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Corporate Investment under Time-Space Compression: Evidence from High-Speed Railway Coverage

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The influence of geographical distance on the decision-making behaviors of economic entities is an interesting topic in new economic geography. To investigate the impact of high-speed railway coverage on firms, with high-speed railway coverage in China as a quasi-natural experiment and a difference-in-difference (DID) regression, the relation between the staggered coverage of high-speed railways and corporate investment was empirically explored using the data of the stations of the Chinese high-speed railways and the listed firms from 2009–2017. Grouping tests were conducted according to corporate operational efficiency and financing constraints. In addition, whether the investment of non-state-*owned enterprises (non-SOEs) and labor-intensive firms improved due to high-speed railway coverage was analyzed. Results corroborate that the investment in listed firms in cities covered by high-speed railways increases more significantly compared with cities that are not covered. Hence, high-speed railway coverage promoted capital factor liquidity, mitigated financing constraints, and increased corporate investment. Moreover, high-speed railway coverage is more likely to optimize the investment of the groups of firms that have higher asset liquidity, lower financing constraints, intensive labor, or private ownership. The conclusion provides critical insights for the decision-making behaviors of high-speed railway construction and constitutes theoretical basis for the promotion effect of transportation infrastructure construction on corporate investment.*

Keywords: *High-speed Railway Coverage; Corporate Investment; Quasi-natural Experiment; Operational Efficiency; Financing Constraints.*

Introduction

Investment is an important part of corporate financial decision-making that determines the value of firms and affects gross investment of the state economy as well. Efficient investment decision-making guarantees the survival and sustainable development of firms in a fiercely competitive environment and is one of the important goals of business management. However, corporate investment decision-making is often influenced by such factors as information asymmetry and principal-agent conflicts, which has always been valued by the academic community. According to neoclassical theory, corporate investment is determined by exogenous variables and will be boosted as the increase of corporate sales revenue, and vice versa. As suggested by free cash flow theory, corporate investment is determined by endogenous variables; and the stronger the corporate financing constraints, the more sensitive the investment to cash flow (Fazzari, Hubbard & Petersen 1988; Fazzari & Petersen, 1993). However, investment in many firms has declined continuously in recent years, which has even become an important indicator for economic downturn. Consequently, it is gradually attracting great attention from governments all over the world.

With the development of new economic geography, many researchers have studied the impact of the spatial location of economic entities on their economic decisions. Compared with other transportation infrastructure, high-speed railways mainly carry passengers, are faster in speed, require huge investment in their construction, and have a great impact on economic growth and economic activities. Although transportation infrastructure and information technology are highly developed, geographical distance still continually affects economic entities (Kalnins & Lafontaine, 2013; Derrible, 2017). Fast-moving high-speed railways compress time and space, connect the world closely, and make it possible to reach many places within a day. High-speed railways bring more intensive flow of passengers, logistics, capital, and information to areas along the routes, which strongly accelerates the development of local economy and propel inland cities to improve services and their soft environment. As an important transportation infrastructure, high-speed railways optimize the spatial layout of cities along the routes and the economic development of the cities. As suggested by Donaldson & Hornbeck (2013), the development of transportation infrastructure is one of the important factors that drive regional economic growth (Donaldson & Hornbeck, 2013). Moreover, the construction and operation of high-speed railways can promote the formation of urban agglomerations along the routes and regional economic integration, save social costs, improve employment, facilitate market access, enhance the value of agricultural land, and stimulate regional economic growth (Ahlfeldt & Feddersen, 2017; Donaldson & Hornbeck, 2013). To sum up, geographical proximity brings more intensive flow of passengers, logistics, capital, and information along high-speed railways, which will effectively stimulate the economic vitality of the cities around the routes. Moreover, firms along the railways will be inevitably affected as well.

Corporate investment has always been the core driving force for economic growth and represents the change of corporate production capacity and future development of firms. Therefore, investigating the impact of transportation infrastructure construction on firms through corporate investment is an interesting perspective. When cities are covered with high-speed railways, will the investment of firms be affected? Despite being an important and interesting topic to be studied, current literature has seldom focused on this area. Therefore, with high-speed railway coverage in China as a quasi-natural experiment, the data of high-speed railway stations, and corporate panel data from 2009 to 2017, this study intends to test the promotion effect of high-speed railway coverage on corporate investment through difference-in-difference regression. In addition, the high-speed railways in China are mostly designed to connect two major cities directly, the purpose of which is to make the transportation more convenient. Therefore, there is not any self-selection existing in the determination of the cities passed by a certain high-speed railway, and the selection of sample cities is surely random.

The rest of the study is organized as follows. Section 2 reviews the relevant literature on the relationship between high-speed railway coverage and corporate investment and puts forward the hypotheses of this study. Section 3 describes data, sample selection, and the measurement of main variables. Section 4 presents the empirical results of difference-in-difference regression and robustness tests and clarifies the paths through which high-speed railway coverage could affect corporate investment. Section 5 further discusses the empirical results and provides the conclusion.

