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Examining the impact of high-speed railways on land value and government revenue: Evidence from China

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ABSTRACT

The Beijing-Shanghai high-speed railway operates at 300 km per hour to connect two of the most important Chinese cities within a travel time of 5 h. By exploiting a unique government land sale dataset, this paper investigates the impact of this high-speed railway on land price and then on the local government revenue. We show that the BSH generally increases the land price by about 87%, which amounts to about RMB 99 billion (around USD 14 billion) more in government land sale revenue or helps to cover about 45% of its construction cost. Furthermore, we show the heterogeneity of the impacts of the BSH on the prices of different types of land. Specifically, we find that residential land located within 3 km from a BSH station experiences a price increase of 278%. This effect is weaker for mixed-use land. Our finding shows that high-speed railway itself could serve as a key channel of infrastructure financing and government revenue sources.

1. Introduction

Ever since the first launch of the high-speed railway (HSR) line between Beijing and Tianjin in 2008, the Chinese government has spent hundreds of billions of dollars on constructing its HSR system. Recently, more and more countries have followed in the footsteps of China, including the USA, India, Russia, Indonesia, Thailand, Malaysia, and so on. And they have also begun or are planning to construct HSRs. However, HSRs involve substantially large investment and high risk of deficit. Thus, a comprehensive understanding of the impacts of HSRs would have academic and policy significance for both researchers and policymakers.

In this paper, we investigate the impact of the most important HSR in China: the Beijing-Shanghai HSR (BSH) on land price and then how this HSR affects local Chinese government revenue through land appreciation. In China, all lands belong to the state. By selling the usage right of state-owned land to others, the local government turns these sales into the so-called “extra-budget revenue” to maintain government operations. Actually, these sales have become a major source of revenue for the local government budget. For instance, land sales revenue comprised, on average, 45.5% of local government revenue from 2011 to 2016. By employing a differences-in-differences approach on the individual level government land sale data along the BSH, we show that this HSR increases the land price by about 87%, which amounts to about RMB 99 billion (around USD 14 billion) more revenue from local government land sales based on the sold land parcels from 2008 to 2015 or helps to cover about 45% of the construction costs of the BSH. Moreover, we also show the heterogeneity of the impacts on the prices of different types of land. Specifically, we find that residential land located within 3 km from an HSR station experiences a price increase of 278%. This effect is weaker for mixed-use land parcels.

This paper contributes to the literature in several aspects. First, this paper contributes to the limited but fast-growing strand of

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literature that examines the impacts of HSRs. There has been much productive research which examines the impacts of the transportation infrastructure on economic growth (Démurger, 2001; Donaldson & Hornbeck, 2016; Ke, Chen, Hong, & Hsiao, 2017; Munnell, 1992; Qin, 2017; Wang & Wu, 2015), trade (Donaldson, 2018; Duranton, Morrow, & Turner, 2014), suburbanization (Baum-Snow, 2007), etc. The new large-scale launch of HSR systems demands fresh insights. Nevertheless, the literature on the impacts of HSRs is very limited. Recently, Zheng and Kahn (2013) show that the HSR network in China increases the residential housing price index in 262 prefecture-level cities. Li & Xu, 2018 study the HSR in Japan and conclude that the HSR can either diffuse or polarize the economic geography. Besides, Chen & Haynes, 2015 evaluate the ex-post impact of the Beijing-Shanghai HSR on housing values and they find that Beijing-Shanghai HSR has an inconsequential influence on housing values in larger cities but a remarkable regional impact in small and medium cites. To the best of our knowledge, this paper is among the first to document the impact of HSRs on the land market and local government revenue in the literature.

Second, this paper enhances our understanding of project financing for HSRs. Infrastructures in developing economies typically suffer from financing problems. For example, according to Ra & Li, 2018, the financing gap is around USD 459 billion per year for Asia. A key channel of infrastructure financing for China is to sell state-owned land near newly developed transport infrastructures (Wang, Zhang, Zhang, & Zhao, 2011; Zhao & Cao, 2011). Examining the extent of the impact of HSRs on government revenue through potential land value appreciation by examining the BSH case may enhance current understanding on this issue and also provide possible valuable lessons to other economies which plan to construct expensive HSRs.

Third, this paper provides insights on the impact of infrastructure investment on the land market within a city scope, not among cities. Zheng and Kahn (2013) use the city-level data to study the benefits of high-speed railway. Besides, Qin (2017) studies the distributional impact of high-speed rail upgrades in China and compares the GDP per capita between the core cities and peripheral counties. Through a microeconomics perspective, our identification strategy is to compare the land market value around BSH stations and that around the stations of a conventional railway in the same city before and after the “HSR shock”. This paper shows the importance of the HSR station placement from the view of the city itself.

Finally, we present a new dataset building on the China Real Estate Index System starting in 2002. In particular, we incorporate the land parcel date with the longitude and latitude data. The geographic information makes our dataset a potentially important resource for future spatial economic and policy analysis.

The rest of this paper is organized as follows. In Section 2, we provide background information on the land market and HSR development of China. Section 3 presents the data and the empirical method. Section 4 reports the baseline results and robustness checks. Five additional robustness tests are presented in Section 5. Section 6 concludes.

2. The background of the land market and HSR development

This section provides brief background information about the land market and HSR development.

2.1. Overview of land sales and infrastructure development in China

Infrastructure financing has undergone a series of different reforms in China. During the centrally planned period (prior to 1978), taxes and profits from state-owned enterprises were the main sources of funds for infrastructure development. These were collected by local governments and allocated by the central government to areas that were considered important (Wang et al., 2011; Wu, 1999). To increase the amount of funds, China then proceeded to introduce a market mechanism at the beginning of the economic reform in 1978. For example, local governments allocated 5% of the industrial and business profits in their jurisdiction to support infrastructure investment (Wang et al., 2011). However, the State Council mandated in 1985 that all business entities would have to pay a “value added tax” and “city maintenance and construction tax”. Moreover, urban area land-use fees were collected when foreign investors started to invest in China in 1988. The introduction of these land-use fees not only relieved the financing pressure of urban infrastructures, but also brought attention to land value. From 1988 to 1990, the government revised the Land Administration Law, which is the legal cornerstone for land-use rights. In the same period, several pilot cities near the coast, such as Shanghai, Shenzhen, and Zhuhai, allowed the exchange of land-use rights among developers. This practice in these coastal cities promoted land market competition. Then from 1990 to 2002, the Chinese government extended the scale of land reforms from the coastal cities to inland cities. Since then, land-market revenue has become a critical source of funds for supporting infrastructures (Wang et al., 2011).

In April-2002, the Ministry of Land and Resources announced the Provisions on the Assignment of the State-owned Land Use Rights by Means of Bid Tendering, Auction, and Quotation.[1] In the provision, Article 4 requires local government following the rule that “Commerce, tourism, entertainment, and commercial residence lands, as well as the other operational lands, shall be assigned by means of public bidding, auction, and quotation”, which is also known as “zhao, pai, gua” The intention is to apply a competition mechanism to regulate the land market in a more just, fair, and transparent way.

