Joint Effect of High-speed Rail and Air Pollution on Tourism in Nearby Cities: Example of Hu-Ning-Hang Area

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ABSTRACT
Most of the previous researchers estimated the influencing factors of the high-speed railway (HSR) on tourism without considering the influential factors on different air quality levels. With high-speed railway construction as a quasi-experiment, this paper contributes to evaluating how air quality affects the passenger-oriented transportation infrastructure's impacts on tourism. As one of the most economically developed regions in China, Hu-Ning-Hang region has become an excellent example to compare this effect. Based on a triple difference (DDD) approach, the results indicate that tourism increase significantly in cities with good air quality and decrease in cities with bad air quality. The results also suggest that industrial development also improved, but the gap between cities with different air quality is not apparent. Therefore, this research support that under the influence of air quality, the opening of HSR will have different impacts on tourism, but the impact on industrial development is similar.

Keywords: *High-speed railway, air quality, tourism development, triple difference model, China*

1. INTRODUCTION

1.1. Background

The well-developed high-speed rail (HSR) has been considered a landmark of scientific and technological achievement in the Chinese transportation industry and has drawn great attention worldwide. By the end of 2019, the total mileage of railway operation in China has reached 3.5 thousand, while the total number of passengers sent throughout the year has exceeded 2.005 billion. Undoubtedly, those astonishing figures indicate the fact that HSR has been playing an indispensable role in China's tourism construction and people prefer to travel by it for its timeliness and relatively lower cost.

Meanwhile, according to the document published by the Chinese government in 2018, in responding to the explosion of tourism, the Chinese domestic tourism market reached 55.39 hundred million. And as the golden tourist belt in China, the total number of visits to the delta area achieved 25.84 hundred million while the total income from tourism exceeded 3.50 hundred million in the same year. For the nucleus of the Yangtze River delta area, which refers to the triangle within Shanghai, Nanjing, and Hangzhou, tourism has become a significant promotion for its economic development.

Therefore, since a new HSR loop named Hu-Ning-Hang HSR, which associates the three cities, was accomplished in succession from 2010 to 2013, its financial impact on tourism in nearby cities is considered to be achingly worth studying. According to previous studies, the opening HSR could be effective for regional industrial development. It may lead to industrial agglomeration phenomenon, spillover effect, or even siphonic effect. In addition, considering that the society is getting increasingly concerned about environment well-being, air pollution is also an important judgment criterion for visitors. This paper fills the gap between the separated influence of opening HSR and the level of air quality on the development of tourism while generating the joint effect of the two factors.

