Influence of "double cross" Shaped High-speed Rail Line on Industrial Development of Cities along Henan

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Abstract—Using panel data and double difference model, this paper analyzes the changes in economic and industrial development in cities along the "double cross" shaped high-speed rail in Henan before and after the opening of the high-speed rail network, considering whether different city sizes have different impacts on industrial development. Quasi-natural experiments are further carried out to verify whether the construction period will affect industrial development by replacing the opening of high-speed rail with the construction of high-speed rail. The results show that the opening of high-speed rail has a significant positive effect on the development of secondary industry, a significant negative effect on the development of tertiary industry, and no significant effect on the development of primary industry; Different city sizes have different impacts on their industrial development. The construction period of high-speed railway has no obvious positive effect on the industrial development of cities along the Henan line, and the industrial development of each city will also be affected by its lagging effect.

Keywords-high-speed railway construction; the "double cross" shaped high-speed rail network; industrial development; double difference model

1. Introduction

In the "Central Plains Urban Agglomeration Development Plan" issued by the National Development and Reform Commission in 2016, it is indicated to build a "double cross" shaped high-speed rail network with Zhengzhou as the center. Several related routes are listed in the 13th Five-Year Traffic Development Plan of Henan Province. All cities in Henan Province are located in the Central Plains urban agglomeration, which, as a national urban agglomeration, should contribute to economic development. The construction and opening of high-speed rail will undoubtedly have a profound impact on the economic development, industrial structure and development quality of cities in urban agglomerations. Therefore, it is of great significance to study the impact of the opening of the "double cross" shaped high-speed railway on the industrial and economic development of cities in Henan province with Zhengzhou as the center, not only on Henan province, but also on the Central Plains urban agglomeration.

Domestic literature mainly studies the impact of high-speed rail on the regional economy. Taking Chengdu-Chongqing high-speed railway as an example, Zhou Luoyi[1] puts forward the viewpoint that high-speed railway can improve regional mobility, promote regional economic development, optimize industrial structure and change urban spatial structure. Song Wenjie, Zhu Qing[2] select 359 high-speed railway stations to study the relationship among the development of different scale cities, the improvement of accessibility and the development around the

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stations. There is also industrial research. Dong Yanmei and Zhu Yingming[3] find that the opening of high-speed rail is helpful to promote the agglomeration of economic factors in cities, and has an important impact on the service industry with strong mobility of production factors. Liu Yongzheng and Li Yan[4] hold the belief that the opening of high-speed rail has brought positive spillover effects to surrounding cities, promoted the rapid development of the tertiary industry which is mainly service industry, and optimized the industrial structure. Wang Lu[5] indicates that high-speed rail has created great value in promoting industrial upgrading and adjusting economic structure. Zhang mengting[6] points out that the opening of high-speed rail has enhanced the spillover effect of central cities and promoted the upgrading of industrial structure of central cities and surrounding cities. Deng Huihui[7] considers that the improvement in transportation infrastructure can significantly improve the rationalization and upgrading level of local industrial structure. Foreign literature mainly studies the impact on high-speed rail between regions on urban economy. Givoni[8]considers that the opening of high-speed rail accelerates the accumulation of resources from non-central cities to central cities along the line, thus promoting the development of central cities and inhibiting the economic growth of non-central cities. Zheng[9]indicates that the opening of high-speed rail is helpful to promote the coordinated development of cities in the region, relieve the traffic and environmental pressure of big cities, reduce the agglomeration cost, and bring more opportunities for small and medium-sized cities. Ahlfeldt[9]considers that the joint effect of the opening of high-speed rail can significantly promote economic growth.

The above literature has drawn some positive conclusions about high-speed rail on urban economic development. From the perspective of industrial development and change, this paper considers the impact of the two periods after the opening of high-speed rail, which is the construction period and lag of high-speed rail, and studies the influence on the industrial development of the cities generated by the “double cross” shaped high-speed railway network in Henan Province, where the core station is Zhengzhou, so as to enrich the existing research results.