Fig. 1 plots the local government revenue structure from 2001 to 2016. The land sales revenue increased from RMB 130 billion to RMB 3.74 trillion and contributed, on average, to 45.5% of the local government revenue during this period. In particular, the land sale revenue contributes more than 75% of the local government revenue in 2010, indicating that local governments rely on land sale revenues heavily.

[1] The detail of the Order No. 10 of the Ministry of Land and Resources could be accessed from the link: http://www.gov.cn/gongbao/content/2003/content_62586.htm.

Fig. 1. Government land revenue structure.
Data source: National Bureau of Statistics of China (2002-2017).

2.2. The background of HSR and BSH

With rapid economic growth, modern infrastructures have become increasingly significant to China. Railway systems have also experienced substantial changes since the economic reform in 1978. In 2008, the railway system had expanded to each province and the total distance covered was 80,000 km. After six rounds of campaigns to increase the average speed of travel by rail, the Chinese government now boasts 20,000 km of railway with travel speed up to 120 km/h; 6003 km up to 200 km/h; and 846 km up to 250 km/h. To further enhance the accessibility across the nation, the government is now constructing an HSR network, which will redefine the spatial distance among different economic regions. The Ministry of Railways announced its construction agenda for an HSR system in the Mid-to-Long Term Railway Network Plan in 2004. The plan stated that the national primary HSR trunk has eight corridors, with four that cross the north to the south, and four that connect the east to the west (otherwise known as the “four verticals and four horizontals”).

As a part of the HSR trunk, the BSH has been paying more and more attention. The initial idea of the BSH that connects capital (Beijing) and the financial center of China (Shanghai) was proposed in 1990. Since then the central government had experienced a long time period to demonstrate the feasibility of the BSH. This State Council of China officially kicked off the project in Feb-2006. In Dec-2007, Beijing-Shanghai High Speed Railway Co., Ltd. was established and the Natural Resources of China approved the land requisition along the BSH. The detailed information about the plan of the construction of all the BSH railway stations is not clear before that. The BSH was formally begun to construct in April-2008. It costs over RMB 220 billion and was ready for commercial use in June 2011.

3. Data and empirical method

3.1. Data

This section describes the data sources and key variable descriptive statistics. Our primary source of data comes from the China Real Estate Index System (CREIS) and Baidu Maps. We obtain land parcel data and geographic information from CREIS. The CREIS, a subordinate of the China Index Academy, is a widely-used and authoritative dataset for the property market in China. Since 2000, it has tracked more than 180,000 land parcel transactions and provides comprehensive land auction data that include variables such as land area, floor area ratio, land starting price, land purchase cost, land coordinates, etc. Geographic information on HSR stations and conventional railway stations is obtained from Baidu Maps. Besides, the geographic coordinates of the courier stops of the Qing Dynasty are taken from Skinner, Yue, and Henderson (2008). Table 1 presents the definition and source of the key variables in this study. We use the floor price of land to represent the land price. Among the four types of land provided in the CREIS, industrial land parcels have insufficient observations. Thus, we only focus on residential, commercial, and mixed-use land. Mixed-use lands have features overlapping with more than two of the usages among residential land, commercial land, and indemnificatory land.

Fig. 2 plots out the locations of each land parcel on the map. It provides a spatial view of the land parcels near the BSH. Each blue dot represents a land parcel. Besides, the red squares and red lines show the HSR stations and BSH route, respectively. We also show the BSH route on the whole map of China at the right bottom of Fig. 2.

Table 1
Description and source of key variables.

Variable	Description	Unit	Data Source
Land price	The floor price of land	RMB per square meter	CREIS
Building area	Land building area	Square meter	CREIS
Land purchase cost	Land purchase cost for each land parcel	1000 RMB	CREIS
Plot ratio	Plot ratio equals to the land floor area divided by the building area		CREIS
Latitude and longitude data of land parcel	The geographic coordinate of land parcel	Degree	CREIS
Latitude and longitude data of HSR stations	The geographic coordinate of HSR stations	Degree	Baidu Map
Latitude and longitude data of conventional railway stations	The geographic coordinate of conventional railway stations	Degree	Baidu Map
Latitude and longitude data of the Qing Dynasty courier stops	The geographic coordinate of Qing Dynasty courier stops	Degree	Skinner et al. (2008)
Distance to HSR stations	The straight-line distance from a land parcel to the nearest HSR station	Kilometer	Author's calculation
Distance to conventional railway stations	The straight-line distance from a land parcel to the nearest conventional railway station	Kilometer	Author's calculation
Distance to Qing Dynasty courier stops	The straight-line distance from a land parcel to the nearest Qing Dynasty courier stop	Kilometer	Author's calculation

Table 2 reports the summary statistics of land price, land building area, land plot ratio and distance to railway stations. As indicated in the table, the price of commercial land is higher than that of residential and mixed-use lands. Among these three types of land, commercial land parcels have the highest plot ratio. In terms of distance, mixed-use land has the shortest distance to HSR stations. The distance to an HSR station, conventional railway station and Qing courier stop for each land parcel are calculated by using the Analysis tool-box in ArcGIS. The distance is measured in kilometers.

3.2. Empirical method

Using the HSR system as an exogenous shock, we use land transaction data and adopt a differences-in-differences (DID) approach to investigate the impact of this transport infrastructure on the land market. Our identification strategy is to compare the land market performance around BSH stations (treatment group) and that around the stations of a conventional railway that connects Beijing and Shanghai in the same city (control group) before and after the "HSR shock".

The baseline regression takes the following form:

$$Y_{ict} = \alpha_0 + \alpha_1 Treat_i + \alpha_2 Post_t + \alpha_3 Treat_i \times Post_t + \alpha_4 X_i + \delta_c + \rho_t + \varepsilon_{ict} \tag{1}$$

where Y_{ict} is the land price for the i^{th} land parcel in city c in year t. The city fixed effects, δ_c, control for all unobserved idiosyncrasies across cities. The year fixed effects, ρ_t, adjust for the patterns in the land market nationwide. The equation also includes two control variables (X_i) - land building area and plot ratio, which are important determinants of the land price.

$Treat_i$ is a dummy variable that equals one when the land parcel simultaneously meets two conditions: (1) the distance from the land parcel to the nearest HSR station is less than 3 km, and (2) the distance from the land parcel to the nearest conventional railway station is more than 3 km. Similarly, $Treat_i$ is set to zero when the land parcel is located within a 3 km radius of a conventional railway station and 3 km away from an HSR station. The radius cannot be too small in case of insufficient observations. We increase the radius to 8 km respectively to demonstrate the robustness of our estimation. The time dummy, $Post_t$, equals to one when the land parcel is sold after the BSH is officially announced to the public.