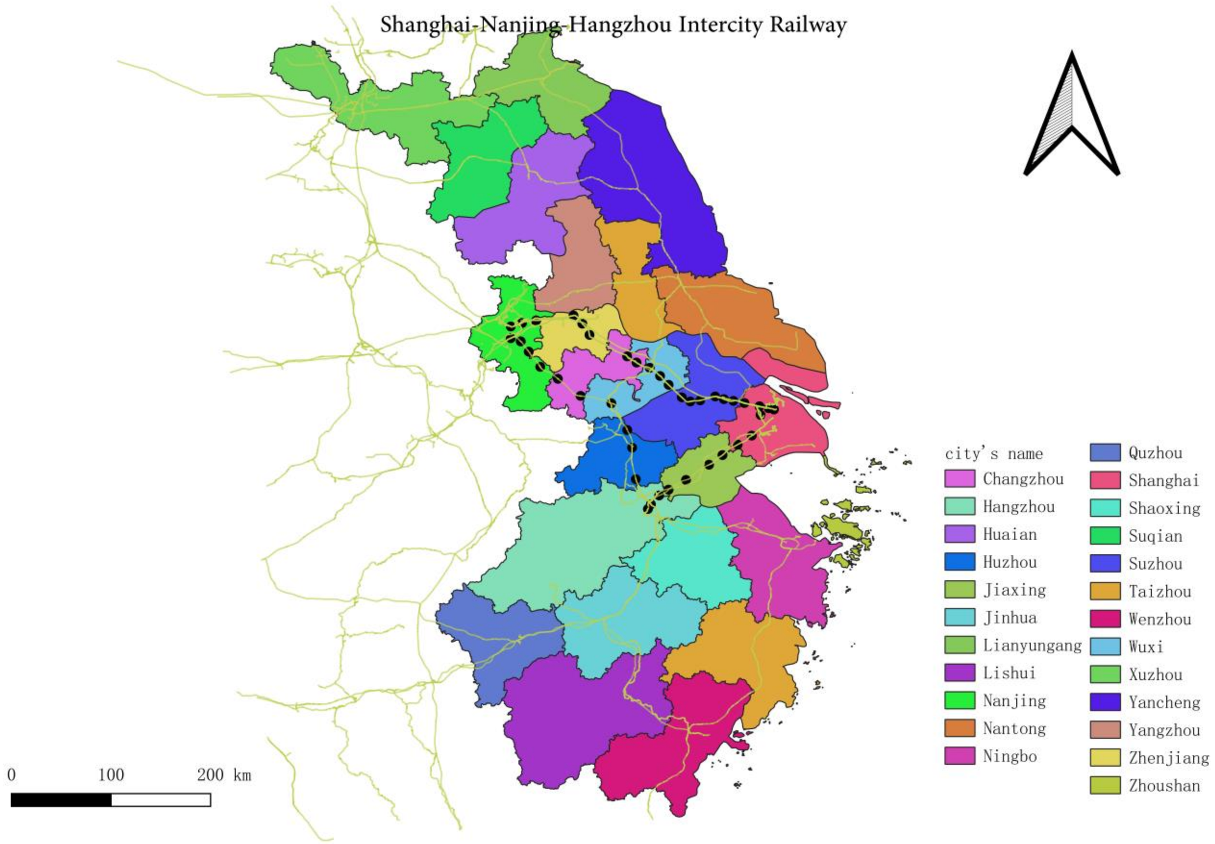

Figure 1. The distribution of cities along the Hu-Ning-Hang HSR. Note: the points in the figure denote the stations of the Hu-Ning-Hang HSR

1.2. Literature Review

This paper is naturally related to a considerable amount of research on the correlation between urbanization and air pollution. By applying the spatial quantile regression model to investigate heterogeneity of influential factors on AQI, Han et al. stated that the joint prevention and control of air pollution requires the implementation of policy measures to differentiate while simply relying on the inefficient expansion of land urbanization is not conducive to improving air quality. The corresponding decline in air quality will have a corresponding impact on urban development [1]. Liu et al. announced that since residents are willing to pay a premium for good air quality, air quality impacts are embodied in housing price. In contrast, housing rental prices have a more significant response to the air quality than housing sale prices [2].

As for the relationship between the development of the tertiary sector and air quality, Wang et al. point out that first, the service sector has released a significant amount of CO2. Second, the emission efficiency varies among different regions while consistent with the regional economic development level [3]. In addition, Lin and Zhang indicated that under both meta-frontier and group-frontier technologies, the energy efficiency of the service sector in China is 0.62 and 0,85. In contrast, only the energy efficiency of eastern regions in China shows an increasing trend [4]. However, Xing et al. suggest that mercantile is one of the two significant sub-sectors in the service industry. At the same time, in the next ten years, an enormous part of energy consumption would be replaced by renewable energy, which could significantly reduce the emission of CO_2 [5].

Regarding the general influence of establishing HSR, based on DID and DDD methods, Chen examined the effect of HSR on energy consumption in China by using China's perfecture-level panel data with DID method and IV regressions. He states that HSR can diminish absolute energy consumption and energy consumption intensity through the ways of increasing industry agglomeration, industry upgrading and technological innovation. Meanwhile, the promotion is more significant in peripheral regions rather than central area[6]. For economic effectiveness, Niu et al. demonstrate that trade value would increase, and market segmentation would decrease with HSR expansion. At the same time, industries with higher technology dependence and provinces with poorer preexisting ICT levels tend to benefit more from it. They also revealed the significant impact of HSR on information flow and knowledge spillover and that HSR could generate more room for freight services than another mode of transportation[7]. Additionally, Ma et al. found out that HSR leads to an increase in entrepreneurship by 3.5%. However, the encouragement of entrepreneurship flows disproportionately to big cities, low-income families, significant assets families, and unemployed heads of households, which leads to the heterogeneous effects of HSR. In contrast, highly educated families and large-sized businesses are more responsive to HSR connectivity[8]. Employing a penal data program evaluation method and prefectural-level data of Wuhan-Guangzhou HSR during the period from 1998 to 2016, Tian et al. investigated the effect of high-speed rail on Chinese service sector agglomeration(SSA). The results from their study have shown that the arrival of WGHSR has increased the SSA of cities by around 9.44% on average. At the same time, the exact impact is heterogeneous and the WGHSR has brought about both spillover effect and siphon effect on the service sector [9].