2. Methodology

2.1 Model setting

This paper selects the “one vertical” of the “double cross” shaped high-speed rail network along Beijing-Guangzhou high-speed railway, including the cites of Zhengzhou, Xuchang, Luohe, Zhumadian and Xinyang, as the experimental group, and selects Jiyuan, Nanyang, Zhoukou, Puyang and Pingdingshan, which have not opened high-speed rail before 2019, as the control group. The data from 2008 to 2018 are all from Henan Statistical Yearbook, city statistical yearbooks and China Economic Net. The model is constructed as follows:

$$Y_{it} = \beta_0 + \beta_1 t_{it} + \beta_2 rail_{it} + \beta_3 HSR + \varepsilon_{it} \quad (1)$$

i represents sample city, t represents the time, Y is the corresponding explained variable. Table 1 shows the classification of the control group and the experimental group. The first-order difference in each group can get the changes of the same sample cities in different periods. The second-order difference shows the high-speed rail effect HSR, which is the value focused on in this paper.

Table 1 Classification of control and experimental group

	t	$rail$	HSR
Control Group from 2008 to 2012	0	0	0
Control Group from 2013 to 2018	1	0	0
Experimental group from 2008 to 2012	0	1	0
Experimental group from 2013 to 2018	1	1	1

Even if the population of different cities grows the same amount, the influences and functions of various industries in cities are not the same. Therefore, we will further consider the influence of the difference in urban scale and grade on industrial development. According to the classification standard of China's large, medium and small cities in the 2010 Green Book of Small and Medium-sized Cities, this paper divides the city size into three grades (1 million-3 million people, 3 million-10 million people, more than 10 million people) according to the population. This paper selects $citysize_{it,j} * popu_{it}$ as the dummy variable interaction term of city population size with different city sizes.

After adding the aforementioned control variables, the completed model form is as follows:

$$Y_{it} = \beta_0 + \beta_1 t_{it} + \beta_2 rail_{it} + \beta_3 HSR + \beta_4 Popu_{it} + \beta_5 CTL_{it} + \sum_{j=1}^{3} \varphi_j \, citysize_{it,j} * popu_{it} + \varepsilon_{it} + \mu_i + \alpha_t \quad (2)$$

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ are estimated coefficients respectively. HSR is the high-speed rail effect. $popu_{it}$ is the core control variable. CTL_{it} is the control variable. $citysize_{it,j}$ is the dummy variable. ε_{it} is the random interference term. β_0 represents the constant term. μ_i indicates all other fixed effects at the local level that are not included in the model but may affect the explained variables. α_t represents the time effect.

2.2 Variable selection

The variables selected for this model are displayed in the following table.

Table 2 Indicators of main variables

	Economic factor	***Variable***
Explained variable	Level of economic development	Per capitaGDP
	Industrial factors	Proportion of added value of primary industry to GDP (percentage)
		Proportion of added value of secondary industry to GDP (percentage)

	Economic factor	***Variable***
		Proportion of added value of tertiary industry to GDP (percentage)
Virtual variable	Time factor	Virtual variable ()t
	Processing variables	Virtual variable ()$rail$
	Double difference variable	Virtual variable ()HSR
Control variable	Urban size	Year-end population () (10,000 people)$Popu$
	Capital factor	Investment in fixed assets () (100 million yuan)I
	Labor force factor	Number of employees at the end of the year () (ten thousand)E
	Technological progress factors	Total retail sales of social consumer goods () (ten thousand yuan)S
	Government factor	Government expenditure () (100 million yuan)Gov

The descriptive statistics of the key variables are organized as follows:

