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Does the High-speed Rail Promote the Medium and Small Cities Innovation Output?

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***Abstract*—The operation of high-speed rail broke the urban barrier, compressed the space-time distance, and the innovation elements were reconfigured between cities, which had a polarized effect on the innovation output of different cities. From the perspective of city innovation factors, based on the double difference model, the data of 12 cities along the Datong-Xian high-speed railway in 2008-2016 were used to analyze the impact of high-speed rail opening on the innovation output of small and medium-sized cities along the line. The results show that the opening of high-speed rail can not effectively promote the innovation output of small and medium-sized cities, but it is a significant negative effect. Due to the siphon effect of large cities and the neglect of soft environment construction in small and medium-sized cities, the innovation factors of small and medium-sized cities are squeezed. Therefore, the innovation and development of small and medium-sized cities along the future will focus on improving the soft environment, retaining and introducing new talents, attracting the accumulation of innovative factors, and driving the rise of small and medium-sized cities along the high-speed rail.**

Keywords—high-speed railway; city innovation; difference-in - differences method

I. INTRODUCTION

Innovation is the primary driving force of urban economic development. Any innovation will be restricted by geographical distance. There are many small innovation activities in cities with close geographical distance. The rapid development of modern transportation technology means that the emergence of high-speed railway makes the space and time distance between cities smaller and the flow of various innovative elements more convenient and efficient. The 13th five-year plan for railway development was issued in 2017, and the length of high-speed railway will reach 30,000 km by the end of the 13th five-year plan, and the "eight vertical and eight horizontal" high-speed railway pattern will be formed by the end of 2030. When completed, the "eight longitudes and eight longitudes" will achieve a 1-4-hour traffic circle in adjacent large and medium-sized cities and a 0.5-2-hour traffic circle in city clusters. High-speed rail breaks down urban boundary barriers, and time distance will dilute spatial distance, allowing innovative elements such as people flow, logistics and capital flow to be reconfigured between cities. The opening of high-speed railway not only reduces the distance between time and space, but also leads to the outflow of human resources in small and medium-sized cities with slow economic development, which indirectly leads to the outflow of capital and economic factors. The cities along the Daxi high-speed railway are located in the middle and mostly resource-based, with a single economic structure and backward development. Although they are undergoing transformation and development under the background of innovation-driven development, they have no obvious advantages in the talent war. With the opening of Daxi high-speed railway, how should the small and medium-sized cities along the route grasp the traffic advantages, break through the existing ways to attract people and capital, improve the urban innovation environment, improve the ability of urban innovation elements to gather, reform the innovation development mechanism of small and medium-sized cities along the route, and promote the economic development of small and medium-sized cities along the route?

II. LITERATURE REVIEW

Research on influencing factors of urban innovation. According to James Simmie[1], there are two main factors of urban innovation: knowledge labor force and convenient real estate facilities and communications. Hall[2] believes that time distance has an important impact on urban innovation. Charles Landry[3] believes that urban innovation elements include diversified, open and tolerant innovative public space, proximity and high-quality livable living environment. American scholar Richard Florida[4] puts forward three T indexes of urban innovation: Technology, Talent and Tolerance. He believes that Technology is the expression of urban innovation, Talent is the competitive advantage of a city, and an inclusive innovation environment is the key to attract people. According to the research of fan xinying and zhang suodi [5], urban innovation agglomeration gathers in the city through various innovation elements and various activities of people, promoting local innovation development. Wang rong and zhang suodi [6] measure urban innovation capacity from three aspects: urban infrastructure, innovation input and innovation output. Cheng xiaoyan and zhang suodi [7] hold that innovation has three core elements. Innovation starts with technology, focuses on talents and becomes capital. Ji xiaoli and hong yinxing [8] hold that talent agglomeration can promote knowledge sharing and promote urban innovation. Talent agglomeration will strengthen innovation incentive on the basis of saving innovation cost and reducing innovation risk, which is conducive to improving innovation agglomeration level.