To be elaborate on the effect of HSR on tourism growth, based on China's city penal data during 2004 and 2015, Gao et al. conducted a natural experiment to study the impact of HSR on domestic tourism by applying DID method as well as IV method. According to their results, HSR does not raise tourism revenue, but it certainly draws tourist arrivals, and leads to a decreasing average revenue per arrival. They also have found out that the promoting effect of HSR on tourism arrivals is more remarkable in less-developed central and western areas than well-developed regions[10].

1.3. Objective

Since the establishment of HSR would contribute to tourism development. At the same time, the degree of promotion is highly correlated to air quality in each city, this paper will further explore the impact of HSR on the growth of tourism in nearby cities while adding their air quality into consideration. In the following article, the opening of Hu-Ning-Hang HSR will be applied as an example. At the same time, the panel data of Shanghai and other cities in Zhejiang and Jiangsu provinces from 2010 to 2019 is used to examine the joint effect of Hu-Ning-Hang HSR on the development of tourism based on their degree of air pollution.

2. DATA AND METHODS

2.1. Data and variables

Our primary data source is from the China Premium Database (CEIC Data). We decided to use the number of domestic tourists and wholesale and retail sales as indicators to measure the development of our tourism industry. The former directly represents the number of tourists, while the latter reflects the practical consumption-ability of tourists, which can reflect the overall level of tourism development. By taking the natural logarithm of domestic tourist, wholesales and retail sales, and industrial added value, we generate lndomestic, lnsales, and lnindustrial variables. Since the Hu-Ning-Hang HSR consists of three major parts and their start-up times are inconsistent, we generate the corresponding dummy variables according to the opening year, respectively. We use the permanent population of the municipal district to subtract the registered population of the municipal district to get the net population inflow. Our air quality data is collected from the Atmospheric Composition Analysis Group at Dalhouse University [11]. We create a dummy variable, AQI, and calculate it based on the PM2.5 concentration over ten years against US standards and determined whether the city's air quality is in a healthy state. Through our calculations, we confirmed that since Yancheng, Nantong, Huzhou in our sample were in an unhealthy state for only one year, we also recorded them as having an air quality index equal to 1. The results of the Zclassification of different cities according to AQI are shown in Table 1. Since some data are missing in the database, we fill in the missing values based on the linear trend of the available data without affecting the results. The summary statistics of all variables used in the empirical analyses are shown in Table 2.

Table 1. AQI and PM2.5 correspondence table

AQI(US)	PM2.5 (μg/m3)	Remark	City's name
0-50	0-12	Good	NA.
51-100	12-35	Moderate	Zhoushan, Wenzhou, Lishui, Taizhou(Jiangsu Province)
101-150	35-55	Unhealthy for Sensitive Individuals	Ningbo, Quzhou, Jinhua, Shaoxing, Hangzhou, Shanghai, Yancheng, Nantong, Huzhou.
151-200	55-150	Unhealthy	Jiaxing, Huaian, Lianyungang,Suzhou, Suqian, Yangzhou, Taizhou(Zhejiang Province), Nanjing, Wuxi, Zhenjiang, Changzhou, Xuzhou.