Table 3 Descriptive statistics of related variables

variable	***minimum***	***maximum***	***average value***	***standard deviation***	***median***
Per capita GDP	9905	101349	33884.151	17054.749	30458
Proportion of added value of primary industry in GDP	1.45	30.3	14.072	8.233	12.545
Proportion of added value of secondary industry in GDP	37.6	69.7	53.531	9.758	52.95
Proportion of added value of tertiary industry in GDP	17.2	54.7	32.392	8.381	32.15
P	216.2	1259	704.761	347.592	644.8
I	21.48	207.56	60.222	40.705	46.35
E	2461900	78985643	16390073.19	14288276.52	12225154.5
S	448813	17633376	3108481.773	2785526.86	2246812

variable	*minimum*	*maximum*	*average value*	*standard deviation*	*median*
Gov	1501369	42680900	8186200.482	7867884.572	5703241

2.3 Correlation tests

To reduce false regression, the unit root test of variables should be carried out before empirical analysis. The universe unit root test methods are LLC, IPS, Fisher-ADF, Fisher-PP, etc. To avoid the error caused by a single unit root test, LLC and IPS are used to test the unit root of each variable. The test results are shown in Table 4. The test results can verify whether the time series is stable. Its original hypothesis is that the series is unstable, and it can be seen that all variables have rejected the original hypothesis. It is considered that all variables have passed the significance test, and the following regression of the panel data can be carried out.

Table 4 Unit root test of each variable

Variable	*LLC*	*IPS*
Per capita GDP	-17.597*	-3.527*
Proportion of added value of primary industry in GDP	-18.539*	-3.161*
Proportion of added value of secondary industry in GDP	-20.473*	-3.857*
Proportion of added value of tertiary industry in GDP	-19.463*	-4.342*
P	-21.376*	-4.478*
I	-41.264*	-10.899*
E	-17.430*	-3.432*
S	-23.754*	-4.389*
Gov	-39.983*	-10.874*

Note: *p<0.05**p<0.01

The average variable inflation factor (VIF) of OLS model used for panel data regression is 1.86, and the VIF of each variable index is not more than 2.00, so there is no multicollinearity among variables.

A parallel trend test is performed on the data as well. The comparative analysis reveals that before 2012, neither the experimental group nor the control group is significant. Neither group of results can reject the null hypothesis with a significant parallel trend, indicating that the data in this paper are applicable to the double difference method.

3. Empirical Results & Discussion

3.1 Double difference DID estimation

It can be seen from the results of model (1) that the high-speed rail effect has failed the significance test for the per capita GDP of the explained variable. The influence of the core control variable city size on per capita GDP is $\beta_4+\varphi_j$, and the regression results show that the larger the city population size, the smaller the negative influence on per capita GDP.

From model (2), the high-speed rail effect has failed the significance test for the proportion of the added value of the primary industry to GDP. From the regression results, the time factor is inversely proportional to the primary industry. With the increase in the city population size, the positive significant promotion effect on the ratio of the added value of the primary industry is smaller.

From model (3), the high-speed rail effect has passed the significance test for the proportion of the added value of the secondary industry to GDP. The rest of the control variables, except the total retail sales of social consumer goods, show a negative significant relationship. However, the values of the control variables are all small. With the growth of the city population size, it has a greater negative impact on the added value ratio of the secondary industry to GDP.

From model (4), the high-speed rail effect has passed the significant test for the added value of the tertiary industry in GDP, but it is a negative significant trend. And the regression coefficient is larger than that of the secondary industry. The rest of the control variables, except the total retail sales of social consumer goods, show a positive and significant relationship. There is a positive and significant relationship between city size and the labor force. With the growth of the city population size, the impact on the added value of the tertiary industry has changed from negative to positive.