Literature Review

The construction and operation of high-speed railways have improved transportation convenience and created investment opportunities. Transportation infrastructure links various market entities and promotes the liquidity of cross-regional production factors, reduces both the transportation and transaction costs, and then pushes the development of regional scale economy and market integration. Since Fogel's (1962) pioneering quantitative analysis on the impact of US railway construction on economic growth, the impact of transportation infrastructure on economic growth and the spatial distribution of infrastructure have become the concerns for economists. High-speed railways change economic geography significantly through space-time contraction effects (Vickerman, 2015; Li, Wen, & Jiang, 2017), creating a corridor for employment, housing, and innovation (Tierney, 2012; Meersman & Nazemzadeh, 2017). Transportation infrastructure promotes economic development by saving trade costs, enhancing industrial agglomeration, and promoting labor division and productivity (Donaldson & Hornbeck, 2013; Banerjee, Duflo, & Qian, 2012). According to the MM theory of Modigliani and Miller, investment opportunities that are represented by Tobin's Q determine corporate investment. Fazzari *et al.* (1988) affirmed that the increase in sales revenue or external demand led firms to expand capital expenditures. Wang & Wang (2018) contended that extensive margin of China's outward FDI has a complement effect on export, while the intensive margin has a substitution effect on export, which supports the theoretical analysis. Zhang (2000) contended that firms would expand investment through option increase when they had better investment opportunities but would cut down investment through option liquidation when they did not have good investment opportunities. Therefore, it is possible for firms to make use of the opportunities brought by the construction and operation of high-speed railways.

The current literature mainly focuses on how transportation convenience brought by high-speed railways promotes the coordinated development of urban economy, regional scale economy, and market integration. For instance, the construction of high-speed railway network in Europe has increased the competitiveness of cities along the routes, such as attracting more immigrants and investment, thereby stimulating the economic vitality of the cities (Garmendia, de Urena, Ribalaygua, Leal, & Coronado, 2008; Vieira, Dias, & Santos, 2018). The agglomeration and diffusion effect of high-speed railway economy has interlaced the "spots" and "axes into a "belt" in a certain region. Hence, high-speed railway economy has led to the "same-city effect," which has promoted deep cooperation among economic entities in the city and economic integration as well. (Preston & Wall, 2008). The construction and operation of high-speed railways have attracted business, tourism, exhibitions, and technologies especially in large cities (Urena, Menerault, & Garmendia, 2009), and promoted efficiency as well. Consequently, cities with high-speed railway stations are usually more competitive and likely to witness economic growth (Monzon, Ortega, & Lopez, 2013). Cities along the high-speed railways, by virtue of their convenient transportation and location advantages, will gradually grow into central cities in a certain region. In addition, Andersson, Shyr, & Fu (2010) suggested that the accessibility brought by the construction and operation of high-speed railways had a great impact on housing prices along the routes based on their study of the high-speed railways in Taiwan. Moreover, Willigers & Wee (2011) validated that high-speed railways had mainly increased the value of the office buildings in the cities that had cross-national high-speed railways in the Netherlands.

According to the above analysis, the operation of high-speed railways has accelerated population mobility, promoted regional scale economy and market integration, and enhanced the market competitiveness of cities along the routes. In reality, the operation of high-speed railways affects the macro economy and greatly influences firms along the routes. However, the current literature seldom focuses on the impact of high-speed railways on corporate behaviors. As the core driving force of economic growth, corporate investment is the capital expenditure for the perspective earnings of firms. As an important strategic plan, investment decision-making is closely related to firm value. Such decision-making directly affects the balance of payments and financial status of firms, thereby promoting the growth and sustainable development of firms. The construction and operation of high-speed railways improve transportation convenience and create opportunities for corporate investment. Therefore, investigating the effect of transportation infrastructure construction on firms from the perspective of investment is justifiable.

First, transportation infrastructure promotes economic development by saving trade costs, strengthening industrial agglomeration, promoting the division of labor, and increasing productivity (Donaldson & Hornbeck, 2013; Banerjee *et al.*, 2012). Additionally, transportation convenience brought by the operation of high-speed railways creates investment opportunities for firms.

Second, the operation of high-speed railways mitigates financing constraints, thereby promoting corporate investment (Ameer, 2014; Alstadsæter & Jacob, 2017). High-speed railways alleviate financing constraints through accelerating economic integration (Campello, Graham, & Harvey, 2010). In addition, they significantly improve corporate operational efficiency, reduce the costs of logistics, transportation, and inventory management; and thus mitigate financing constraints (Shirley & Winston, 2004; Magud & Sosa, 2017). Corporate investment relies on internal funds (Fazzari *et al.*, 1988; Firth, Malatesta, Xin, & Xu, 2012). Therefore, sufficient internal funds promote corporate investment. Moreover, they enhance scale economy and diversification in economic activities, thereby lowering the risks of cash flow through diversified marketing (Campa & Shaver, 2002; Seker, 2012; Liu, Li, Hu, & Pan, 2017). Consequently, these activities enhance the internal financing capability of firms.

Third, high-speed railways make more sufficient external funds available for corporate investment because of the alleviated financing constraints. Moreover, well-funded firms could seize investment opportunities provided by the operation of high-speed railways through expanding investment and actively participating in trade. Firms can obtain sufficient external funds because of the operation of high-speed railways. Cities along high-speed railways can send positive signals to corporate credit providers (Bellone, Musso, Nesta, & Schiavo, 2008; Calomiris, Larrain, & Schmukler, 2018), allowing firms to obtain more relaxed credit conditions (Bridges & Guariglia, 2008) or even giving firms direct access to financial market in developed regions (Tornell & Westermann, 2003).

To sum up, high-speed railways, which are different from ordinary railways and expressways, have greatly changed the life and travel of residents and improved the life quality of o residents. Moreover, these railways have a significant impact on regional economic development. Further, they have promoted cooperation and exchanges between firms by shortening travel time. Given the operation of high-speed railways, such productive factors as capital, technologies, and knowledge flow are more frequently. Consequently, more investment opportunities are available for firms. Therefore, this study intends to explore empirically the impact of high-speed railway coverage on corporate investment.