Table 2. Summary statistics

Year	ln(domestic tourist)	ln(industrial added value)	Net inflow of the population	ln(wholesales and retail sales)	Air quality	HSR	Public expenditure
2010	10.19	7.191	51.37	4.769	0.520	0	283.5
	0.794	1.095	170.0	1.345	0.510	0	629.6
2011	10.36	7.348	55.90	5.036	0.520	0.360	346.8
	0.757	1.087	182.5	1.247	0.510	0.476	743.8
2012	10.50	7.424	62.51	5.178	0.520	0.360	377.2
	0.731	1.072	191.3	1.251	0.510	0.476	793.5
2013	10.63	7.397	24.67	5.414	0.520	0.360	424.8
	0.703	0.964	60.36	1.235	0.510	0.476	857.5
2014	10.75	7.375	62.61	5.559	0.520	0.360	465.7
	0.682	0.783	200.9	1.262	0.510	0.490	931.2
2015	10.87	7.402	61.58	5.496	0.520	0.360	576.8
	0.673	0.771	199.4	1.202	0.510	0.490	1171
2016	11.00	7.544	93.32	5.478	0.520	0.360	634.5
	0.670	0.952	211.7	1.219	0.510	0.490	1348
2017	11.12	7.547	86.74	5.724	0.520	0.360	698.4
	0.663	0.848	206.9	1.262	0.510	0.490	1475
2018	11.23	7.599	85.14	5.843	0.520	0.360	781.3
	0.653	0.842	193.6	1.294	0.510	0.490	1632
2019	11.32	7.658	84.90	5.981	0.520	0.360	820.8
	0.648	0.817	194.0	1.309	0.510	0.490	1600
Total	10.80	7.448	66.87	5.448	0.520	0.360	541.0
	0.773	0.923	183.5	1.289	0.501	0.481	1166

2.2. Methods and Models

We exploit the fact that cities with high-speed rail will be more accessible, attracting tourists while boosting consumption and small business entrepreneurship. At the same time, the differences in air quality from city to city will allow different regions to be affected differently by the opening of high-speed rail. Specifically, we believe that the air quality and the opening of the high-speed rail will have a common effect on domestic tourists and wholesale and retail sales. Still, the air quality will not have a significant impact on the industrial added value. Therefore, we conducted estimations of DID and DDD with multiple periods to identify this change. Specifically, we use high-speed rail changes (Hu-Ning-Hang HSR connection vs non-Hu-Ning-Hang HSR connection), time changes (opening times of the three railroads), and air quality index changes (healthy air quality vs non-healthy air quality). As a result, the DID and DDD estimation specification are as follows:

$$Y_{i,t} = \beta_0 + \beta_1 HSR_{i,t} + \beta_2 X_{i,t} + \gamma_i + \eta_t + \varepsilon_{i,t} \quad (1)$$

$$Y_{i,t} = \beta_0 + \beta_1 AQI_{i,t} \times HSR_{i,t} + \beta_2 HSR_{i,t} + \beta_3 X_{i,t} + \gamma_i + \eta_t + \varepsilon_{i,t} \quad (2)$$

where $Y_{i,t}$ is the natural logarithm of domestic tourists, wholesales and retail sales, and industrial added value for the city i in year t. HSR_{it} is the dummy variable indicating whether the city i is connected by Hu-Ning-Hang HSR in year t. HSR_{it} equals 1 if city i is connected by Hu-Ning-Hang railway in year t and equals 0 otherwise. AQI_{it} is a dummy variable indicating whether the city i has a good air quality. X_{it} is the control variable, including the net inflow of the population and Government consumption expenditure.

γ_i and η_t denote city fixed effects, capturing city-level and time-invariant characteristics, respectively. ϵ_{it} is the error term. Using the Pesaran test, Wooldridge test, we found that serial correlation and cross-sectional correlation problems exist in panel data. Therefore, the method proposed by D & K (1998) is used to address the heteroskedasticity, serial correlation, and cross-sectional correlation problems. We set 2010 as the base year.

3. EMPIRICAL RESULTS

3.1. Parallel Trend Test

A possible problem with the dependent variable is that this impact is not caused by the opening of the Hu-Ning-Hang HSR but by other factors before and after the high-speed railway operation. To explore whether the opening of the HSR has an impact on the city, we estimate the following model:

$$Y_{i,t} = \beta_0 + \sum_{j=-1}^{8} \beta_j HSR_{i,t-j} + a_1 X_{i,t} + \gamma_i + \eta_t + \varepsilon_{i,t} \quad (3)$$

$Y_{i,t}$ is the natural logarithm of domestic tourists, wholesales and retail sales, and industrial added value in our model. γ_i and η_t denote city fixed effects, capturing city-level and time-invariant characteristics, respectively. β_{-1} is the effect of the first phase before the opening of the high-speed rail, and β_1 to β_8 are the effects of phase 1-8 after the restructuring. The results are shown in Figure 2. In this paper, the current period is the benchmark group of the model. The β_{-1} is significantly 0, indicating the parallel trend hypothesis is valid.