The opening of high-speed railway can reduce the space and time distance, improve the accessibility between cities, reconfigure innovation elements, and increase the output of regional innovation. Liang shuanglu and liang qiaoling hold that the modern transportation infrastructure provides the possibility for the rapid flow of innovation elements between global regions and is of great significance to the promotion of urban innovation agglomeration [9]. Huang suping and li yan [10] found that high-speed railway has a promoting effect on scientific and technological innovation of urban agglomeration along the Yangtze river delta urban agglomeration. Tan chenglin and zong zhaohui [11] believe that due to the opening of high-speed railway, the accessibility of cities has been improved, and the population is converging to cities along the high-speed railway, and urban agglomeration has become the main population agglomeration area. Tan chenglin and Yang lishan [12] hold that the development of railway transportation attracts three major factors of foreign direct investment, labor force and science and technology to gather in the cities along the route on the basis of improving the location conditions of the cities along the route. At the same time, many scholars believe that agglomeration effect also brings uneven distribution of innovation elements between regions or cities. Long yu et al. [13] found that after the opening of high-speed railway, compared with non-high-speed railway cities, the new venture capital of high-speed railway cities increased significantly. Cantos et[14] believes that transportation infrastructure has different effects on different urban innovation elements. Large cities with a high level of development may squeeze the agglomeration of innovation elements in underdeveloped cities through siphon effect. Boarnet found that the opening of high-speed railway will make the central city attract the resource elements of the small and medium-sized cities to gather, and then the negative effect of the expansion of the economic scale of the central city and the economic recession of the small and medium-sized cities will occur [15]. Zhang ke and tao dongjie found that the opening of high-speed railway not only enhanced the economic cohesion of central cities, but also strengthened the "siphon effect", making economic elements transfer from small and medium-sized cities along the route to central cities [16]. Preston & Wall[17] and Ortega & Lopez[18] both believe that the opening of high-speed rail will generate polarization effect and corridor effect, strengthening the status of central cities, while negatively affecting small and medium-sized cities.

Through the above literature review found that at present, the research on high-speed rail is relatively abundant, and the research focused on the high-speed rail, urban agglomeration of metropolitan area in the accessibility, regional economic development, the influence of urban spatial pattern, but the less developed the Midwest single high-speed lines have covered less influence on urban innovation. How does the opening of high-speed railway in central China affect the agglomeration of urban innovation elements? This is the problem that the city of central area needs to solve urgently at present. This paper takes datxi high-speed railway as the research object to study the impact of high-speed railway operation on innovation of small and medium-sized urban belt along the route.

III. Research Design

A. *Difference-in-differences Model*

This paper mainly draws on the difference-in-differences Method (DID) of Villa[19] to study the impact of the opening of high-speed railway on the innovation output of cities along the route. In this paper, the cities with high-speed railway are taken as the experimental group and the cities without high-speed railway as the control group, so as to construct the innovation output model of high-speed railway to cities:

$$\mathrm{LN\ PAT}_{it} = \alpha_0 + \alpha_1 G_i * D_t + \alpha_2 G_i + \gamma D_t + \delta Control_{it} + \varepsilon_{it}$$

In the formula, $\mathrm{LN\ PAT}_{it}$ represents the total number of patent applications for invention patents, utility model patents and appearance design patents of city i in the period of t, and the number of patent applications is used as an indicator to describe innovation changes. Gi is the dummy variable of the experimental group (Gi=1 for cities with high-speed railway, otherwise 0), and Dt is the time dummy variable. Gi*Dt is the dummy variable of whether city i is open to high-speed railway in period t. When city i belongs to the experimental group and takes a value of 1 in the year when the high-speed railway is opened and in the year after, otherwise takes a value of 0. $Control_{it}$ is the set of Control variables that affect the change of urban innovation output, and the ε_{it} is the random disturbance term.

B. *Variable Selection*

Referring to existing studies, this paper divides the factors affecting urban innovation output into high-speed railway opening variables and control variables, and the control variables select indicators from four aspects: urban economic environment, innovation environment, human capital environment and urban traffic environment.

Explained variable. Considering the lag of urban innovation, the output variable of urban innovation in this paper is represented by the number of patent applications of urban invention patent, utility model patent and appearance design patent in the same year.

Core explanatory variables. According to China railway yearbook, a high-speed railway line was opened in the same year through a city. When city i belongs to the experimental group and the value is 1 when the high-speed railway is opened, and 0 when it is not.