Research Design

Sample and Data

Chinese government began to promote the construction of high-speed railways since 2009. And then, the intensive construction of high-speed railways spreads out in China. Therefore, this study selected 2009 to 2017 as the research period with data accessibility into account. Moreover, the study assigned the listed firms in the cities covered by high-speed railways as the experimental group and the rest as the control group. Furthermore, the data of financial and insurance firms, ST and *ST, and sample with missing variables were excluded as well in the study. Finally, 13,368 "Firm-Year" observations were obtained. The data of high-speed railways, such as when the high-speed railways started operations, were manually sorted out from the website of National Railway Administration. Firm-level financial data were retrieved from China Stock Market and Accounting Research (CSMAR) and the WIND financial databases. For the minimization of the effect of outliers, all variables that had potential to be unbounded at the 1 % and 99 % levels were winsorized as well.

Models and Variables

In the study, DID regression was used to examine how the staggered coverage of high-speed railways affected corporate investment. Following Duchin, Ozbas & Sensoy (2010), the following model was estimated:

$$Invest_{i,t} = \alpha_0 + \alpha_1 HSR_{i,t} + \alpha_2 Controls_{i,t} + \alpha_3 \sum Firm + \alpha_4 \sum Year + \varepsilon_{i,t} \quad (1)$$

The explanatory variable *Invest* indexes corporate investment. Referring to Duchin *et al.* (2010), *Invest1*, *Invest2*, *Invest3*, and *Invest4* were used to measure corporate investment. *Invest1* is equal to (cash for the purchase of fixed, intangible, and other long-term assets) / total assets at the beginning of the period; *Invest2* is equal to (cash for the purchase of fixed, intangible, and other long-term assets + net cash paid by subsidiaries and other business units) / total assets at the beginning of the period. *Invest3* is equal to (cash for the purchase of fixed, intangible, and other long-term assets - net cash recovered from the disposal of fixed, intangible, and other long-term assets) / total assets at the beginning of the period; and *Invest4* is equal to (cash for the purchase of fixed, intangible and other long-term assets + net cash paid by subsidiaries and other business units - net cash recovered from the disposal of fixed, intangible, and other long-term assets - net cash received from the disposal of subsidiaries and other business units) / total assets at the beginning of the period. Among them, *Invest3* and *Invest4* were used in robustness tests.

Because the time when cities begin to be covered by the high-speed railways is different, the study uses the difference-in-difference regression.n.And the listed firms in the cities covered by the high-speed railways are included in the experimental group, while the listed firms without any high-speed railways during the sample period are included in the control group. The *HSR* indicates whether the city is covered by high-speed railways. If a listed firm is in a city that is covered by high-speed railways, then its *HSR* for the year when the high-speed rail gets into operation and beyond takes the value of 1 and 0 otherwise. Thus, if no high-speed railway in a city, then the *HSR* takes the value of 0 in all years for the listed firms in the city. For instance, the Wuhan-Guangzhou high-speed railway came into operation on December 26, 2009. Hence, the *HSR* for the listed firms located in the cities along the railway in 2009 and beyond is 1, but 0 before 2009. The control variables are as follows: *Size*, *Roa*, *Lev*, *Growth*, *Tobin's Q*, *Cash*, *Age*, *Dual*, and *Board*. Given the hysteretic nature of corporate investment and the possible reverse causality between investment and high-speed railway coverage, all the control variables were lagged by one period except for *Cash* and *Age*. *Table 1* presents the definition of variables.

Empirical Results

Descriptive Statistics and Difference Test

Table 2 presents the results of the descriptive statistics of the variables. The mean and standard deviation of *Invest1* are 0.0881 and 0.0990, respectively, and they are 0.0977 and 0.111 for *Invest2*, 0.0820 and 0.0952 for *Invest3*, and 0.0808 and 0.0912 for *Invest4*.The regression results reflect the overall low investment of the sample and insignificant difference in corporate investment. In addition, the medians of investment indicators are less than their mean value, indicating that the distribution of corporate investment data slightly deviates to the right. Moreover, the mean value of *HSR* is 0.446, indicating that an average of 44.6 % of the listed firms are covered by high-speed railways.

Table 1

Definition of Variables

VARIABLES	Description
Invest1	(Cash for the purchase of fixed, intangible and other long-term assets) / total assets at the beginning of the period.
Invest2	(Cash for the purchase of fixed, intangible and other long-term assets + net cash paid by subsidiaries and other business units) / total assets at the beginning of the period.
Invest3	(Cash for the purchase of fixed, intangible and other long-term assets - net cash recovered from the disposal of fixed, intangible and other long-term assets) / total assets at the beginning of the period.
Invest4	(Cash for the purchase of fixed, intangible and other long-term assets + net cash paid by subsidiaries and other business units - net cash recovered from the disposal of fixed, intangible and other long-term assets - net cash received from the disposal of subsidiaries and other business units) / total assets at the beginning of the period.
HSR1	If a listed firm locates in cities covered by high-speed railways, HSR takes the value of 1, but 0 otherwise.
Size	The natural logarithm of the total book value of assets.
ROA	Return on Assets.
Lev	Long-term debt over total assets.
Growth	The income growth rate of main business.
Tobin's Q	Market value divided by total book assets.
Age	The natural logarithm of the listed years of firms.
Cash	The ratio of cash to total assets at the end of one period.
Dual	Dummy variable, when CEO serves as general manager as well, it takes the value of 1, but 0 otherwise.
Board	The natural logarithm of board size.