The Natural Resources of China approved the land requisition along the BSH in Dec-2007. Before that, the exact location of the HSR station is indecisive. After the approval, all the doubt was cleared. Therefore, we take this approval of the Chinese Natural Resource Ministry as the starting time of all the stations. Specifically, we choose 01-Jan-2008 as the treatment point in this paper. The coefficient of the interaction term,α_3, is the differences-in-differences estimator, which captures the impact of the BSH on the land market.

One critical assumption of the differences-in-differences strategy is the parallel trend that requires the difference between the treatment group and the control group is constant overtime when the intervention is absent. To verify this assumption, we run an event study and plot the pre and post coefficients in Fig. 3. Specifically, we create several dummy variables around 2008. We set 2008 as the year of adoption. The result shows that coefficients before 2008 are not statistically significant. In contrast, coefficients of 2008 and later on are positive statistically significant. The result shows that the parallel trend assumption stands.

Table 3 shows the list of HSR stations and conventional stations, respectively. The BSH passes 23 cities. In our paper, we focus on passenger railway stations. According to the national railway administration of China, railway stations are classified into six classes: special, first, second, third, fourth and fifth, depending on the scale and transport capacity of the station. Some cities have more than one conventional station. For those cities, we only select the highest-class passenger station as the conventional railway station. For example, Wuxi has 6 conventional stations, two of which are special stations, namely Wuxi station and Wuxi South station. Wuxi station serves as the passenger station, while the Wuxi South station serves as the freight station. Thus, we choose the Wuxi station as

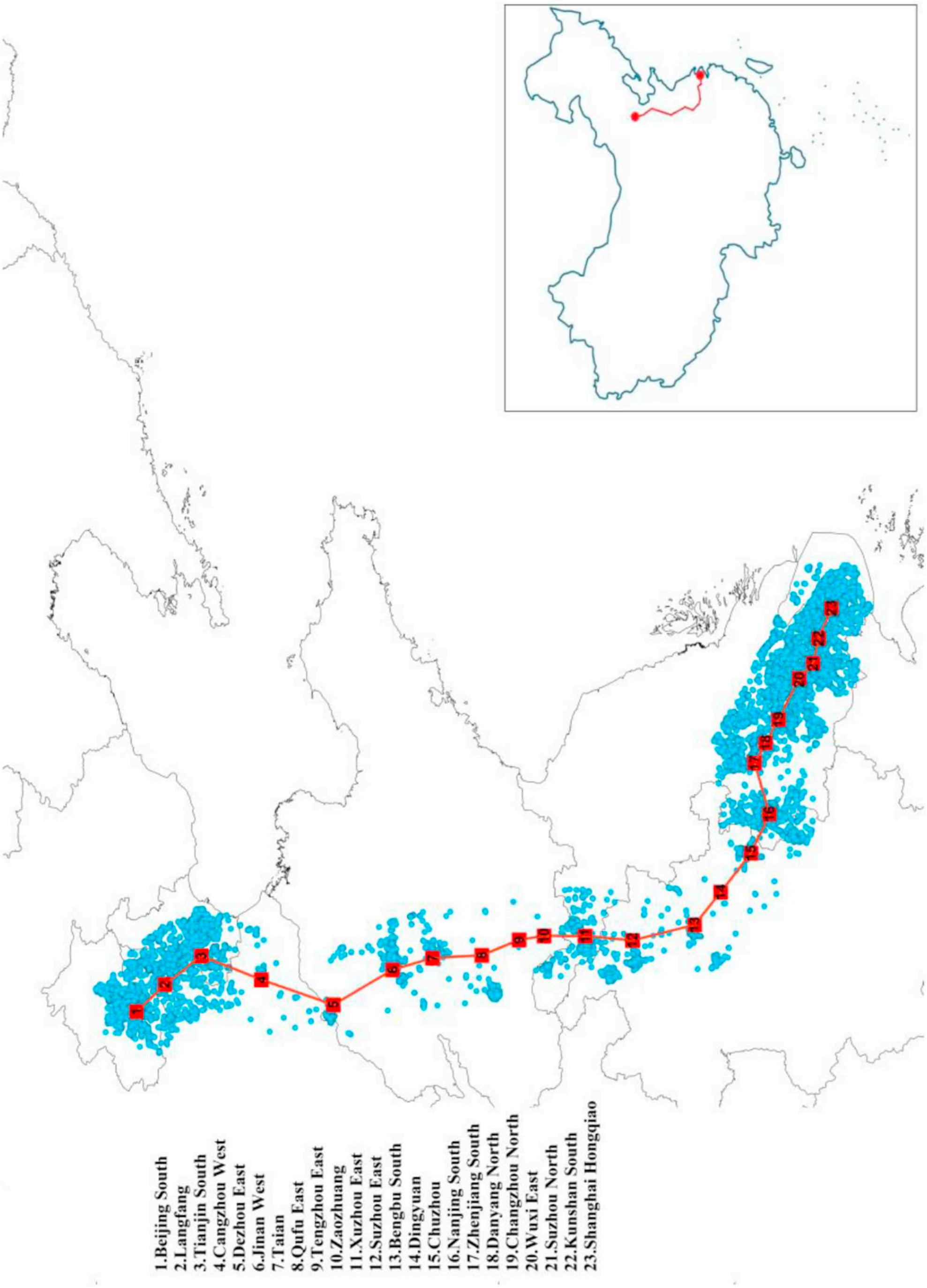

Fig. 2. The location of land parcels on map.

Table 2
Summary statistics.

Variable	Land Type	Obs.	Mean	Std.Dev	Min.	Max.
Land price	Full Sample	15,571	2879.21	4336.38	28.00	30,973.95
	Residential	6086	2298.21	3245.22	28.00	19,998.08
	Commercial	6045	3275.35	5124.89	144.00	30,973.95
	Mixed-use	3440	3210.98	4399.79	165.56	25,749.27
Land purchase cost	Full Sample	15,571	26,992.38	54,695.65	64.00	488,180.00
	Residential	6086	24,094.50	41,817.37	64.00	252,000.00
	Commercial	6045	16,796.75	36,578.20	71.00	242,900.00
	Mixed-use	3440	50,035.71	85,849.43	199.00	488,180.00
Building area	Full Sample	15,571	51,493.89	60,966.25	750.00	549,047.10
	Residential	6086	58,191.28	52,176.15	1256.10	272,298.40
	Commercial	6045	29,880.25	41,183.90	750.00	238,477.90
	Mixed-use	3440	77,625.90	86,294.00	2323.40	549,047.10
Plot ratio	Full Sample	15,571	2.18	1.29	0.20	9.80
	Residential	6086	1.95	0.79	0.40	4.90
	Commercial	6045	2.40	1.76	0.20	9.80
	Mixed-use	3440	2.18	0.92	0.66	5.73
Distance to HSR station	Full Sample	15,571	29.00	22.95	1.01	117.58
	Residential	6086	29.84	22.84	1.61	115.36
	Commercial	6045	28.56	22.30	1.01	111.50
	Mixed-use	3440	28.28	24.21	1.60	117.58
Distance to conventional railway station	Full Sample	15,571	22.82	22.60	0.79	113.29
	Residential	6086	23.76	22.37	0.89	110.84
	Commercial	6045	22.16	21.85	0.79	103.36
	Mixed-use	3440	22.33	24.19	0.85	113.29
Distance to Qing Dynasty courier stop	Full Sample	15,571	40.04	32.52	1.29	124.43
	Residential	6086	41.53	32.59	1.49	122.99
	Commercial	6045	40.65	32.71	1.40	123.48
	Mixed-use	3440	36.34	31.77	1.29	124.43