Other control variables. (1) urban economic environment: the logarithm of GDP is adopted to reflect the impact of urban economic environment on innovation output. (2) urban innovation environment :a urban information environment, expressed by the number of users of urban mobile phones at the end of the year, good information exchange environment is conducive to innovative communication; B. Wage environment: the logarithm of the per capita wage of on-post employees is adopted to reflect the attraction of urban wage level to urban talents; C. Financial environment of science and technology, using the financial expenditure of science and technology to indicate the intensity of the city's financial investment in science and technology; D the natural environment is represented by the green coverage rate of built-up areas. (3)

human capital environment: emerging talents are expressed in the logarithm of the number of college students, and urban education level is expressed in the logarithm of the number of full-time urban teachers. The development of a city cannot be separated from the efforts of practitioners from all walks of life, who will indirectly affect the innovation of a city. (4) urban traffic environment: expressed by the logarithm of the city's annual total bus (electric) passenger transport.

IV. The Measurement Results And Analysis

A. Data Description and Descriptive Statistical Analysis

Daxi high-speed railway is a special railway passenger line from datong city, Shanxi Province to xi 'an city, shaanxi province in the national medium and long term railway network planning. The line starts from datong city, Shanxi Province in the north and runs through 9 cities and 31 counties (districts) to xi 'an city, shaanxi province. In view of the opening of the taiyuan to xi 'an section of Daxi high-speed railway in 2014, and the availability of data, the research period from 2008 to 2016 is selected as the research object. Xi 'an is a big city, so xi 'an is excluded. A total of 5 cities including taiyuan, jinzhong, linfen, yuncheng and weinan, which have opened high-speed railway, will be taken as the experimental group. 7 cities including datong, xinzhou, changzhi, xinzhou, luliang, tongchuan and shangluo, which have not yet opened high-speed railway along the high-speed railway line, will be taken as the control group by the end of 2014. The city's three major patent applications come from the state intellectual property office. Other data of prefecture-level cities are from China urban statistical yearbook.

B. Benchmark Regression Result

The opening of high-speed railway is a quasi-natural experiment. Therefore, DID method is used in this paper to estimate the direct impact of the opening of Daxi high-speed railway on the innovation of cities along the route. The benchmark regression results are shown in Table I and column 1. According to the benchmark regression results in Table I and column 1, the opening of Daxi high-speed railway has a significant negative effect on urban innovation. While the high-speed railway improves the accessibility of cities, small and medium-sized cities lose innovative talents under the siphon effect of big cities. Therefore, the high-speed railway has a negative and significant effect on the innovation of cities along the routes. The regression results of control variables show that, in the urban innovation development, the scientific and technological financial environment, information environment, wage level and urban education level in the innovation environment play an obvious role in promoting urban innovation. Among them, the higher the financial expenditure of science and technology, the higher the city attaches importance to innovation, which is conducive to the improvement of urban innovation. The information environment represents the intensity of urban information exchange, and the more information exchange and dissemination, the more beneficial to urban innovation. The higher the urban salary level is, the more attractive it is to the emerging talents in the city, which will promote the development of urban enterprises, attract more enterprises into the city, and drive the capital agglomeration of the city, which plays an important role in urban innovation. The higher the level of urban education, the more urban innovative talents will be cultivated, thus promoting urban innovation. Educational financial environment and social practitioners play a negative role in promoting urban innovation. The greater the financial investment in urban education, the greater the cultivation of emerging urban talents; Social practitioners reflect the size of urban market. The larger the size of the market, the stronger the attraction to capital economic factors. However, under the "siphon effect" of central cities, emerging talents join the social workers after graduation and flow to the developed cities with better resource endowment, which squeezes the innovation of small and medium-sized cities along the route. Urban emerging talents, urban regional GDP representing urban economic environment, natural environment in urban innovation environment and urban traffic environment have no significant role in promoting urban innovation. Although urban economic environment and natural environment to some extent will attract emerging talents and capital economic input, it is also influenced by the latest policy environment conducive to urban innovation. The above all confirm the views of dong yanmei and zhu yingming [20], that the siphon effect of agglomeration in big cities inhibits the development of small and medium-sized cities, and the innovation elements flow from cities with poor resource endowment to big cities. The development of Daxi high-speed railway is an important measure to coordinate the national intention to promote urban development, but its effect on urban innovation will also be affected by the local policy environment. With the construction and opening of the dashi high-speed railway, its role in promoting urban innovation may gradually change.