Table 5 Empirical results of the research

	Model (1)	***Model (2)***	***Model (3)***	***Model (4)***
Explained variable	Per capita GDP	Proportion of added value of primary industry in GDP	Proportion of added value of secondary industry in GDP	Proportion of added value of tertiary industry in GDP
constant	32272.037** (14.705)	3.201* (2.500)	77.791** (39.466)	18.961** (9.879)
Popu	-16.680** (-3.000)	0.022** (18.860)	-0.023** (-12.883)	-0.025** (-4.274)
E	84.101 (1.550)	-0.033 (-1.044)	-0.090 (-1.840)	0.124* (2.604)
I	0.001** (4.179)	0.000 (0.191)	-0.000** (-4.057)	0.000** (4.055)

	Model (1)	*Model (2)*	*Model (3)*	*Model (4)*
Gov	-0.000 (-0.453)	0.000** (5.199)	-0.000** (-4.918)	0.000 (1.560)
S	-0.000 (-0.280)	-0.000** (-3.766)	0.000** (5.396)	-0.000** (-3.047)
rail	690.863 (0.416)	3.841** (3.962)	-5.861** (-3.929)	2.022 (1.392)
t	818.375 (0.457)	-0.708 (-0.678)	-3.807* (-2.368)	4.576** (2.924)
*rail * t (HSR)*	730.076 (0.318)	0.099 (0.074)	5.184* (2.515)	-5.312** (-2.646)
$Citysize_1$ *Popu	-25.186** (-5.343)	0.025** (9.919)	-0.017** (-3.028)	-0.008 (-1.601)
$Citysize_2$ *Popu	-9.531* (-2.370)	0.009** (3.979)	-0.031** (-6.502)	0.022** (5.180)
$Citysize_3$ *Popu	13.422* (2.193)	0.002 (0.666)	-0.042** (-5.766)	0.039** (6.030)
R^2	0.898	0.85	0.748	0.676
R adjustment	0.89	0.839	0.728	0.65
F(8, 101)	F=110.722, p=0.000	F=71.770, p=0.000	F=37.428, p=0.000	F=26.319, p=0.000

Note: *p<0.05 **p<0.01 The t-values are in parentheses

The above model shows that the high-speed rail effect of the “double cross” shaped high-speed rail line has a certain promoting effect on the development of the secondary industry. But it still has a certain negative impact on the development of other industries in small and medium-sized cities along Henan Province, due to factors such as the siphon effect and unsatisfactory diffusion effect.

3.2 Expanding research

To verify whether the construction period of a high-speed railway has an impact on industrial development, this paper has taken the construction of high-speed railway line instead of the opening as a quasi-natural experiment, and has made an extended analysis by using double difference model. A one-period lag term of the dependent variable is introduced to expand it into a dynamic model.

Through the results in Table 6, it is found that the effects of high-speed rail construction on per capita GDP and the primary, secondary and tertiary industries have all disappeared in the lag phase. As dependent variables, the lagged explained variables have all passed the significance test of the original explained variables, which shows that with the development of the economy, the later industrial development is the inheritance of the earlier stage.

Table 6 Experimental results of extended research

	Model (1)	***Model (2)***	***Model (3)***	***Model (4)***
Explained variable	Per capita GDP	Proportion of added value of primary industry in GDP	Proportion of added value of secondary industry in GDP	Proportion of added value of tertiary industry in GDP
constant	4502.573 (1.216)	-0.338 (-0.586)	-1.604 (-0.368)	-0.293 (-0.370)
Explained variable lag term	0.960** (8.510)	1.001** (21.471)	1.022** (21.759)	0.973** (23.366)
Popu	-1.352 (-0.471)	-0.000 (-0.231)	0.002 (0.862)	-0.000 (-0.029)
E	-89.460 (-1.813)	0.024 (1.389)	-0.020 (-0.629)	0.053* (2.155)
I	-0.000 (-0.850)	0.000 (1.399)	-0.000* (-2.257)	0.000 (0.846)
Gov	-0.001 (-0.856)	-0.000 (-0.823)	0.000 (0.887)	-0.000 (-1.652)
S	0.001* (2.669)	-0.000 (-1.065)	0.000 (1.263)	-0.000 (-1.175)
rail	-527.038 (-0.517)	0.085 (0.206)	0.667 (0.809)	0.350 (0.660)
t	-876.729 (-0.683)	-0.209 (-0.459)	-1.491* (-2.022)	2.072** (3.666)
*rail * t (HSR)*	1251.582 (1.015)	0.120 (0.278)	0.318 (0.451)	-0.953 (-1.721)
$Citysize_1$ $*Popu$	-4.825 (-1.265)	0.002 (0.759)	-0.001 (-0.294)	-0.002 (-1.131)