Table 2

Descriptive Statistics

VARIABLES	N	mean	sd	min	p50	max
Invest1	13368	0.088	0.099	0	0.057	0.535
Invest2	13368	0.098	0.111	0	0.063	0.604
Invest3	13368	0.082	0.095	0	0.052	0.514
Invest4	13368	0.081	0.091	0	0.052	0.494
HSR1	13368	0.446	0.497	0	0	1
Size	13368	21.79	1.228	19.100	21.66	25.470
ROA	13368	0.062	0.065	-0.167	0.056	0.289
Lev	13368	0.468	0.224	0.048	0.470	1.100
Growth	13368	0.150	0.332	-0.613	0.112	1.702
Tobin's Q	13368	2.041	1.812	0.205	1.533	10.820
Age	13368	2.100	0.748	0	2.303	3.091
Cash	13368	0.190	0.142	0.009	0.151	0.685
Dual	13368	0.207	0.405	0	0	1
Board	13368	2.171	0.197	1.609	2.197	2.708

Table 3

Difference Test

VARIABLES		Before the coverage	After the coverage	Difference	Diff-in-Diff
Invest1	Control group	0.076	0.070	0.004 (p<0.138)	0.008** (p<0.014)
	Treatment group	0.080	0.092	0.012*** (p<0.001)	
Invest2	Control group	0.095	0.088	-0.006 (p<0.115)	0.012*** (p<0.006)
	Treatment group	0.095	0.101	0.006*** (p<0.003)	

VARIABLES		Before the coverage	After the coverage	Difference	Diff-in-Diff
Invest3	Control group	0.074	0.078	0.004 (*p*<0.124)	0.008*** (*p*<0.002)
	Treatment group	0.078	0.090	0.012*** (*p*<0.001)	
Invest4	Control group	0.091	0.086	-0.005 (*p*<0.205)	0.011** (*p*<0.013)
	Treatment group	0.092	0.097	0.006*** (*p*<0.002)	

Table 3 depicts that the value of all corporate investment indicators in the experimental group is greater than it's before after the operation of high-speed railways and has increased significantly. However, the value of the corporate investment indicators of the control group shows a downward trend and the indicators do not change significantly after the operation of high-speed railways. In the difference-in-difference test, the four indicators of corporate investment are all significantly positive at the 5 % and 1 % levels. These results confirm that high-speed railways have indeed promoted corporate investment, which is consistent with the assumption in this study.

Regression Results

Table 4

The Impact of High-Speed Railway Coverage on Corporate Investment

VARIABLES	Invest1	Invest1	Invest2	Invest2
HSR	0.012*** (3.47)	0.011*** (3.22)	0.013*** (3.33)	0.012*** (3.24)
Size		0.034*** (8.37)		0.044*** (9.94)
ROA		0.189*** (8.31)		0.225*** (8.46)
Lev		-0.018 (-1.48)		-0.013 (-0.99)
Growth		0.007** (2.51)		0.015*** (4.53)
Tobin's Q		0.002** (2.01)		0.002* (1.65)
Age		-0.063*** (-10.01)		-0.065*** (-9.46)
Cash		-0.067*** (-5.62)		-0.103*** (-7.33)
Dual		0.002 (0.66)		0.001 (0.25)
Board		0.004 (0.44)		0.004 (0.43)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Constant	0.058*** (4.03)	-0.551*** (-6.22)	0.065*** (3.99)	-0.760*** (-7.82)
Observations	13,368	13,368	13,368	13,368
Adj-R^2	0.0465	0.107	0.0369	0.108
F	45.58	41.14	38.04	40.56

*Note: t-statistics are in parentheses *** p<0.01, ** p<0.05, * p<0.1*

Table 4 displays the regression results of high-speed railway coverage and corporate investment. The fixed-effect model, without any control variables included, shows that *HSR* is significantly positively correlated with *Invest1* and *Invest2* at the 1 % level. Moreover, the positive relation between *HSR* and corporate investment exists still when the control variables are added. Hence, high-speed railway coverage has promoted corporate investment, which verifies the hypothesis.

In terms of control variables, *Size*, *ROA*, *Growth*, and *Tobin's Q* are significantly positively correlated with corporate investment, while *Age* and *Cash* are significantly negatively correlated with corporate investment. Hence, firms that have larger size, greater profitability, higher market value, shorter listing years, and hold less cash are more likely to expand their investment. This finding is consistent with the existing literature.

Robustness Test

First, propensity score matching analysis was conducted. The sample firms of control group were re-selected through propensity score matching with the purpose of ruling out the possible influence resulting from different corporate characteristics between the experimental and the control groups on research conclusions. On the basis of whether high-speed railways started operations or not in cities during the sample interval, the sample firms were divided into experimental and control groups. Moreover, city characteristics that influence the coverage of high-speed railways were sorted out. These characteristics are total city GDP and city per capita GDP, the average annual net balance of fixed assets, as well as road freight, railway and air passenger traffic volumes. With the above variables, the year-fixed and firm-fixed effect controlled, the propensity score PSCORE was calculated and the sample was subject to 1:1 no-return matching based on the propensity score. Finally, 5362 pairs of matched experimental-control group sample were collected. The regression results in columns (1) and (2) of *Table 5* show that *HSR* is still significantly positively correlated with *Invest1* and *Invest2* at the 1 % level.