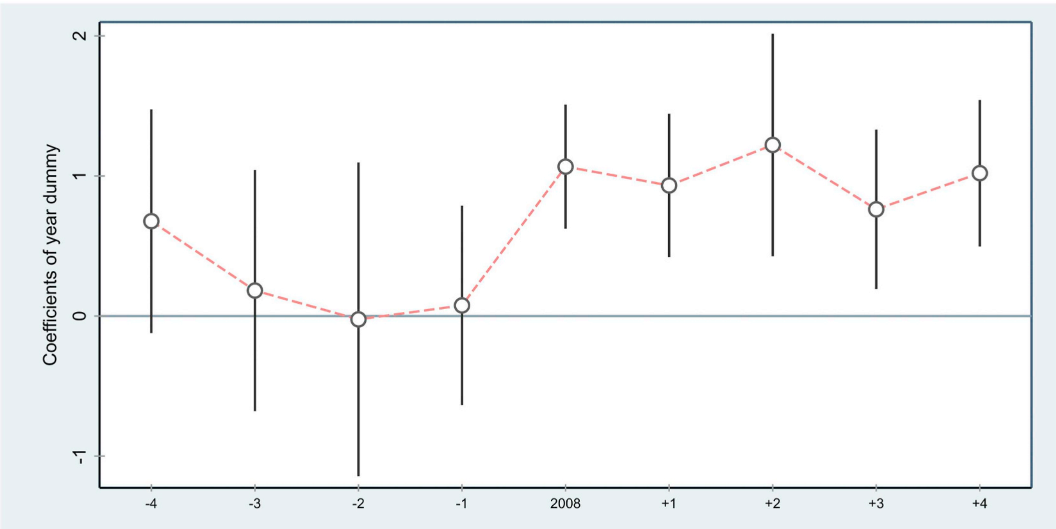

Fig. 3. The parallel trend assumption test.
Note: Vertical bands represent +(-)1.96 times the standard error of each point estimate.

the conventional railway station in Wuxi.

Fig. 4 plots the trends of the land price across time, with the blue line representing the treatment group and the red line representing the control group. We also plot the 95% confidence interval for the land price in Fig.4. Under a steady rate of growth, the overall land price appreciates more than 3 times during this investigation period. The graph has a dashed black line that denotes the treatment point (2008). As indicated in Fig. 4, the treatment and control groups generally have similar volatility before 2008. After the construction of the BSH, the gap between the two groups is reduced and the treatment group increases in value, which means that the BSH benefits the nearby land parcels. Intuitively, the BSH has a significantly positive impact on the land market.

Table 3
The list of HSR stations and conventional stations.

No.	HSR Station	Conventional Station	No.	HSR Station	Conventional Station
1	Beijing South	Beijing	13	Bengbu South	Bengbu East
2	Langfang	Langfang North	14	Dingyuan	Dingyuan North
3	Tianjin South	Tianjin	15	Chuzhou	Chuzhou North
4	Cangzhou West	Cangzhou	16	Nanjing South	Nanjing
5	Dezhou East	Dezhou	17	Zhenjiang South	Zhenjiang
6	Jinan West	Jinan	18	Danyang North	Danyang
7	Taian	Taian North	19	Changzhou North	Changzhou
8	Qufu East	Qufu	20	Wuxi East	Wuxi
9	Tengzhou East	Tengzhou	21	Suzhou North	Suzhou
10	Zaozhuang	Zaozhuang West	22	Kunshan South	Kunshan
11	Xuzhou East	Xuzhou North	23	Shanghai Hongqiao	Shanghai
12	Suzhou East	Suzhou			

4. Empirical results

Tables 4 to 5 provide the baseline results of the effect of the HSR system on the land price for different land types. For each table, the radius is 3 km in Columns (1)–(2) and Columns (4)–(5). Besides, the radius is 8 km in Columns (3) and Columns (6). Among each column, we adopt different fixed effects in the DID estimates. More precisely, Column (1) in Table 4 reports the regression result which includes year and city fixed effects in the regression. The regression result suggests that the land price near an HSR station increases by 87%[2] compared to the land near a conventional railway station. From Columns (1)–(2) in Table 4, it is evident that the HSR system has a positive significant impact on the land market when the radius is 3 km. The regression results are still robust even if we increase the radius to 8 km. All the impacts are large, thus reflecting the significance of the infrastructure on the land price. Columns (4)–(6) in Table 4 shows the results for residential land. According to the results in Column (4), the price of residential land close to HSR station is 278% higher than that close to the railway station. This suggests that the HSR system has a higher than average influence on residential land. Overall, the coefficient of the interaction term is significantly positive and large in magnitude. Local governments have mapped out amenities and facilities, from hospitals to transportation, around HSR stations to support its operation and accessibility. To take advantage of the potential benefits from the HSR stations, residential property developers compete fiercely for land-use rights of the surrounding areas. Consequently, the competition pushes up the residential land price along the HSR.

Table 5 shows the impact of HSR on commercial land and mixed-use land. All the coefficients of interaction terms are insignificant, which indicates that there are no incremental effects of HSR on the price of commercial land. In China, when local government policymakers plan the construction of HSR, they usually hope to use this opportunity to boost the economy of the less developed area in their cities. Therefore, most HSR stations are located in remote regions that are far away from the central business area of a city. Because HSR stations provide easy access to people to take highspeed railway, therefore, in the beginning some people who would choose that area to live would be willing to pay a higher price to be closer to the HSR stations. Thus, the residential land price would increase first. However, due to the remote location in the less developed, the business atmosphere near the HSR station needs more time to develop. Therefore, the effect on the commercial land price might be relatively less responsive in the short run. So, in the beginning, the effect on commercial land price is less significant. But we conjecture, in the long run, the effect will become significant with more people moving to live nearby and more facilities provided, which can be tested in the future when we have more data sample with longer time span.

