



The Opening of High-speed Rail and Enterprise Innovation——Research based on Multi-period DID

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Abstract

The opening of high-speed rail has had a profound impact on China's society and economy, greatly promoted the exchanges between regions, and brought the development of various regions into the era of high-speed rail. This paper selects all A-share non-financial listed companies from 2008 to 2019 and uses a double differential model to study the relationship between the opening of high-speed rail and corporate innovation. The study finds that the opening of high-speed rail can promote corporate innovation. Further analysis of its impact mechanism found that the opening of high-speed rail can ease the financing constraints of enterprises and improve the level of enterprise innovation. This research is not only a supplement to the economic consequences related to the opening of the high-speed rail, but also a further expansion of the research on the factors affecting enterprise innovation.

Keywords: *high-speed rail opening; corporate innovation; financing constraints*

1. INTRODUCTION

Since the opening of the Beijing-Tianjin intercity high-speed rail in 2008, China's high-speed rail has developed rapidly and has achieved world-renowned results. At present, it has formed the world's largest high-speed rail network layout. As of the end of 2020, China's high-speed rail journey has reached 38,000 kilometers, ranking first in the world. The opening of high-speed rail has had a profound impact on China's society and economy, greatly promoted regional exchanges, accelerated the flow of resources, human resources, capital, and information^[1], and drove the development of various regions into the era of high-speed rail.

The impact of the opening of high-speed rail on the social economy is mainly reflected in both macro and micro aspects. From a macro perspective, the opening of high-speed rail can not only reduce travel time, but also attract investment, promote factor flow, create new employment opportunities, stimulate economic growth^[2,3], bring more companies and capital into the local area, and promote enterprises. The growth of total factor productivity, which in turn increases the local GDP per capita^[4], promotes regional economic growth, and reshapes the spatial structure of the regional economy^[5,6]. In terms of micro-enterprises, the opening of the high-speed rail has greatly reduced the information asymmetry between investors and listed companies, thereby

increasing the investment of venture capital in the region^[7], and reducing the risk of listed companies' stock price collapse in the region^[1]. However, research on enterprise innovation in the opening of high-speed rail is not yet complete. Can the opening of high-speed rail promote the innovation and development of enterprises? Through what kind of channel?

Based on this, this article selects 2008-2019 A-share non-financial listed companies as sample data. Based on the quasi-natural experiment of the opening of high-speed rail, the difference-in-differences method is used to explore the impact of the opening of high-speed rail on the level of enterprise innovation and its mechanism. The results show that after the opening of the high-speed rail in the company's office location, the level of innovation of the company has been significantly improved. Through group inspection, it is found that the opening of high-speed rail has a more significant role in promoting innovation for companies with a high degree of financing constraints. The opening of the high-speed rail has greatly reduced the space-time distance, reduced the degree of information asymmetry, and eased the financing constraints of enterprises, which in turn played a certain role in promoting the innovation level of enterprises.

The main contributions of this paper are: (1) With the help of the exogenous event of the opening of high-speed

rail, exploring the impact of transportation infrastructure conditions on the level of innovation of enterprises will help to provide a new perspective for studying the influencing factors of enterprises. (2) Existing research on the economic consequences of the opening of high-speed rail is mostly focused on the macro perspective. This article takes enterprise innovation as the endpoint to analyze the micro-economic impact of the high-speed rail opening theory, which will help enrich the impact of transportation infrastructure construction. Research. (3) Using the exogenous event of the opening of the high-speed rail as the starting point, studying the impact of the opening of the high-speed rail on corporate innovation will help expand the application of new geo-economics in the field of corporate finance and governance.

2. LITERATURE REVIEW AND HYPOTHESIS

The opening of high-speed rail will have an important impact on the macroeconomics of cities along the route. The time-saving effect brought about by the opening of high-speed rail has increased the spatial spillover effect of urban economic output [5] and has significantly improved the fixed asset investment and economic growth of cities along the route [8]. The opening of the high-speed rail not only promoted the local economic growth, but also promoted the economic growth of neighboring cities [9], which played a significant role in promoting regional economic integration [10]. In addition, the opening of the high-speed rail has also had an important impact on micro-enterprises. The opening of the high-speed rail promotes the flow of capital and talent elements, optimizes the allocation of capital elements among enterprises, and improves enterprise productivity [11]. At the same time, it reduces the travel and time costs of all parties, helps investors and analysts to conduct on-site investigations on the company more efficiently and frequently [12], reduces the cost of obtaining "soft information", and eases the relationship between investors and companies. The degree of information asymmetry.

The degree of financing constraints of a company largely affects the level of innovation of the company. Modigliani and Miller believe that in a perfect capital market, the internal and external capital of a company can be substituted for each other, and the investment behavior of a company is only related to the company's own investment needs. And it will not be affected by the company's financial status [13]. However, in the actual capital market, due to the existence of factors such as information asymmetry and agency problems, the external financing cost of a company is usually higher than the internal financing cost, which triggers financing constraints for the company. Existing studies have confirmed that the higher the degree of information asymmetry of a company, the greater the degree of

financing constraints the company is subject to [14]. The opening of the high-speed rail breaks the barriers between cities, making it easier for companies and investors to conduct on-site investigations and face-to-face communication, reduce the cost of information acquisition, and ease the financing constraints of companies.