Second, the dynamic change before and after the high-speed railway coverage was observed (Yonghui, Linrong, Ying, Yali, & Ou, 2017).

$$\begin{aligned} Invest_{i,t} = \alpha + \beta_1 * HSR\_before2 + \beta_2 * HSR\_before1 \\ + \beta_3 * HSR\_current + \beta_4 * HSR\_after1 \\ + \beta_5 * HSR\_after2 + \beta_6 * controls_{i,t} \\ + \beta_7 \sum Firm + \beta_8 \sum Year + \varepsilon_{i,t} \end{aligned} \quad (2)$$

Current is a dummy variable, which is the benchmark for the dynamic effect model. The variable takes the value of 1 in the year when high-speed railways start operations in the cities where the firms are; otherwise, the value is 0. *Before2* is a dummy variable, taking the value of 1 for the second year before the high-speed railway operation of a city; otherwise, the value is 0. *Before1* is a dummy variable, taking the value of 1 for the first year before the high-speed railway operation of a city; otherwise, the value is 0. *After* is a dummy variable as well. *After1* takes the value of 1 for the first year after the high-speed railway operation of a city; otherwise, the value is 0. *After2* takes the value of 1 for the second and subsequent years after the operation of high-speed railways; otherwise, the value is 0. The regression results in columns (3) and (4) of *Table 5* show that the positive impact of high-speed railway coverage on corporate investment begins to be reflected from the first year or even the second year after the operation of the high-speed railways. The positive relation of high-speed railway operation and corporate investment is gradually enhanced in the first two years after the operation and does not exist before and in the year during which the railways are into operations.

Third, *Invest3* and *Invest4* were used as alternative variables for corporate investment. The regression results verify that *HSR* is still significantly positively correlated with *Invest3* and *Invest4* at the 1 % level. This finding is consistent with the conclusions of the main regression.

Table 5

Propensity Score Matching and Dynamic Effect Analysis

VARIABLES	Invest1	Invest2	Invest1	Invest2
HSR	0.018*** (4.28)	0.019*** (4.20)		
HSR_before2			0.011 (1.062)	0.010 (1.108)
HSR_before1			0.011 (1.030)	0.009 (0.853)
HSR_current			0.016 (1.534)	0.017* (1.767)
HSR_after1			0.028** (2.507)	0.023** (2.118)
HSR_after2			0.021* (1.849)	0.022** (2.043)
Size	0.037*** (8.26)	0.047*** (9.74)	0.035*** (9.11)	0.039*** (10.17)
ROA	0.196*** (7.92)	0.232*** (8.14)	0.157*** (7.33)	0.173*** (7.73)
Lev	-0.006 (-0.40)	0.003 (0.16)	-0.020* (-1.74)	-0.021* (-1.88)
Growth	0.009** (2.55)	0.017*** (3.69)	0.008*** (3.06)	0.016*** (5.48)
Tobin's Q	0.003** (2.23)	0.003** (2.09)	0.002** (2.39)	0.003*** (2.98)
Age	-0.070*** (-9.49)	-0.073*** (-9.20)	-0.065*** (-10.68)	-0.067*** (-11.82)
Cash	-0.070*** (-4.70)	-0.099*** (-5.79)	-0.065*** (-5.62)	-0.091*** (-7.80)
Dual	0.004 (0.93)	0.002 (0.44)	0.002 (0.48)	0.001 (0.26)
Board	-0.002 (-0.18)	-0.000 (-0.02)	0.006 (0.68)	0.006 (0.69)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Constant	-0.600*** (-6.11)	-0.792*** (-7.65)	-0.575*** (-6.83)	-0.645*** (-7.76)
Observations	10,724	10,724	13,368	13,368
Adj-R^2	0.116	0.114	0.113	0.106
F	36.73	37.69	34.77	31.02

*Note: t-statistics are in parentheses *** p<0.01, ** p<0.05, * p<0.1*

Finally, to exclude the impact of different characteristics of the experimental group and the control group before the operation of high-speed railways, and the possible interference of the unobservable variables, a placebo test was conducted. The study randomly set 2001 to 2009 as the fictitious event period of the sample. The regression results in columns (3) and (4) in *Table 6* show no significant relation between *HSR* and corporate investment. Hence, corporate investment improvement mainly resulted from the high-speed railway infrastructure construction from 2009 to 2017.

Additional Analyses

1. Regression by operational efficiency

Macro-level inventory is one of the main sources of GDP volatility (Bils & Kahn, 2000), while corporate inventory indexes the operational scale and efficiency of firms (Cannon, 2008). Transportation infrastructure can make firms gain access to external markets out of their location, accelerate corporate inventory turnover, and boost scale economy (Seker, 2012). Furthermore, transportation infrastructure improvement can speed up the flow of working capital. Transportation infrastructure can promote corporate inventory transfer and operational efficiency. At the same time, they make it easier for more firms to enter the market resulting in scale economy and the improvement of firm performance, which provides firms with sufficient cash flow to invest in fixed assets such as actively strengthening infrastructure construction. Hence, the construction of high-speed railways and the space-time compression effect brought by the railways will help improve corporate operational efficiency. Will higher operational efficiency increase corporate investment? The answer must be further analyzed.