In terms of the mixed-use land, the estimation results are presented in Column (4) to Column (6). The coefficient of the interaction term is statistically positive significant only with 8 km radius. Comparing with the coefficient magnitude of residential land, that of the mixed-used land is smaller. The results indicate that HSR has a weaker impact on mixed-used land. As mentioned above, mixed-use land parcels have complicated compositions. Owing to the data limitation, we fail to get the exact composition of the mixed-use land. The results might be dominated by its main feature.

As for infrastructure financing, the BSH had created approximately RMB 99 billion by pushing up the land price.[3] This is about 45% of the construction cost of the BSH, which helped the government to manage the gap in infrastructure investment. The BSH is invested by the Jinghu High Speed Railway Co., Ltd. which financed by several provincial financing platforms (Beijing, Tianjin, Hebei, Shandong, Anhui, Jiangsu and Shanghai) and other central government companies.[4] The provincial government financing platforms hold around 30% shares and the central government companies hold the remainder.[5] The main founding resource for those

[2] In Column (1), the coefficient of α_3 is 0.624. When the dependent variable is log transformed, it is natural to interpret the exponentiated regression coefficients. Thus, $exp(\alpha_3) = \exp.(0.624) = 1.87$. We can say the land price will be 87% higher for the land parcels near the HSR than for the land near the conventional railway station.

[3] From 2008 to 2015, the sale revenue of land within 3 km to BSH stations is around RMB 114 billion. According to our baseline regression, the HSR increases the land price by 87%. Under a counterfactual scenario, the land sale revenue should decrease 87% from RMB 114 billion to RMB 15 billion. Owing to the impact of HSR, the land sale revenue appreciates RMB 99 billion. This estimation is dynamic when apply different fixed effects or enlarge the radius in our regression.

[4] Source: National railway administration of China; http://www.nra.gov.cn/xwzx/zlzx/xgqyfz/tlys/201401/t20140103_4370.shtml.

[5] Data source: https://new.qq.com/omn/20180717/20180717A1N0J4.html.

Fig. 4. Land price for control and treatment groups.

Table 4
The baseline results.

Dependent Variable: Logarithm of the Land Price						
	(1)	(2)	(3)	(4)	(5)	(6)
	Full Sample			Residential Land		
Post	1.022***	1.052***	1.212***	1.009***	1.096***	1.228***
	(5.793)	(5.279)	(10.923)	(4.336)	(5.831)	(4.213)
Treat	−0.867***	−0.913***	−0.610***	−1.438***	−1.504***	−0.571***
	(−5.410)	(−5.801)	(−7.377)	(−8.401)	(−9.112)	(−3.379)
Treat × Post	0.624**	0.660**	0.342***	1.330***	1.373***	0.396*
	(2.319)	(2.515)	(3.713)	(6.919)	(7.141)	(2.028)
Constant	8.612***	8.529***	8.332***	7.879***	7.709***	7.503***
	(93.347)	(63.879)	(112.044)	(57.732)	(49.700)	(63.878)
Observations	1813	1813	4544	605	605	1593
R-squared	0.447	0.448	0.409	0.398	0.403	0.380
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	No	Yes	No	No	Yes	No
Radius (km)	3	3	8	3	3	8

Notes
1. Standard errors are clustered at the city level. T-statistics are reported in parentheses.
2. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table 5
The baseline results.

Dependent Variable: Logarithm of the Land Price						
	(1)	(2)	(3)	(4)	(5)	(6)
	Commercial Land			Mixed-use Land		
Post	0.544**	0.547**	0.780**	3.096***	3.134***	1.717***
	(2.402)	(2.309)	(2.521)	(13.143)	(12.954)	(13.102)
Treat	−0.406**	−0.394**	−0.399***	−0.497*	−0.396	−0.695***
	(−2.703)	(−2.938)	(−3.606)	(−1.757)	(−1.218)	(−9.398)
Treat × Post	0.013	0.002	0.077	0.269	0.166	0.481**
	(0.051)	(0.007)	(0.438)	(0.933)	(0.584)	(2.917)
Constant	9.378***	9.376***	9.075***	7.159***	7.176***	8.263***
	(61.006)	(57.612)	(29.451)	(46.126)	(41.974)	(120.745)
Observations	799	799	1923	409	409	1028
R-squared	0.515	0.516	0.451	0.569	0.570	0.529
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	No	Yes	No	No	Yes	No
Radius (km)	3	3	8	3	3	8

Notes
1. Standard errors are clustered at the city level. T-statistics are reported in parentheses.
2. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

provincial financing platforms comes from the local government revenue which is dominated by the land sale revenue. Thus, the appreciation of land sale revenue indirectly reduces infrastructure financing pressure.

To shed light on the infrastructure financing, we use the land sale revenue of each land parcel as the dependent variable in the estimation and re-estimate the impact of HSR on land sale revenue. We use the land purchase cost to proxy the land sale revenue. The land purchase cost is what a land developer pays to the local government for the land use right and equals to the land sale revenue from each land transaction. The results are presented in Table 6. Column (1) and Column (2) present the DID estimation for our full sample. We also apply the same estimation for different land types. More precisely, the coefficient of *Treat* × *Post* in Column (1) suggests that the land sale revenue near an HSR station increases 121% compared to the land near a conventional railway station. For residential land, the impact is even higher. In Column (3), the coefficient of the interaction term is 1.76 and significant at 1% level, which indicates that the land sale revenue near the HSR station is 482% higher than that near the railway station. But, the land sale revenue of those mixed-used land and commercial land does not affect by HSR.

The current paper is estimating the average impact of the BSH railway on the land surrounding the HSR stations. We believe that the land value increase will be distance dependant. We use Fig. 5 to show the impact of distance on the estimation. The y-axis on the

Table 6
The impact of HSR on the land sale revenue.

Dependent Variable: Logarithm of the land purchase cost	Full Sample		Residential Land		Commercial Land		Mixed-used Land	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post	1.316***	1.422***	1.507***	1.549***	0.430*	0.459**	4.468***	4.513***
	(7.278)	(6.792)	(6.474)	(6.380)	(2.124)	(2.367)	(13.774)	(12.187)
Treat	−0.864**	−0.897***	−1.678***	−1.715***	−0.302	−0.326	−0.327	−0.343
	(−2.909)	(−3.022)	(−14.999)	(−12.550)	(−1.133)	(−1.319)	(−0.968)	(−1.051)
Treat × Post	0.796*	0.817*	1.761***	1.787***	0.287	0.306	0.219	0.236
	(1.841)	(1.920)	(10.232)	(10.236)	(0.672)	(0.764)	(0.533)	(0.572)
Constant	9.215***	8.968***	8.112***	7.960***	9.785***	9.683***	6.878***	6.755***
	(93.632)	(56.141)	(46.660)	(35.190)	(56.545)	(57.585)	(32.450)	(24.399)
Observations	1813	1813	605	605	799	799	409	409
R-squared	0.521	0.524	0.590	0.593	0.530	0.532	0.624	0.626
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	No	Yes	No	Yes	No	Yes	No	Yes
Radius (km)	3	3	3	3	3	3	3	3

Notes
1. Standard errors are clustered at the city level. T-statistics are reported in parentheses.
2. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

left side is the coefficients of *Treat* × *Post*. The y-axis on the right side is the land value creation which is calculated following the method in our paper. The x-axis is the radius of each estimation. As shown in Fig. 5, the magnitude of the coefficient declines with radius, which means the impact of BSH becomes weaker with increasing radius. Because the larger the radius, the more land parcel affected by HSR, the land value creation increases with radius. In other words, the radius setting is an important factor that will affect the value of the estimation. When the bands change, the estimated magnitude is different.

