opening of the high-speed rail, otherwise it is 0. When measuring this indicator, we observed three different samples, first the full sample, secondly the sample excluding the municipalities and sub-provincial cities, and finally the sample excluding the second-tier and above cities. All regressions control the time effect.

TABLE II. BENCHMARK REGRESSION RESULTS

	(1) Full sample	(2) Municipalities and sub-provincial cities excluded	(3) Cities above the second tier excluded
Panel A: No Controls			
High-speed rail opened	62.23** (6.25)	33.32** (5.36)	15.72** (4.00)
Time effect	Yes	Yes	Yes
R square	0.336	0.529	0.659
Panel B: With Controls			
High-speed rail opened	14.15** (3.06)	12.05** (3.52)	6.05* (2.12)
Science and technology expenditure	15.58** (6.64)	6.72** (3.07)	4.60** (2.80)

Real estate investment	2.09** (5.33)	1.58** (4.17)	1.59** (4.76)
FDI	0.01** (2.67)	0.00 (1.58)	0.00* (1.98)
Urban employees	0.01 (0.28)	0.08** (3.14)	0.04 (1.60)
Time effect	Yes	Yes	Yes
R square	0.855	0.757	0.759

Notes: Robust standard errors are reported in parentheses; * and ** indicate statistical significance at the 5% and 1% level respectively.

In Panel A of Table 2, the regression results with urban GDP as the explained variable show that when other influencing factors are not controlled, the impact coefficient of high-speed rail construction is significantly positive at the 1% level. This result shows that, compared with cities without high-speed rail, the construction of high-speed rail can significantly increase the GDP of cities along the high-speed rail and promote the development of urban economy. For example, in the full sample column, after the opening of the high-speed rail, the GDP of each city has increased by about 62.2 billion yuan on average. After excluding municipalities and sub-provincial cities, the GDP of each city has also increased by about 33.3 billion yuan on average. After the above cities, the GDP of each city has also increased by about 15.7 billion yuan on average.

In panel B, we control the factors such as science and technology expenditure, real estate investment, foreign direct investment (FDI), and urban employees. After adding the control variables, the impact of high-speed rail construction is also significantly positive at the 5% level. This shows that even if these factors that will affect economic development and changes are controlled, the city's GDP growth will be positively affected by the high-speed rail construction after the high-speed rail construction. Similarly, we can see that in the regression results of the full sample, the GDP of each city in China can increase by about 14.2 billion yuan after the opening of the high-speed rail. After excluding municipalities and sub-provincial cities, the average GDP growth of each city can also reach About 12.1 billion yuan, after excluding the second-tier and above cities, the GDP growth of each city averaged about 6 billion yuan.

It can be seen that, whether it is the full sample or the two sub-samples that exclude the more developed cities, the city's GDP has increased significantly after the opening of the high-speed rail. And in all the regression results, the dummy variable of the opening time of the high-speed rail is statistically significant at the 5% level, which also shows that the construction of the high-speed rail has a more significant positive impact on the city's GDP.

3.2 The dynamic impact of the opening of high-speed rail

In order to illustrate the impact of high-speed rail on urban GDP intuitively, we draw the dynamic impact of high-speed rail on the GDP of each city in Figure 1. According to and construct the following model:

$$GDP_{st}=\alpha+\beta_1 D_{st}^{-10}+\beta_2 D_{st}^{-9}+\ldots+\beta_{20} D_{st}^{+10}+A_s+B_t+\varepsilon_{st} \quad (2)$$

D_{st} is a dummy variable for the opening time of the high-speed rail. Specifically, D_{st} means the year when the city s high-speed rail is opened, the year after the opening is 1, and the other years are 0. The superscript of the core variable D_{st} indicates the advance and lag items of the event. For example, D_{st}^{-5} means 1 in the fifth year before the opening of the high-speed rail in city s, and 0 in other years; D_{st}^{+5} means 1 the opening of the high-speed rail in city s for the next fifth year, and 0 for all other years. D_{st}^{-10} to D_{st}^{-1} are the advance terms of the policy, which characterize the effect before the opening of the high-speed rail. If $D_{st}^{-10}= D_{st}^{-9}=\ldots= D_{st}^{-1}=0$, it means that the opening of high-speed rail in different periods cannot have a significant impact on urban GDP. GDP of the treatment group and the control group in each year before the policy occurs is not significant difference, for which the parallel trend assumption can be satisfied. And D_{st}^{+1} to D_{st}^{+5} are the lag items of the policy, which describe the effect of the event in the jth year after the policy occurs. In order to avoid the trap of dummy variables, this formula does not include the year when the policy occurred (ie D_{st}^{0}), then the estimated results of D_{st}^{-10} to D_{st}^{+5} are relative results based on D_{st}^{0} as the base year, that is, it is estimated that the opening of high-speed rail will affect the urban economy. A_S and B_t represent urban fixed effects and time fixed effects, respectively.