Table 6

Alternative Measurement of Variable and Placebo test

VARIABLES	Invest3	Invest4	Invest1	Invest2
HSR	0.006* (1.74)	0.006* (1.78)	0.003 (1.31)	0.003 (1.36)
Size	0.035*** (9.07)	0.039*** (10.19)	-0.001 (-0.71)	-0.001 (-0.39)
ROA	0.159*** (7.37)	0.174*** (7.75)	-0.010 (-0.77)	-0.014 (-1.06)
Lev	-0.021* (-1.83)	-0.021* (-1.91)	0.005 (0.80)	0.004 (0.64)
Growth	0.008*** (2.94)	0.016*** (5.41)	-0.002 (-1.37)	-0.002 (-1.04)
Tobin's Q	0.002** (2.44)	0.003*** (2.99)	-0.001 (-1.09)	-0.001 (-0.94)
Age	-0.064*** (-10.42)	-0.066*** (-11.68)	-0.084*** (-5.91)	-0.096*** (-6.60)
Cash	-0.068*** (-5.87)	-0.092*** (-7.85)	-0.012 (-1.42)	-0.012 (-1.39)
Dual	0.002 (0.65)	0.001 (0.31)	-0.003 (-0.88)	-0.003 (-1.09)
Board	0.006 (0.67)	0.006 (0.71)	-0.004 (-0.64)	-0.004 (-0.61)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Constant	-0.571*** (-6.81)	-0.646*** (-7.79)	0.283*** (5.55)	0.293*** (5.65)
Observations	13,368	13,368	9,320	9,320
Adj-R^2	0.104	0.106	0.0371	0.0288
F	38.88	37.70	10.38	8.828

*Note: t-statistics are in parentheses *** p<0.01, ** p<0.05, * p<0.1*

Table 7

Regression by Operational Efficiency

VARIABLES	Low current asset turnover	High current asset turnover	Low current asset turnover	High current asset turnover
	Invest1	Invest1	Invest2	Invest2
HSR	0.006 (1.31)	0.010** (2.03)	0.008 (1.37)	0.010* (1.92)
Size	0.020*** (2.98)	0.044*** (8.98)	0.033*** (4.07)	0.052*** (9.65)
Roa	0.136*** (3.91)	0.221*** (6.49)	0.163*** (4.02)	0.255*** (6.67)
Lev	-0.024 (-1.41)	0.011 (0.66)	-0.016 (-0.75)	0.016 (0.84)
Growth	0.008** (2.35)	0.009* (1.79)	0.018*** (4.36)	0.015** (2.35)
Tobin's Q	0.002 (1.51)	0.002 (1.43)	0.002 (1.02)	0.002 (1.31)
Age	-0.076*** (-8.62)	-0.056*** (-5.88)	-0.079*** (-8.02)	-0.061*** (-6.02)
Cash	-0.081*** (-4.99)	-0.062*** (-2.75)	-0.138*** (-6.83)	-0.071*** (-2.89)
Dual	0.002 (0.44)	-0.000 (-0.07)	0.000 (0.05)	-0.001 (-0.28)
Board	0.015 (1.35)	-0.016 (-1.18)	0.011 (0.77)	-0.013 (-0.93)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Constant	-0.267* (-1.82)	-0.740*** (-6.80)	-0.501*** (-2.91)	-0.891*** (-7.46)
Observations	6,681	6,686	6,681	6,686
Adj-R^2	0.0928	0.128	0.0875	0.130
F	16.36	26.35	15.64	26.63

*Note: t-statistics are in parentheses *** p<0.01, ** p<0.05, * p<0.1*

On the basis of the median of current asset turnover rate, the study divided the sample into two groups. The regression results in *Table 7* claim that (1) with *Invest1* as the dependent variable, the coefficient of *HSR* in the group with higher current asset turnover rate is significantly positive at the 5 % level, and (2) with *Invest2* as the dependent variable, the coefficient of *HSR* in the group with higher current asset turnover rate is significantly positive at the 10 % level. While the coefficient of *HSR* in the group with lower current asset turnover rate is positive, but not significant. Therefore, high-speed railway coverage may boost corporate investment by accelerating the current asset turnover rate.

Table 8

Regression by Financing Constraints

VARIABLES	High financing constraints	Low financing constraints	High financing constraints	Low financing constraints
	Invest1	Invest1	Invest2	Invest2
HSR	0.008 (1.38)	0.010** (2.35)	0.010 (1.53)	0.010** (2.02)
Size	0.026*** (3.11)	0.048*** (8.48)	0.026*** (2.79)	0.063*** (9.14)
ROA	0.340*** (6.43)	0.121*** (5.05)	0.395*** (6.62)	0.150*** (5.33)
Lev	0.084*** (2.88)	-0.026* (-1.93)	0.103*** (3.15)	-0.026* (-1.66)
Growth	0.005 (0.98)	0.003 (0.86)	0.013** (2.36)	0.009** (2.07)
Tobin's Q	0.001 (0.45)	0.003*** (3.04)	0.001 (0.38)	0.003*** (2.68)
Age	-0.032*** (-2.91)	-0.090*** (-11.47)	-0.034*** (-2.87)	-0.097*** (-11.19)
Cash	-0.043* (-1.67)	-0.099*** (-7.11)	-0.058** (-2.00)	-0.138*** (-8.34)
Dual	0.000 (0.03)	0.002 (0.42)	-0.002 (-0.21)	0.002 (0.52)
Board	0.002 (0.12)	0.007 (0.65)	0.008 (0.44)	0.008 (0.65)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Constant	-0.527*** (-2.79)	-0.774*** (-6.49)	-0.562*** (-2.63)	-1.057*** (-7.31)
Observations	6684	6684	6684	6684
Adj-R^2	0.109	0.122	0.105	0.123
F	18.63	27.79	18.07	27.04

*Note: t-statistics are in parentheses *** p<0.01, ** p<0.05, * p<0.1*

2. Regression by financing constraints

Investment decisions are subject to corporate financing capabilities (McConnell & Servaes, 1995) and financing constraints affect corporate cash holdings, and subsequently corporate investment. Through improving traffic and compressing time and space, the operation of high-speed railways could directly improve corporate cash holdings. This effect sends positive signals to external investors, which would strengthen corporate financing capabilities, relieve corporate financing constraints, and promote corporate investment. Whether the lowering of financing constraints will promote corporate investment requires further study.