To exam the heterogeneity among cities, we calculate the cities' extra government revenue from land appreciation and reports in Table 7. Among those cities, Shanghai benefits RMB 31. 803 billion from land appreciation. And, Jinan benefits RMB 14.37 billion. Overall, those results remain the same as our previously baseline results. It indicates that HSR plays an important role in reducing the infrastructure financing gap.

5. Robustness check

We carry out four additional tests to ensure that the effect of the HSR system on the land market is robust.

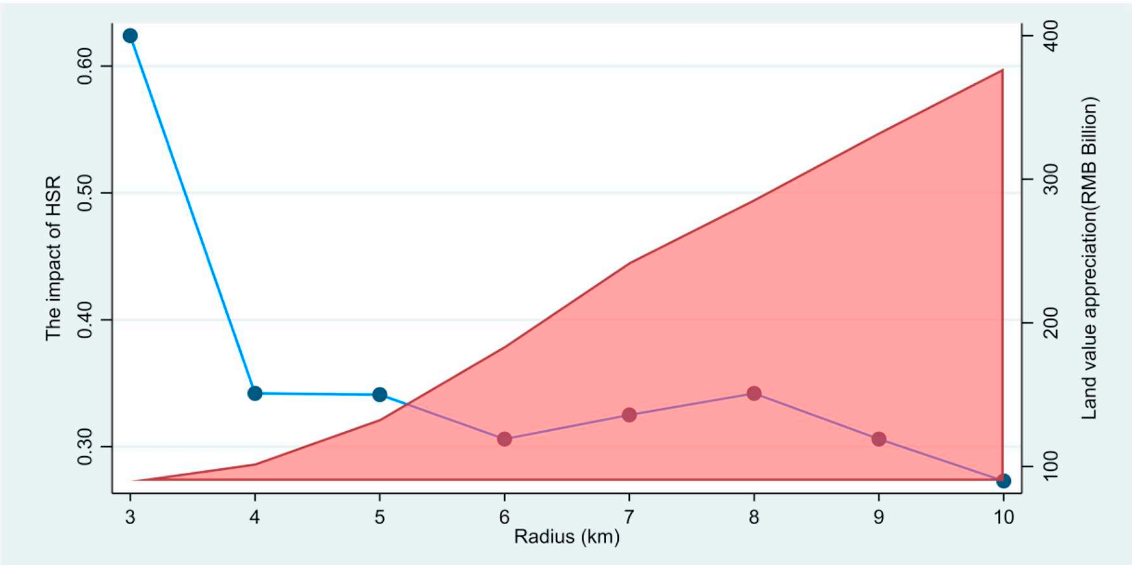

Fig. 5. The impact of distance on the land value appreciation.

Table 7
The extra revenue from land appreciation.

City	Billion RMB	City	Billion RMB	City	Billion RMB
Shanghai	31.803	Beijing	3.985	Tianjin	1.476
Jinan	14.346	Wuxi	3.521	Bengbu	1.163
Nanjing	9.359	Zhenjiang	2.989	Chuzhou	0.915
Langfang	6.849	Xuzhou	2.174	Cangzhou	0.407
Suzhou (Jiangsu)	6.538	Taian	1.628	Suzhou (Anhui)	0.289

Note:
The estimation is based on the land sale revenue 3 km around the HSR Station.

5.1. Placebo test

A fundamental assumption of the differences-in-differences model is the parallel trend which requires the pre-treatment trends in land price are same for both the treatment and control groups. We apply the placebo test to test the validity of this assumption. Specifically, we re-estimate the differences-indifferences model using a lead intervention point, that is, a "fake" treatment point. Jan-2006 and Jan-2012 are assigned as the "placebo" treatment point in the placebo test. If the parallel trend is valid, the coefficients of the interaction term should be insignificant. Table 8 presents the results of the placebo test. Panel A and Panel B show the results of the treatment point of Jan-2006 and Jan-2012, respectively. Each panel shows the heterogeneity of different land types. Post period dummy ($Post_t$), Treatment dummy ($Treat_i$) and constant terms are included but not reported for brevity in Table 8. The coefficients of the $Treat \times Post$ are not significant, which indicates the validity of our parallel trend assumption.

5.2. Different control groups

To examine the robustness of the baseline result, we construct three other different sets of control and treatment group.

5.2.1. Qing courier stops

We use the land parcel near the Qing Dynasty courier stops as the control group. The courier stops are taken from Skinner et al. (2008) who construct a dataset that contains the geographical information of cities and courier stops in China from 1820 and 1893. The courier stops played an essential role in ancient Chinese transportation. These courier stops were also used to convey information for political, economic, cultural, and military purposes back then. To some extent, the stops also served as both communication and transportation modes. Thus, we use the Qing Dynasty courier stops as a proxy for the conventional railway stations. Table 9 presents the result of the DID estimation. Column (1) and Column (2) report the results for the full sample. As for the residential land, the coefficients of the interaction term are positive and significant in Column (3) and Column (4). Besides, Column (5) to Column (8) show the results for the commercial land and mixed-use land. The coefficients of the interaction term are insignificant, indicating the

Table 8
Robustness check: placebo test.

Dependent Variable: Logarithm of the Land Price				
	Full Sample	Residential Land	Commercial Land	Mixed-use Land
	(1)	(2)	(3)	(4)
Panel A. Treatment Point: 2006				
Treat × Post	0.166	0.294	0.094	0.516
	(1.211)	(1.187)	(0.547)	(0.824)
Observations	3385	1171	1454	760
R-squared	0.557	0.396	0.485	0.509
Panel B. Treatment Point: 2012				
Treat × Post	0.072	0.176	−0.058	0.079
	(0.490)	(1.013)	(−0.253)	(0.460)
Observations	3385	1171	1454	760
R-squared	0.426	0.395	0.485	0.508
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Radius (km)	5	5	5	5

Notes
1. Standard errors are clustered at the city level. T-statistics are reported in parentheses.
2. For conciseness, this table only presents the coefficient and T-statistic for critical variables.
3. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table 9
Robustness check: qing courier stops.