Innovation is the main theme of today's social development, and enterprise technological innovation has significant positive significance for itself and the macroeconomy [15-19]. However, the uncertainty of corporate innovation leads to serious financing constraints for corporate innovation. The opening of high-speed rail eases the information asymmetry and agency problems faced by enterprises, reduces the degree of uncertainty faced by enterprises in innovation to a certain extent, eases the degree of financing constraints of enterprises, and thus is conducive to the improvement of the level of enterprise innovation.

Based on the above analysis, this article proposes the following hypotheses:

Hypothesis 1: The opening of high-speed rail can promote enterprise innovation.

3. RESEARCH DESIGN

3.1. Data selection

Given that China's first high-speed railway, the Beijing-Tianjin Intercity Railway, was officially opened to traffic on August 1, 2008, this article selects all A-share non-financial listed companies from 2008 to 2019 as the research object, to ensure the exogenous nature of the high-speed rail effect. In this paper, the central city samples of municipalities, provinces, and sub-provincial levels are excluded; the samples of ST and *ST companies are also excluded, and the samples with missing values are eliminated, and finally 6234 sample observations are obtained. The financial data in the sample comes from the CSMAR database, and the data related to the opening of the high-speed rail comes from the official website of the China Railway Administration and is manually collected.

3.2. Variable definition

1) Explained variable

The explained variable in this article is the degree of enterprise innovation. The existing research on the measurement of enterprise innovation degree mainly includes two types of indicators: input and output. The input indicator is the enterprise's R&D investment (RD) and the output indicator is the number of patents (PAT) of the enterprise. To avoid the influence of a single variable on the research results, this paper uses both input indicators and output indicators to measure the degree of

innovation of enterprises. The innovation investment indicator uses the ratio of the total R&D investment of the enterprise to the total assets of the enterprise to eliminate the impact of scale effect; in terms of the number of patent applications, my country's patent system divides patents into three types: invention patents, utility model patents and design patents Type, this article uses the sum of the number of patent applications of enterprises plus 1 to take the logarithmic value as a measure of enterprise innovation output.

2) Explanatory variables

The explanatory variable of this article is the dummy variable (HSR) of whether the high-speed rail was opened in the company's office located in that year. If the high-speed rail is opened in the company's office located in the same year, the HSR value of the company's current and subsequent years will be 1, otherwise, it will be 0. The specific variables are described as follows.

3) Control variable

Regarding relevant literature, this article selects a series of control variables that may affect corporate innovation over time, including corporate size (Size), total net asset interest rate (ROA), asset-liability ratio (LEV), and whether the two positions are combined. One (Dual), TobinQ (TobinQ), the largest shareholder's shareholding ratio (TopHold), institutional shareholding ratio (Insti), equity balance (Balance), total operating income growth rate (Growth), changes in working capital (Δ NWC), fixed assets ratio (PPE), company establishment age (Age), board size (Board).

3.3. Model building

Based on the research of Bertrand & Mullainathan, this paper constructs the following double differential model to study the impact of the opening of high-speed rail on enterprise innovation:

$$Innovation_{i,t} = \alpha_0 + \alpha_1 HSR_{i,t} + \sum Controls + \alpha_i + \alpha_t + \varepsilon_i \quad (1)$$

Among them, $Innovation_{i,t}$ indicates the degree of innovation of enterprise I in year t (R&D investment and patent applications PAT), $HSR_{i,t}$ indicates whether enterprise office is located in year t When high-speed rail is opened, $\sum Controls$ represents a series of control variables, and α_i and α_t represent firm fixed effects and annual fixed effects.

4. EMPIRICAL ANALYSIS

4.1. Descriptive statistics

Table 1 shows the descriptive statistical results of the main variables. The results show that the average R&D investment of enterprises is 0.021, the maximum value is

0.276, and the minimum value is 0. The average value of enterprise innovation output is 2.3425, the maximum value is 9.5069, and the minimum value is 0, indicating that the level of R&D input and output of Chinese enterprises is generally biased. Low, and there are big differences between different companies. The mean value of the explanatory variable HSR is 0.605, and the sample of the treatment group accounts for 60.50% of the total sample, indicating that the sample size of the study is sufficient.

Table 1. Descriptive statistical results of main variables

Variable	N	Mean	Sd	Min	Max
RD	6234	0.021	0.017	0.000	0.276
PAT	6234	2.342	1.640	0.000	9.507
HSR	6234	0.605	0.489	0.000	1.000
Size	6234	7.985	1.024	5.695	11.568
ROA	6234	0.040	0.075	-0.382	0.202
LEV	6234	0.373	0.186	0.056	0.979
Dual	6234	0.352	0.478	0.000	1.000
TobinQ	6234	2.038	1.205	0.887	8.948
TopHold	6234	33.115	13.772	2.197	85.230
Institu	6234	38.191	25.224	0.001	96.002
Balance	6234	27.272	12.386	2.380	55.970
Growth	6234	0.206	0.472	-0.597	3.868
Δ NWC	6234	0.095	0.384	-4.388	6.300
PPE	6234	0.261	0.152	0.003	0.774
Age	6234	14.906	5.812	1.000	39.000
Board	6234	9.006	2.003	4.000	19.000

4.2. Benchmark regression results

Table 2 shows the relationship between the opening of high-speed rail and enterprise innovation. The results show that the explanatory variable HSR coefficients are significantly positive at the 5% level, indicating that the opening of high-speed rail can significantly improve the innovation level of enterprises. This result verifies hypothesis 1 proposed above.