Following Hadlock & Pierce (2010), Size Age (*SA*) index was used in the study to measure financing constraints. The larger the SA index, the more serious the financing constraints. Hadlock & Pierce (2010) believed that problems with the KZ index are in terms of calculation accuracy and applicability. Firm size (*Size*) and market age (*Age*) are particularly effective indicators for measuring financing constraints. Thus, SA here was calculated as follows: $SA=-0.737*Size+0.043*Size^2-0.040*Age$. The study divided the sample into two groups according to the median of the SA index. Firms with the SA index equal to and higher than the median were in one group, and the rest of the firms were in another group. The regression results in *Table 8* show that, with *Invest1* and *Invest2* as the dependent variables, the coefficient of *HSR* in the group with lower financing constraints is significantly positive at the 5 % level. As the value is positive but not significant in the group with higher financing constraints, high-speed railway coverage may promote corporate investment by alleviating corporate financing constraints.

3. Regression by property rights

Intrinsic problems of "consignor absence" and "insider control" in state-owned enterprises (SOEs) could lead to low investment efficiency in SOEs. On the one hand, SOEs are larger in size, and their decision-making is highly programmed. Therefore, they are less sensitive to the convenience brought by high-speed railway operation. On the other hand, non-SOEs face greater competition and are more sensitive to the transportation convenience brought by the operation of high-speed railways. Thus, non-SOEs are more likely to seize the market opportunities brought by the railways through expanding investment. Whether property rights will affect corporate investment needs to be further discussed.

Table 9

Regression by Property Rights

VARIABLES	SOEs	Non-SOEs	SOEs	Non-SOEs
	Invest1	Invest1	Invest2	Invest2
HSR	0.006 (1.22)	0.019*** (3.75)	0.007 (1.28)	0.020*** (3.50)
Size	0.029*** (5.21)	0.038*** (6.57)	0.037*** (6.02)	0.051*** (7.88)
ROA	0.238*** (6.52)	0.158*** (5.45)	0.285*** (6.75)	0.184*** (5.37)
Lev	0.018 (0.89)	-0.045*** (-3.05)	0.027 (1.20)	-0.046*** (-2.68)
Growth	0.005 (1.23)	0.008** (2.22)	0.009* (1.72)	0.020*** (4.31)
Tobin's Q	0.001 (0.85)	0.003** (2.05)	0.002 (0.91)	0.002 (1.49)
Age	-0.039*** (-3.44)	-0.072*** (-8.85)	-0.040*** (-3.18)	-0.076*** (-8.51)
Cash	-0.066*** (-3.46)	-0.080*** (-5.17)	-0.077*** (-3.63)	-0.132*** (-7.01)
Dual	0.001 (0.13)	0.003 (0.79)	-0.001 (-0.17)	0.003 (0.49)
Board	0.014 (1.07)	-0.005 (-0.39)	0.010 (0.67)	0.001 (0.06)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Constant	-0.557*** (-4.35)	-0.582*** (-4.68)	-0.710*** (-5.03)	-0.844*** (-6.13)
Observations	6,079	7,268	6,079	7,268
Adj-R^2	0.0892	0.126	0.0944	0.124
F	17.77	25.75	16.84	25.41

*Note: t-statistics are in parentheses *** p<0.01, ** p<0.05, * p<0.1*

In *Table 9*, the sample was divided into SOEs and non-SOEs according to different property rights. The regression results show that the significant positive correlation between *HSR* and the two investment indicators *Invest1* and *Invest2* is mainly reflected in non-SOEs, and is significant at the 1 % level. Thus, non-SOEs are more likely to respond to the construction and operation of high-speed railways and seize the opportunities brought by high-speed railways through expanding investment.

4. Regression by industrial characteristics

Generally, the capital composition, fixed assets occupied by laborers and profit rate are not that high for firms in labor-intensive industries (Chakrabarti, 2009). Thus, the scale economy effect brought by high-speed railway coverage has a greater impact on labor-intensive industries. These industries are more likely to expand corporate investment using free cash flow, promoting the transformation and upgrading of firms. Whether corporate investment will be affected by labor-intensive industries requires further analysis.

Table 10

Regression by Industry Characteristics

VARIABLES	Capital and technology intensive industries	Labor-intensive industry	Capital and technology intensive industries	Labor-intensive industry
	Invest1	Invest1	Invest2	Invest2
HSR	0.004 (0.68)	0.015*** (3.54)	0.006 (0.94)	0.016*** (3.37)
Size	0.033*** (5.55)	0.034*** (6.49)	0.049*** (7.07)	0.042*** (7.37)
ROA	0.232*** (5.53)	0.166*** (6.27)	0.258*** (5.32)	0.208*** (6.66)
Lev	0.015 (0.69)	-0.037** (-2.58)	0.012 (0.50)	-0.029* (-1.78)
Growth	-0.001 (-0.13)	0.011*** (3.30)	0.006 (1.08)	0.021*** (4.98)
Tobin's Q	0.001 (0.39)	0.003** (2.24)	0.001 (0.29)	0.003* (1.85)
Age	-0.056*** (-4.87)	-0.066*** (-8.80)	-0.053*** (-4.22)	-0.070*** (-8.53)
Cash	-0.071*** (-3.20)	-0.068*** (-4.77)	-0.104*** (-4.03)	-0.106*** (-6.29)
Dual	0.002 (0.31)	0.003 (0.73)	0.003 (0.40)	0.001 (0.20)
Board	0.005 (0.30)	0.003 (0.25)	0.002 (0.13)	0.004 (0.32)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Constant	-0.538*** (-4.25)	-0.562*** (-4.83)	-0.848*** (-5.87)	-0.728*** (-5.80)
Observations	9,010	4,358	9,010	4,358
Adj-R^2	0.0917	0.117	0.101	0.114
F	12.28	30.18	12.69	29.18