Dependent Variable: Logarithm of Land Price								
	Full Sample		Residential Land		Commercial Land		Mixed-used Land	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post	1.633***	1.643***	1.751***	1.903***	0.297	0.338*	2.214***	2.088***
	(11.169)	(9.009)	(10.367)	(11.322)	(1.557)	(1.783)	(16.523)	(12.625)
Treat	−1.135***	−1.147***	−1.440***	−1.486***	−0.759***	−0.765***	−0.552	−0.484
	(−4.431)	(−4.471)	(−5.685)	(−6.160)	(−4.187)	(−4.337)	(−1.552)	(−1.319)
Treat × Post	0.541*	0.545*	1.274***	1.288***	−0.062	−0.053	0.109	0.050
	(1.710)	(1.704)	(4.200)	(4.417)	(−0.264)	(−0.216)	(0.382)	(0.165)
Constant	8.789***	8.622***	6.808***	6.555***	10.399***	10.182***	8.698***	8.915***
	(60.599)	(52.855)	(49.977)	(46.656)	(47.910)	(38.804)	(70.082)	(54.056)
Observations	1641	1641	573	573	660	660	408	408
R-squared	0.495	0.500	0.504	0.514	0.583	0.588	0.546	0.552
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	No	Yes	No	Yes	No	Yes	No	Yes
Radius (km)	3	3	3	3	3	3	3	3

Notes
1. Standard errors are clustered at the city level. T-statistics are reported in parentheses.
2. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

land price of mixed-used land and commercial land does not affect by HSR.

Generally, the coefficients of the full sample and residential land are positively significant, which indicates that the land price near an HSR station is higher than that near a conventional railway station.

5.2.2. Different districts in the same city

To further confirm the effect of the HSR system on the land market, we use the district to differentiate between the treatment and control groups rather than distance. Specifically, we set the land parcels in the same district with an HSR station as the treatment group and the other land parcels in the same cities as the control group. If our baseline result is robust, the land parcels in the same district as an HSR station should appreciate higher than those in other districts. Table 10 reports the related results. For the full sample and residential land, coefficients of *Treat × Post* are positive and statistically significant. Again, the results are consistent with our baseline results.

Table 10
Robustness check: different districts in the same city.

Dependent Variable: Logarithm of the Land Price								
	Full Sample		Residential Land		Commercial Land		Mixed-use Land	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post	0.546***	0.584***	0.477*	0.540**	0.567*	0.590*	1.084***	1.152***
	(3.729)	(3.759)	(2.020)	(2.259)	(2.040)	(2.044)	(10.654)	(10.978)
Treat	−0.278	−0.280	−0.232	−0.233	0.028	0.034	−0.107	−0.127
	(−1.246)	(−1.265)	(−0.812)	(−0.822)	(0.156)	(0.193)	(−0.503)	(−0.576)
Treat × Post	0.592**	0.596**	0.596*	0.599*	0.274	0.272	0.229	0.245
	(2.509)	(2.532)	(1.955)	(1.979)	(1.585)	(1.572)	(1.492)	(1.558)
Constant	7.975***	7.887***	7.584***	7.460***	8.338***	8.268***	8.201***	8.078***
	(179.461)	(135.228)	(57.023)	(52.282)	(34.344)	(32.975)	(100.321)	(71.491)
Observations	15,571	15,571	6086	6086	6045	6045	3440	3440
R-squared	0.292	0.293	0.266	0.267	0.328	0.330	0.481	0.484
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	No	Yes	No	Yes	No	Yes	No	Yes

Notes
1. Standard errors are clustered at the city level. T-statistics are reported in parentheses.
2. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table 11
Robustness check: land parcels far from stations.

Dependent Variable: Logarithm of the land purchase cost								
	Full Sample		Residential Land		Commercial Land		Mixed-used Land	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post	0.589***	0.627***	0.571**	0.636**	0.786***	0.812***	1.032***	1.098***
	(4.031)	(4.062)	(2.632)	(2.835)	(5.328)	(4.628)	(9.674)	(9.283)
Treat	−0.053	−0.065	−0.725***	−0.740***	0.342**	0.337**	0.219	0.181
	(−0.565)	(−0.700)	(−5.391)	(−5.291)	(2.646)	(2.490)	(0.644)	(0.560)
Treat × Post	0.253*	0.265*	0.935***	0.943***	−0.220	−0.217	0.165	0.195
	(1.942)	(1.982)	(4.991)	(4.906)	(−1.144)	(−1.087)	(0.678)	(0.793)
Constant	7.914***	7.823***	7.492***	7.358***	8.092***	8.020***	8.205***	8.074***
	(164.930)	(132.523)	(44.241)	(42.156)	(125.018)	(83.768)	(97.850)	(69.231)
Observations	14,015	14,015	5534	5534	5440	5440	3041	3041
R-squared	0.296	0.297	0.274	0.275	0.330	0.332	0.500	0.503
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	No	Yes	No	Yes	No	Yes	No	Yes
Radius (km)	3	3	3	3	3	3	3	3

Notes
1. Standard errors are clustered at the city level. T-statistics are reported in parentheses.
2. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

5.2.3. *Land parcels far from stations*

In our baseline estimation, we set the control group as the land parcel located within 3 km radius of a conventional station and 3 km far from a BSH station. Some functionality might shift from the conventional railway stations to the BSH station because of the availability of BSH station. For instance, the conventional railway station in Shijiazhuang has turned into a railway museum. Wuhan government has reconstructed the conventional railway station into a transportation hub. Besides, some of the conventional railway stations have been or are to reconstruct as a freight station. BSH station and conventional railway stations can have a substitution relationship. It means that the availability of BSH can change the price of the land along near the conventional railway station. To adjust the bias caused by the above concern, we propose the third control group which only contains the land parcel that is not within 3 km radius of both conventional railway stations and BSH stations. The results are presented in Table 11. The coefficients of *Treat* × *Post* are positive and statistically significant for the full sample and residential land. The results are in concert with our baseline results.

5.3. *Inconsequential units approach*

One potential issue of our findings is that the BSH route might not have been randomly selected. The route selection may be correlated with several observed or unobserved attributes of the non-core cities which are between Beijing and Shanghai such as the population, economic development potential, rate of urbanization, and so on. Although there are several control variables and fixed effects that are adopted in our estimation, the estimation may not be sufficient enough to address the endogeneity issues. Thus, we follow the inconsequential units approach in Chandra and Thompson (2000) proposed inconsequential units approach in their research of the relationship between infrastructure investment and the level of economic activity in rural counties in the US. Similarly, Banerjee, Duflo, and Qian (2012) and Faber (2014) apply this approach to address the endogeneity problems in their works. Following their idea, we assume that the HSR stations in the non-core cities between Beijing and Shanghai are situated only because these locations make the most convenient route for HSR. In other words, these non-core cities are inconsequential to the choice of the HSR route and are less subject to endogeneity issues.