TABLE 2. THE IMPACT OF THE OPENING OF HIGH-SPEED RAIL ON ENTERPRISE INNOVATION

	(1)	(2)
	RD	PAT
HSR	0.0011** (1.98)	0.0200** (2.20)
Controls	Yes	Yes
Firm FE	Yes	Yes
Year FE	Yes	Yes
R ²	0.0704	0.1256
N	6234	6234

Note: *, **, *** mean significant at the level of 10%, 5%, and 1%, respectively. The t-value is in parentheses, the same below.

4.3. Robustness test

To exclude the influence of potentially missing variables, this paper conducted a placebo test, lagging the opening years of the high-speed rail by 2-4 years, and redefining the explanatory variable HSR. If the “pseudo-high-speed rail opening” has a significant impact on the innovation level of the enterprise, it means that the original conclusion may be caused by some omitted variables. On the contrary, it indicates that the opening of the high-speed rail will have an impact on the innovation level of the enterprise. This paper regressed the high-speed rail opening time after 2-4 years, and the results show that the HSR coefficients are not significant, which illustrates the effect of the high-speed rail opening on corporate financing constraints. Due to space limitations, the table results are no longer listed here.

5. FURTHER ANALYSIS

Based on the previous analysis, the opening of high-speed rail can reduce the degree of financing constraints of enterprises and thus increase the degree of innovation of enterprises. At present, there is no unified standard for the measurement of corporate financing constraints. This article draws on the method of Hadlock and Pierce and uses the SA index to measure corporate financing constraints. The index is constructed by two relatively exogenous variables of firm size and firm age. To a certain extent, to avoid the endogenous problem^[20,21], and refer to Ju Xiaosheng's practice to take the absolute value of the SA index. The larger the SA index, the greater the degree of financing constraints of the enterprise. The formula for calculating the SA index is as follows:

$$SA = -0.737Size + 0.043Size^2 - 0.04Age \quad (2)$$

This paper uses the median of the SA index as the demarcation point, divides the sample companies into two sets of sample data with a higher degree of financing constraint than with a lower degree of financing constraint, and uses R&D investment and patent applications as corporate innovation proxy variables for group regression. If the high-speed rail opening has a more significant effect on the degree of innovation of enterprises in the group of enterprises with a high degree of financing restraint, it means that the opening of high-speed rail can alleviate the degree of financing restraint of enterprises and improve the innovation level of enterprises. The results of group regression are shown in Table 3. The results show that with enterprise R&D investment and patent applications as proxy variables, the explanatory variable HSR is significantly positive at 1% and 5% in the group of companies with a high degree of financing constraints, while the group of companies with a low degree of financing constraints. The results of the explanatory variables are not significant, indicating that the opening of high-speed rail can improve the innovation

level of enterprises by reducing the path of corporate financing constraints.

TABLE 3. TEST RESULTS OF MECHANISM BASED ON FINANCING CONSTRAINTS

	RD		PAT	
	The high degree of financing constraint	The low degree of financing constraint	The high degree of financing constraint	The low degree of financing constraints
HSR	0.0031*** (3.36)	-0.0009 (-1.01)	0.3488** (2.88)	0.0017 (0.01)
Control	Yes	Yes	Yes	Yes
<i>Firm FE</i>	Yes	Yes	Yes	Yes
<i>Year FE</i>	Yes	Yes	Yes	Yes
R ²	0.1256	0.0977	0.0919	0.1472
N	6234	6234	6234	6234

6. CONCLUSION AND INSPIRATION

This paper selects all A-share non-financial listed companies from 2008 to 2019 and uses a double differential model to study the relationship between the opening of high-speed rail and corporate innovation, and draws the following conclusion: the opening of high-speed rail can promote the level of corporate innovation. Further analysis of its impact mechanism concludes that the opening of the high-speed rail can alleviate the degree of financing constraints of enterprises and improve the level of enterprise innovation.

The research conclusions of this article show that the opening of high-speed rail improves the opportunities for face-to-face communication between corporate stakeholders, reduces information asymmetry, eases financing constraints, and promotes corporate innovation. This indicates that relevant departments are promoting inter-regional transportation facilities. At the same time of construction, it is especially necessary to encourage investors to conduct on-site inspections of enterprises, strengthen the construction of information intermediaries such as financial analysts in the capital market, and encourage relevant personnel to increase the frequency of on-site inspections of enterprises. At the same time, as far as enterprises are concerned, entrepreneurs should plan their offices to gather in cities where high-speed rail opens. This move is conducive to improving the degree of innovation of enterprises and promoting faster and better development of enterprises.

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