3.2. Placebo test

Endogenous problems in the layout of high-speed rail may bias the impact of high-speed rail connections on the tourism industry. In order to see if other unobserved factors are affecting our dependent variables, we conducted the following robustness test. We first randomly select a year from our sample for each city as the year of policy occurrence, then regression Equation (1) and Equation (2) to simulate our multi-period DID model. We randomly repeated the results 500 times to prevent the contingency of the results. Figure 3 shows the distribution of 500 estimated coefficients and the related p-value of the placebo test, and the core density function of the distribution. The distributions center around zero, and the proper estimator lies outside the distribution. Meanwhile, most of the estimates' p-values are much greater than 0.1. Combined with these facts, this figure confirms that our results are not significantly biased due to any omitted variable.

3.3. Main results

The main estimations results of this paper are presented in Table 3. The first, third, and fifth columns are obtained by regressing Equation (1). The HSR coefficients are insignificant, indicating that the impact on the city brought by the opening of the railroad alone is not significant. The second, fourth, and sixth columns are obtained by regressing Equation (2). The coefficients of HSR and ddd are significant at the 1 percent level, indicating that the opening of high-speed rail has a different effect on cities with good and bad air quality and that the effect is very significant. The regression results show that from 2010 to 2019, after the Hu-Ning-Hang HSR, the number of domestic tourists in cities with good air quality along the railway increased by 12.2% compared with cities with poor air quality on the railway. While in cities with poor air quality along the Hu-Ning-Hang HSR dropped by 16.5% after the railway was opened. The results also show that after the opening of the Hu-Ning-Hang HSR, the wholesale and retail sales of cities along the railway with good air increased by 8.3% compared with cities with bad air quality along the railway. While in cities with poor air quality along the Hu-Ning-Hang HSR dropped by 31.0% after the railway was opened. In contrast, the air quality in cities does not significantly affect the industrial added value. The regression result in the fifth column tells us that the industrial added value of cities passed by Hu-Ning-Hang HSR increased by 16.0%.