In this robustness check, we re-estimate whether there are any effects of the HSR system only based on the data sample of non-core cities. Especially, we want to examine whether the new results show any significant difference compared with the case when we include all the cities. The regression results are presented in Table 12. The results are qualitatively similar to the baseline results in Table 4 to Table 5 and provide robust evidence that the incremental effect of the HSR system on the land market is not only found in the core cities but also in the non-core cites.

5.4. *The transaction method*

The land transaction method in China has evolved from the negotiation method to the public auction method. Bidding, auction, and quotation are the three main transaction method. In our data sample, the proportion is 3.72%(bidding), 17.65%(auction), and 78.63% (quotation), respectively. Cai, Henderson, and Zhang (2013) state that the two-stage auctions (quotation) result in lower land sales prices and might be related to more corruption activities. To address the impact of transaction methods on the land price, we

Table 12
Robustness check: inconsequential units approach.

Dependent Variable: Logarithm of the Land Price								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Full Sample		Residential Land		Commercial Land		Mixed-use Land	
Post	0.915***	0.938***	0.768***	0.881***	0.295	0.282	2.832***	2.829***
	(7.324)	(6.993)	(4.722)	(7.883)	(1.612)	(1.350)	(14.915)	(16.044)
Treat	−0.819***	−0.828***	−1.309***	−1.342***	−0.586***	−0.578***	−0.558**	−0.542*
	(−4.830)	(−5.093)	(−29.845)	(−27.751)	(−3.636)	(−4.242)	(−2.390)	(−2.159)
Treat × Post	0.505*	0.512**	1.208***	1.232***	0.082	0.077	0.277	0.275
	(2.115)	(2.166)	(11.511)	(11.987)	(0.335)	(0.332)	(1.150)	(1.066)
Constant	8.330***	8.252***	8.174***	7.952***	8.863***	8.874***	6.857***	6.934***
	(230.310)	(65.347)	(82.450)	(49.244)	(109.377)	(70.063)	(46.315)	(41.967)
Observations	1527	1527	526	526	661	661	340	340
R-squared	0.396	0.397	0.402	0.409	0.474	0.475	0.511	0.512
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	No	Yes	No	Yes	No	Yes	No	Yes
Radius (km)	3	3	3	3	3	3	3	3

Notes
1. Standard errors are clustered at the city level. T-statistics are reported in parentheses.
2. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

propose a robustness test that includes land transaction method fixed effect. Table 13 shows the related results. Column (1) to (8) report the results for the full sample, residential land, commercial land, and mixed-use land, respectively. For the full sample and residential land, coefficients of *Treat* × *Post* are still positive and statistically significant, which indicates that the baseline result is not sensitive to the land transaction method.

5.5. The land policy across cities and years

The administrations might regulate and control the land supply in response to the heterogeneity across cities. Besides, the land policy might change across each year. Thus, we propose additional robustness to control the city-level time unobservable variations in the land market. Specifically, we include a city-year fixed effect in the estimation. Table 14 shows the related results. Column (1) to (4) report the results for the full sample, residential land, commercial land, and mixed-use land, respectively. For the full sample and

Table 13
Robustness check: the transaction method.

Dependent Variable: Logarithm of the Land Price								
	Full Sample		Residential Land		Commercial Land		Mixed-used Land	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Post	1.305***	1.334***	1.194***	1.295***	0.754***	0.764***	3.071***	3.110***
	(6.690)	(6.220)	(5.560)	(6.610)	(3.243)	(3.116)	(13.687)	(13.601)
Treat	−0.829***	−0.841***	−1.185***	−1.226***	−0.403**	−0.386**	−0.487	−0.499
	(−5.439)	(−5.509)	(−6.341)	(−6.602)	(−2.703)	(−2.728)	(−1.715)	(−1.729)
Treat × Post	0.599**	0.609**	1.088***	1.122***	0.004	−0.013	0.261	0.287
	(2.255)	(2.271)	(5.008)	(5.216)	(0.017)	(−0.050)	(0.915)	(0.987)
Constant	8.781***	8.691***	8.454***	8.275***	9.543***	9.542***	7.718***	7.674***
	(98.742)	(67.064)	(35.144)	(33.164)	(34.161)	(35.572)	(55.889)	(49.058)
Observations	1813	1813	605	605	799	799	409	409
R-squared	0.458	0.460	0.462	0.468	0.525	0.526	0.584	0.586
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Transaction Method FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	No	Yes	No	Yes	No	Yes	No	Yes
Radius (km)	3	3	3	3	3	3	3	3

Notes
1. Standard errors are clustered at the city level. T-statistics are reported in parentheses.
2. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

Table 14
Robustness check: city-year fixed effect.

Dependent Variable: Logarithm of the Land Price				
	(1)	(2)	(3)	(4)
	Full Sample	Residential Land	Commercial Land	Mixed-use Land
Post	0.870***	1.336***	0.803	0.030
	(17.147)	(9.153)	(1.629)	(0.496)
Treat	−0.700***	−1.054***	−0.180	−0.679**
	(−4.571)	(−3.779)	(−0.990)	(−2.390)
Treat × Post	0.482*	0.943***	−0.171	0.498
	(1.757)	(3.122)	(−0.498)	(1.382)
Constant	7.393***	7.323***	8.448***	7.635***
	(79.948)	(48.700)	(16.945)	(22.376)
Observations	1813	605	799	409
R-squared	0.546	0.620	0.629	0.690
Controls	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	No
CityYear FE	Yes	Yes	Yes	Yes
Radius (km)	3	3	3	3

Notes
1. Standard errors are clustered at the city level. T-statistics are reported in parentheses.
2. *, **, and *** denotes significance at the 10%, 5%, and 1% level, respectively.

residential land, coefficients of *Treat* × *Post* are positive and statistically significant. The results are consistent with our baseline results.

6. Conclusion

This paper evaluates the impact of the most important HSR in China, the BSH, on land price and then how it affects local government revenue through land appreciation. Our results suggest that BSH increases the price of the nearby land. The incremental value is about RMB 99 billion or 45% of the construction cost of the BSH. Besides, we show the heterogeneity of the impacts on the prices of different types of land.

The immense amounts of investment and high risk of the deficit are the major policy concerns of constructing HSR. Our results suggest the HSR itself could serve as a key channel of infrastructure financing and government revenue source. The development model of the HSR in China provides a good example for countries who have begun or are planning to construct an HSR.

There are several worthwhile directions for extending the research in this paper. First, studies could apply the unique database presented in this paper to evaluate the impact of the HSR on local government revenue among different cities. On the one hand, the HSR could contribute to the economic development of cities along the HSR line. On the other hand, cities with similar development potential but located further away from the HSR line may suffer economic repercussions. Secondly, examining the impact of the HSR could be extended to other economic factors such as labor movement among cities, development of tourism and so on. Finally, HSR experience rapid growth. Further research could expend our time frame and the scope of our paper to all HSR lines built in China, not only the BSH.

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