*Note: t-statistics are in parentheses *** p<0.01, ** p<0.05, * p<0.1*

The proportion of fixed assets and R&D expenditure of 21 industries was calculated. Industries were divided into three groups, namely, labor-intensive, capital-intensive, and technology-intensive, using the squared deviation method in cluster analysis. Technology-intensive group includes electronic C5, machinery, equipment, and instrumentation C7, medicine, biological products C8, other manufacturing C9, and information technology industry G; capital-intensive group includes paper and printing C3, petroleum, chemistry, plastic C4, metal, non-metal C6, real estate industry J, social service industry K; and the rest are labor-intensive industries. *Table 10* shows that the significant positive correlation between *HSR* and the two investment indexes *Invest1* and *Invest2* is mainly reflected in the group with labor-intensive firms, indicating that labor-intensive firms are more likely to react to high-speed railway coverage through expanding investment.

Discussion

According to the above analysis, the investment of listed firms in cities covered by high-speed railways has increased significantly compared with the listed firms in cities that are not covered by high-speed railways. Hence, high-speed railway coverage has increased corporate investment. Therefore, the need is to increase the infrastructure construction of underdeveloped areas, promote the comprehensive utilization efficiency of high-speed railways and other infrastructure, and fully use the advantages of high-speed railways. The construction and operation of high-speed railways have improved corporate operational efficiency and mitigated financing constraints, thus promoting corporate investment. The promotion effect of high-speed railways is mainly reflected in non-SOEs and in labor-intensive firms because these firms are more likely to respond to the operation of high-speed railways.

First, in *Table 7*, with the sample divided into two groups with high and low operational efficiency based on the median, the adjusting effect of operational efficiency of the two groups on the relationship between high-speed railway coverage and corporate investment was observed.

It is found that high-speed railways had accelerated the circulation of working capital, improved asset utilization rate, and enhanced corporate profitability. The construction and operation of high-speed railways compress time and space, which improves corporate operational efficiency and investment. This finding is consistent with the conclusions of Donaldson & Hornbeck (2013), namely, scale economy resulting from transportation infrastructure construction has improved the operational efficiency of firms.

Second, in *Table 8*, with the sample divided into two groups with strong and weak financing constraints based on the median, the adjusting effect of financing constraints of the two groups on the relationship between high-speed railway coverage and corporate investment was investigated. The construction and operation of high-speed railways accelerated the turnover of funds, mitigated corporate financing constraints, and provided sufficient cash flow for corporate investment. According to current literature (Campello *et al.*, 2010), transportation infrastructure could effectively mitigate corporate financing constraints. This study mainly focuses on high-speed railways, a highly developing form of transportation at present. The regression results assert that high-speed railways can mitigate financing constraints through speeding up information spread. Therefore, the study extends the research of Campello *et al*. (2010).

Third, in *Table 9*, with the sample divided into SOEs and non-SOEs, the adjusting effect of different property rights of the two groups on the relationship between high-speed railway coverage and corporate investment was analyzed. The investment of SOEs did not increase significantly after the operation of high-speed railways, but it increased greatly in non-SOEs. Intrinsic problems of "consignor absence" and "insider control" in SOEs affected their investment efficiency. Therefore, the study verified current research of Chen, Khan, & Yu, (2013). Specifically, SOEs have difficulty in using the opportunities brought by the operation of high-speed railways because of their innate drawbacks, such as multiple agents and lesser lax supervision.

Finally, labor-intensive industries, as their lower profit margins and laborer occupation of fixed assets, are more sensitive to the construction and operation of transportation infrastructure. The grouping test based on industrial characteristics in *Table 10* shows that the space-time compression effect resulted from the operation of high-speed railways is more beneficial to labor-intensive industries. Most existing studies mixed labor-intensive industries with non-labor-intensive industries for full-sample analysis, without considering the industry heterogeneity of corporate investment. *Table 10* exhibits that labor-intensive industries are more likely to improve corporate investment using free cash flow brought by transportation convenience. Hence, this study provides new empirical evidence for the heterogeneity of corporate investment.

Conclusion

The "space and time compression" resulting from high-speed railway coverage will have significant impact on resource allocation. Using DID regression, this study empirically analyzed the relationship between high-speed railway coverage and corporate investment. Investment in listed firms in cities covered by high-speed railways increased more significantly, compared with cities not covered by high-speed railways. Hence, high-speed railway coverage has increased corporate investment. This conclusion holds still after a series of robustness tests, such as propensity score matching, dynamic effect, and placebo tests. The positive correlation between high-speed railway coverage and corporate investment is mainly reflected in firms that have lower financing constraints, higher current asset turnover rate, intensive labor, and private ownership. The above firms are easier to be affected by the construction and operation of high-speed railways.

As the sample period for high-speed railway coverage began in 2009 and ended in 2017, this study can only observe the changes in corporate investment during the years just after the construction and operation of high-speed railways. Corporate investment is a relatively long-term process, which makes the study not that satisfactory. In addition, obtaining geographic distance data is difficult; thus, the distance of firms to the high-speed railway stations was not distinguished during the study. With the advancement of the high-speed railway construction, high-speed railways are becoming more important in economic development. Therefore, the economic consequences of high-speed railway construction need further tests. In addition, the many high-speed railways under construction will soon cover more countries in the world. Hence, more detailed data will become available for academic research in geographical economics.

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