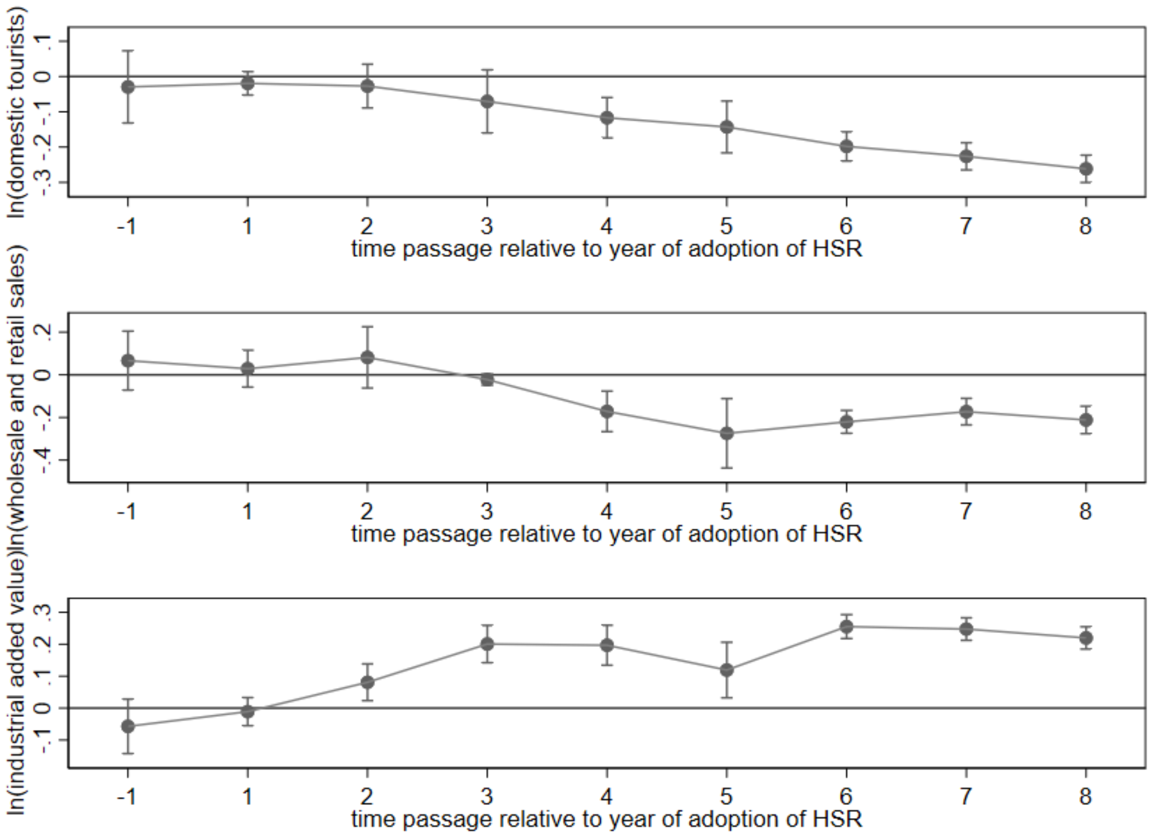

Figure 2. Parallel trend before HSR operation. Notes: The graph shows the estimated coefficients of the pre-trend leads variables and post-trend lags variables.

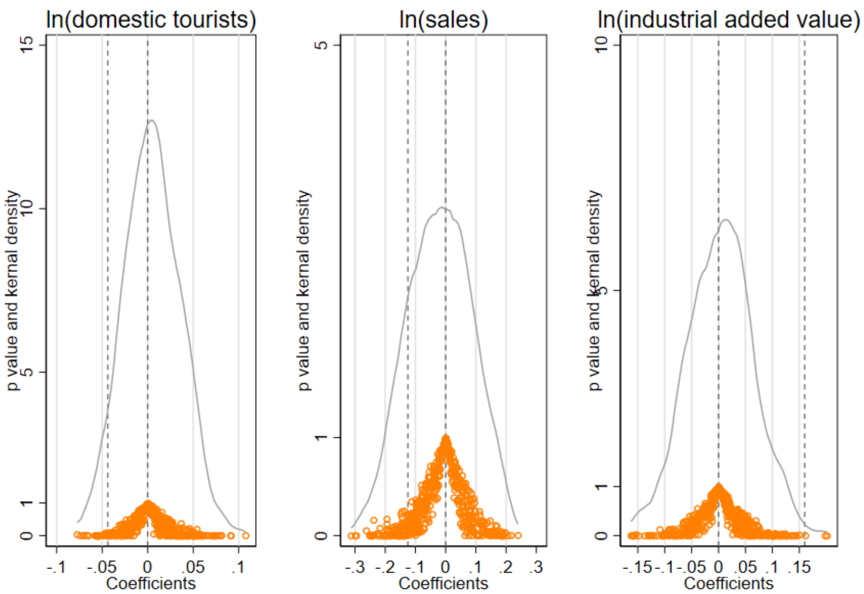

Figure 3. Robustness check-randomly assigned HSR connections. Notes: Assuming that HSR station and lines are randomly assigned