C. Robustness Test

TABLE I. Test Results Of Benchmark Regression AndReplacement Explained Variables

Table Head	(1) Benchmark regression result	(2) Replace be explained variable test	Table Head	(1) Benchmark regression result	(2) Replace be explained variable test
Dt	0.226	0.163	LN PTE	-0.0794	-0.0729
	(1.45)	(1.07)		(-1.34)	(-1.15)
Gi	-0.405**	-0.476***	GR	-0.00127	-0.00119
	(-2.51)	(-2.85)		(-0.16)	(-0.15)
Dt* Gi	-0.440*	-0.414*	Ln IE	0.956***	1.020***
	(-1.94)	(-1.84)		(4.51)	(4.92)
Ln STE	0.229***	0.223***	Ln	-0.291***	-0.281***
	(3.93)	(3.64)	PRAC	(-2.85)	(-2.86)
Ln EFE	-0.273**	-0.281**	Ln	1.356***	1.343***
	(-2.32)	(-2.37)	SALA	(5.30)	(5.20)
Ln CS	0.145	0.211*	Ln GDP	0.234	0.199
	(1.23)	(1.81)		(1.39)	(1.15)
Ln	0.253**	0.254**	Intercept	-17.15***	-18.48***
EDU	(2.11)	(2.04)	item	(-7.03)	(-7.47)

Replace explained variables. Referring to the treatment method of bai junhong [21], this paper assigns 0.5, 0.3 and 0.2 weights to three types of patents of invention patent, utility model and appearance design according to their different degrees of innovation, and USES their weighted average value as the explained variable to test the robustness of the empirical results. As shown in Table I and column 2, the impact coefficient of the opening of Daxi high-speed railway on the

innovation of cities along the route is statistically significant, and the opening of high-speed railway has a significant negative effect on the innovation of cities along the route. In the regression results of control variables, only the coefficient of urban emerging talents changed from 0.145 to 0.211, which was significant at the level of 10%, and the significance of other control variables remained unchanged. The above analysis further proves the robustness of benchmark regression results.

Placebo test. In this paper, using double difference model testing high-speed onishi opened the city innovation output, the influence of the double difference method is one of the basic conditions of effective parallel trend hypothesis, namely innovation output in the high-speed opening before and after the change trend is parallel, the placebo tests, which can be switched by the experimental group or time to implement the policy works. In order to exclude the influence of characteristics differences existing in cities before the opening of high-speed railway and other unobserved factors, this paper assumes the opening time of high-speed railway as 2010, and USES panel data from 2008 to 2013 to do the DID regression of the innovation output of the experimental group and control group. According to the results of test on virtual high-speed opening time for after the handover, no significant cross coefficient P value is 0.947, that until the opening of the high-speed rail group and experimental group city innovation output change meet the trend of parallel assumptions, and thus proves that high-speed rail onishi opened on the effects of the negative significantly along the city innovation results with robustness.

V. Conclusions And Implications

Based on the data of the cities along the high-speed railway in dazi from 2008 to 2016, this paper adopts the method of double difference to study the impact of the opening of high-speed railway on the innovation output of the small and medium-sized cities along the high-speed railway from the perspective of innovation agglomeration, enriching the research results on the impact of the single high-speed railway line in the central region on the innovation of the cities along the high-speed railway. The research results show that the opening of Daxi high-speed railway has a significant negative effect on the innovation output of small and medium-sized cities along the line. While improving urban accessibility and exerting the "space-time effect", high-speed railway strengthens the "siphon effect" of developed cities, further accelerating the flow and allocation of urban innovation elements, and taking small and medium-sized cities as buffer zones to flow to the faster developing central cities.

The research results of this paper have certain policy enlightenment for the innovation and development of small and medium-sized cities along the high-speed railway. Firstly, talents are the key to the innovation and development of cities, and all small and medium-sized cities should optimize the mechanism of "retaining and attracting people", attract capital with people, and improve the attractiveness of cities in the process of the allocation of innovative elements. Secondly, in the long run, we should constantly improve the soft environment such as the incentive mechanism of urban innovation, the protection mechanism of urban innovation achievements and the improvement of urban education level, so as to attract the agglomeration of urban innovation elements on the basis of cultivating emerging talents.

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