Fig. 1 shows the coefficient estimation results of the opening of high-speed rail D_{st}^{-10} to D_{st}^{+10}. The value of the circle represents the average value of the dynamic impact of the opening of the high-speed rail on the urban GDP, and the dotted line represents the 95% confidence interval. It can be seen from the figure that the confidence intervals of the coefficients from D_{st}^{-10} to D_{st}^{-1} all include 0, That is, the coefficients from D_{st}^{-10} to D_{st}^{-1} are not different from 0. It shows that there is no significant difference between the control group and the treatment group, so we can think that the parallel trend hypothesis can be satisfied. In addition, when the high-speed rail is opened, the coefficients from D_{st}^{+1} to D_{st}^{+10} are significantly positive, indicating that the opening of the high-speed rail has a significant impact on the city GDP, and this impact will continue for several years. Three years after the opening of the high-speed rail, the urban GDP will be significant increasing every year. And the opening of the high-speed rail has continued to stimulate urban economic development for about 8 years, after which such a stimulating effect has stabilized.

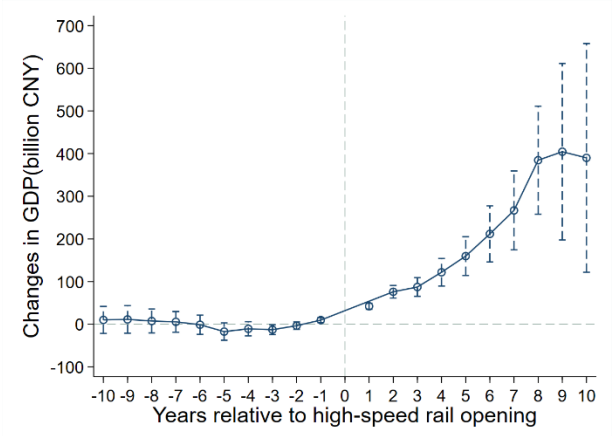

Figure 1. The dynamic impact of opening high-speed rail on GDP

3.3 Impact mechanism analysis

Table 3 lists the regression results of the analysis of the three mechanisms that the opening of high-speed rail affects urban economic development. The dependent variables in columns (1)-(3) are employees in R & D industry, real estate investment, and FDI respectively. These three columns are all regressed using a fixed-effect model. It can be seen from the regression results that in these three columns, the coefficients of high-speed rail opening are all significantly positive and both are significant at the level of 1%, indicating that after the opening of the high-speed rail, employees in R & D industry, real estate investment, and the FDI have increased significantly.

TABLE III. IMPACT MECHANISM ANALYSIS

	(1) employees in R & D industry	**(2) real estate investment**	**(3) FDI**
High-speed rail opened	0.31* (4.15)	11.84* (6.03)	358.74* (4.03)
Time effect	Yes	Yes	Yes
Controls	Yes	Yes	Yes
obs	3740	4003	3525
R square	0.06	0.28	0.05

Notes: Robust standard errors are reported in parentheses; * indicats statistical significance at the 1% level.

4. CONCLUSIONS

The high-speed rail construction policy has a huge impact on China's economic development. It has reshaped China's spatial structure in many ways and has made a huge contribution to the circulation of China's economic factors. And with the improvement of high-speed rail lines, the influence of high-speed rail is also increasing. How high-speed rail affects the economic development of cities along the route by influencing capital, talent flow and investment is the core proposition of this article. This article elaborates on the respective effects of these three mechanisms, and finally draws the following conclusions. (i)The opening of high-speed rail has a significant stimulating effect on the economic GDP of cities along the route. Although mainstream research shows that the opening of high-speed rail may have both positive and negative effects, the analysis in this article does not support the idea of a “siphon effect” of high-speed rail. (ii)The mechanism of the opening of high-speed rail on the GDP of cities along the route is reflected in the increase in employees in R & D industry, real estate investment, and FDI.

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