Table 3. Regression results

	ln(domestic)	ln(domestic)	ln(sales)	ln(sales)	ln(industrial)	ln(industrial)
HSR	-0.0438	-0.165**	-0.125	-0.310***	0.160**	0.169**
	(0.0637)	(0.0470)	(0.0852)	(0.0514)	(0.0440)	(0.0487)
net inflow of	0.000178	0.000214*	-0.0000205	0.0000145	-0.000144	-0.000146
population	(0.0000879)	(0.0000919)	(0.000193)	(0.000186)	(0.000393)	(0.000394)
public	-0.000159***	-0.000171***	0.0000679**	0.0000517***	0.0000201	0.0000209
expenditure	(0.00000903)	(0.0000179)	(0.0000152)	(0.00000831)	(0.0000304)	(0.0000296)
Year 2011	0.189***	0.216***	0.303***	0.332***	0.106***	0.104***
	(0.0204)	(0.0117)	(0.0271)	(0.0125)	(0.0142)	(0.0149)
Year 2012	0.334***	0.360***	0.443***	0.472***	0.182***	0.181***
	(0.0204)	(0.0111)	(0.0277)	(0.0130)	(0.0147)	(0.0154)
Year 2013	0.477***	0.506***	0.675***	0.706***	0.149***	0.147***
	(0.0211)	(0.0146)	(0.0216)	(0.0113)	(0.0190)	(0.0190)
Year 2014	0.602***	0.622***	0.823***	0.845***	0.124***	0.123***
	(0.0236)	(0.0113)	(0.0298)	(0.0136)	(0.0164)	(0.0170)
Year 2015	0.735***	0.757***	0.752***	0.777***	0.150***	0.149***
	(0.0240)	(0.0118)	(0.0282)	(0.0135)	(0.0170)	(0.0173)
Year 2016	0.871***	0.892***	0.731***	0.755***	0.295***	0.294***
	(0.0242)	(0.0107)	(0.0323)	(0.0173)	(0.0198)	(0.0203)
Year 2017	1.001***	1.023***	0.973***	0.998***	0.296***	0.294***
	(0.0244)	(0.0117)	(0.0304)	(0.0164)	(0.0186)	(0.0190)
Year 2018	1.129***	1.153***	1.086***	1.112***	0.346***	0.344***
	(0.0247)	(0.0128)	(0.0290)	(0.0162)	(0.0188)	(0.0189)
Year 2019	1.227***	1.251***	1.221***	1.248***	0.404***	0.403***
	(0.0249)	(0.0133)	(0.0284)	(0.0163)	(0.0190)	(0.0190)
ddd		0.287**		0.393**		-0.0196
		(0.0734)		(0.0848)		(0.0324)
constant	10.23***	10.23***	4.751***	4.753***	7.192***	7.192***
	(0.00602)	(0.00670)	(0.00653)	(0.00963)	(0.0140)	(0.0139)
N	220	220	250	250	250	250

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

4. DISCUSSION

4.1. General impacts of HSR

The two chief functions of establishing HSR are based on openness and flourishment of the cities. For those reasonably well-established cities such as Shanghai, since the quantity demand for high-speed transportation is significant, the opening of Hu-Ning-Hang HSR can share the traffic pressure of preexisting rails. And for those relatively occlusive regions, this convenient means of transportation can attract more visitors and entrepreneurs. So, the accomplishment of Hu-Ning-Hang HSR is expected to inevitably promote economic growth and commercial liquidity within the entire region. According to the result, the industrial added value of all cities has been significantly developed by 16.9% after HSR opening to traffic, which is satisfied with initial anticipation.

The prominent spillover effect on tourism development from constituting the HSR can also be observed from the statistics. With the running HSR, while the development of tourism in nearly all the cities within Jiang Su and Zhe Jiang provinces was burgeoning, the growth rate in other cities outside the triangle within the HSR was even higher than cities inside. Thus, the Hu-Ning-Hang HSR has facilitated the progress of the tourism connected by the railway, and accelerated the industry blossom, almost overriding the Yangtze River Delta area.

4.2. Variance among cities with different AQI.

Based on the initial prediction, the correlation between operating HSR and lndomestic (which refers to the volume of domestic tourists) should be significantly positive, considering that HSR has been widely treated as a great measure to transport visitors. However, the regression result based on the DDD model shows an inverse result that the coefficient for cities with bad air quality is negative. The three factors listed below could be explanatory for this phenomenon.

First, after detecting the correlation between the sample cities' domestic tourists and AQI level (Figure 4), the number of domestic tourists is negatively correlated with AQI, which means those cities with inferior air quality are likely to have fewer initial visitors. The reason is that these cities are already highly developed, so those cities' railway networks tend to be pre-established. For instance, the rail connecting Shanghai and Nanjing (Hu-Ning line) overlapped with Jing-Hu HSR, which opened two years earlier than Hu-Ning-Hang and has been listed. Consequently, since establishing new rail mainly aims to share the burden of transportation of previous lines, it is hard to draw great advances for industrial progress. At the same time, those cities' tourism development may have reached saturation during the past years.

Second, high-speed rail has brought benefits to the development of rural areas. Due to the inconvenience of transportation in rural areas, fewer tourists initially went to the local areas. The completion of the Shanghai-Nanjing-Hangzhou Railway provides a more convenient way for tourists to transfer from other stations to the rural areas where they had previously visited difficultly. Therefore, the Hu-Ning-Hang HSR has promoted the integration of urban and rural areas to a certain extent and is conducive to the construction of the rural regions.