	Model (1)	*Model (2)*	*Model (3)*	*Model (4)*
$Citysize_2$ *$Popu$	0.508 (0.178)	0.002 (2.001)	-0.005* (-2.447)	0.001 (0.679)
$Citysize_3$ *$Popu$	6.750 (1.707)	0.003* (2.194)	-0.002 (-0.684)	-0.002 (-0.667)
R^2	0.981	0.995	0.99	0.985
R adjustment	0.976	0.993	0.987	0.982
F (9,40)	F=223.793, p=0.000	F=825.975, p=0.000	F=423.756, p=0.000	F=300.729, p=0.000

Note: *p<0.05 **p<0.01 The t-values are in parentheses

4. Conclusions

This paper empirically tests and analyzes the changes in economic and industrial development in two periods before and after the opening of high-speed rail, by using the panel data of 10 cities along the “double cross” shaped high-speed rail network in Henan from 2008 to 2018. It also considers whether different city sizes have different influences on industrial development. This article further expands the research and introduces the lag phase to verify whether the high-speed rail construction period has an impact on industrial development. The results show that the high-speed rail effect of “double cross” shaped high-speed rail network is positive for the development of secondary industry in cities along Henan Province, but negative for the development of tertiary industry, which may be caused by the siphon effect. However, per capita GDP and the proportion of added value of primary industry haven’t passed the significance test, which may be caused by the unsatisfactory effect of high-speed rail technology diffusion. And different city sizes have different influences on economic and industrial development, suggesting that the city size should be controlled reasonably. The construction period of high-speed rail has no obvious positive effect on the industrial development of cities in Henan Province, and the industrial development of cities in the “double cross” shaped high-speed rail network in Henan Province will also be affected by their lag effect.

References

[1] Zhou Luoyi. Study on Regional Economic Effect of High-speed Railway Construction, taking Chengdu-Chongqing High-speed Railway as an Example. Chongqing Jiaotong University, Chongqing, 2016, pp.23–27.

[2] Song Wenjie, Zhu Qing. Impact of high-speed rail on the development of cities of different scales. Economic Geography, 2015, pp.57–63.

[3] Dong Yanmei, Zhu Yingming. Can high-speed rail construction reshape the economic spatial layout of China, based on the regional heterogeneity of employment, wages and economic growth. China Industrial Economy, 2016, pp.92–108.

[4] Liu Yongzheng, Li Yan. High-speed railway construction and urban economic growth in China. Financial Research, 2017, pp.18–33.
[5] Wang Lu. Research on the impact of China's high-speed rail on economic development and residents' welfare. Price Theory and Practice, 2019, pp.149–151.
[6] Zhang Mengting, Yu Feng, Zhong Changbiao. High-speed rail network, market access and enterprise productivity. China Industrial Economy, 2018, pp.137–156.
[7] Deng Huihui, Yang Luxin, Pan Xueting. Can the opening of high-speed railway help upgrade the industrial structure: facts and mechanisms. Financial Research, 2020, pp.34–48.
[8] Givoni M. Development and Impact of the modern high-speed train:A review. Transport Reviews, 2006, pp.593–611.
[9] Zheng, Siqi and Matthew E.Kahn. China’s Bullet Trains Facilitate Market Integration and Mitigate the Cost of Megacity Growth. Proceedings of National Academy of Science, 2013, pp.1248–1253.
[10] Ahlfeldt G.M., Feddersen A.. From periphery to core:Measuring agglomeration effects using high-speed rail. Journal of Economic Geography, 2019, pp.355–390.