Third, concerning Zhejiang Province, Jiangsu Province, and Shanghai are among China's most economically developed areas, the population is mainly concentrated in large cities. The air quality in these cities is poor. Most people living in these large cities will choose the surrounding relatively small towns with good air quality as their travel destinations. Therefore, our results show that after opening the Hu-Ning-Hang HSR, the domestic tourists of cities with good air quality along the Shanghai-Nanjing-Hangzhou line have increased significantly. At the same time, the domestic tourists of cities with poor air quality have reduced due to competition.

4.3. Implications, limitations and future studies.

The results of this study apply to all regions with a high concentration of economic development. The construction of HSR will promote the development of small and medium-sized cities, improve the competitiveness of small towns, and promote rural development. In addition, the results also show that cities should pay attention to the improvement of air quality, especially for those vast cities. But our results may have potential limitations. First, due to the inconsistency of statistical caliber, our data was minimal before 2010, so we only limited the results to 2010-2019. Further research can analyze the long-term effects of this effect. Second, the article results are limited to the two levels of tourism and industrial added value and cannot reflect the overall changes adequately. Future articles can try to analyze this impact from other aspects.

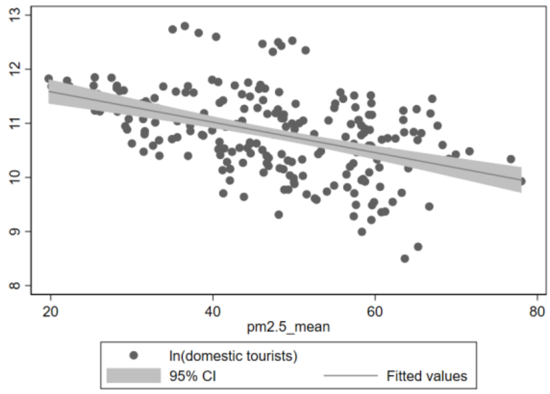

Figure 4. The relationship between domestic tourists and air quality. Notes: X-axis is the concentration of pm2.5. Y-axis is the ln(domestic tourists).

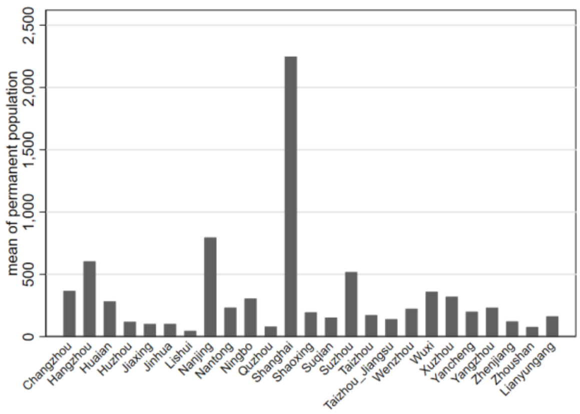

Figure 5. The relationship between population and cities.

5. CONCLUSION

Establishing HSR can promote staff mobility, cause industry agglomeration, and bring about spillover effects to the surrounding area. Although the HSR has been widely regarded as an effective way to drive economic growth, little is known about its exact impact on tourism development in surrounding districts. Using the construction of Hu-Ning-Hang HSR as an instance, this paper investigates the role of HSR in motivating the development of domestic tourists, cultivating wholesale and retail sales and the industrial added value. The results indicate that the influence of opening the HSR on tourism and merchandise sales is notably discrepant among cities depends on their level of air quality. Compared with cities with bad air quality, cities obtaining good air quality are estimated to have a comparative advantage of a 12.2% larger amount of domestic visitors, and an 8.3% increase in wholesale and retail sales. However, the activated HSR has caused a 16.0% industrial added value growth for both kinds of cities.

The results also contribute to comprehending the function of setting up HSR to help develop tourism in nearby cities on account of their air quality. However, heterogeneous effects should not be neglected in the results. Only a proportion of cities' tourism could be beneficial from the transportation network expansion. HSR may even harm cities' tourism of cities with bad air quality since they have lost their bulge of travel convenience. Policymakers accordingly should generate additional consciousness of improving air quality to amplify profit gain from the added HSR.

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