Transportation Improvement and Firm Innovation: Evidence from China

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Abstract. Transportation infrastructure improved with the construction of high-speed rail (HSR) has an increasingly significant role in promoting economic growth in China, so it is urgent to describe and measure its economic benefits. By matching the database of China's urban data, HSR data, and China's listed firms' data in the period of 2003–2016, we applied the time-varying difference in difference (DID) method to quantitatively explore the relationship between transportation improvement and firms' innovation. As revealed by the results, we found that transportation improvement has a significantly positive economic effect on firm innovation. Therefore, both firms and policymakers should not ignore the role of infrastructure in firm innovation.

Keywords: Transportation improvement · Firm innovation · Time-varying DID

1 Introduction

Transportation infrastructure helps reduce the barriers to connection, information exchange, and resource flow, which then affects firms' behaviors and performances [1]. The high-speed railway (HSR), as a new but advanced type of transportation infrastructure, reflects a major technological breakthrough in transportation. With such characteristics as high speed, low transport cost, punctuality, safety, comfort, and high efficiency, HSR facilitates passenger traffic among cities and benefits regional economic growth [2]. When assessing the economic impact of HSR, most prior studies have focused on a single high-speed rail line or local narrow networks rather than large-scale HSR construction in different regions. It is unclear whether and to what extent mega-investment in HSR can reshape economic growth and influence firm innovation [3].

In order to fill in the above-mentioned research gap, based on a 14-year panel data of 12,817 firm-year observations covering 201 cities in 30 provinces, we applied time-varying difference-in-difference (DID) method to investigate the relationship between transportation improvement and firm innovation, discovering that transportation improvement exerts a significant positive influence on firm innovation.

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2 Theoretical Background and Hypotheses Development

Firm innovation refers to the generation, adoption, implementation, and incorporation of a new idea, product, and service adopted within the firm [4]. Generally, innovation is considered as a key strategy that contributes to promoting the development of the firm. In the existing literature, several studies have treated firm innovation as the essence of firms' long-term success and the source of sustained competitive advantage [5], and have widely examined various determinants of firm innovation from the perspective of organizational characteristics, and environmental factors. Prior studies have shown that the opening of high-speed rail reduces commuting costs between cities, thereby promoting information dissemination and knowledge spillover at the level of face-to-face communication, and reducing the social cost of firm innovation [6] and investment risk [7]. Meanwhile, transportation improvement can improve the geographic proximity among cities, providing access to soft information, and reducing supervision costs [8]. In addition, transportation improvement connects fragmented markets into a relatively large market, and the market size has expanded as transportation has improved, which may create more opportunities for firms to innovate. Accordingly, we can now advance our hypothesis as follows:

Hypothesis 1: Transportation improvement is positively related to firm innovation.

3 Model and Data

3.1 Data Sources

We combine data from various sources to explore the impact of the opening of high-speed rail on firm innovation. Firstly, high-speed rail data and patents for listed companies are obtained from the China Research Data Service Platform (CNRDS). Second, we obtain firm-level control variables from the China Stock Market and Accounting Research Database (CSMAR), which contains basic information about all listed companies in China. Third, city-level control variables are collected from the "China City Statistical Yearbook", which provides us with detailed demographic, economic, and fiscal indicators at the city level. We use the code of the city, where the firm is located, to merge the innovation data with HSR and city-level data. Based on the firm-level data of all listed manufacturing firms collecting from Shanghai and Shenzhen A-shares from 2003 to 2016, we cleaned our observations and finally obtained a sample consists of 12,817 firm-year observations that cover 201 cities in 30 provinces from 2003 to 2016.

3.2 Variables

Dependent variable.
Following previous studies [9], we use the number of invention patents granted by the listed firm as a measure of innovation (G_Invent). Meanwhile, taking into account that some companies have no patents granted in certain years and the number of patents presents an obvious right-skewed distribution, we take the natural logarithm for normalizing the distribution.

Independent variable.

The independent variable high-speed rail (HSR), a proxy for transportation improvement, is a dummy variable that is equal to 1 or 0. It is worth noting that a city may construct two or more lines over time; therefore, we only consider the first HSR lines of the city in this article. More specifically, if the city where the listed firm is located has constructed the first high-speed rail in the year t, the value is equal to 1 in the year t and after, and 0 before year t. Meanwhile, if the city was not constructed between 2003 and 2016, the value of HSR is 0.

Control variables.

Referring to existing literature on firm innovation [10, 11], we select the following variables as control variables based on data collected from the firm level and the city level: firm size, return of asset, the shareholding ratio of the largest shareholder in the firm, debt to assets ratio, firm age, firm's Tobin's Q, the net fixed assets divided by total assets, the nature of the firm, regional GDP growth rate, and regional population.

3.3 Empirical Model

In order to estimate the impact of transportation improvement on firm innovation, we established a difference in difference model (DID) to conduct empirical research. Given that the years of the construction of HSR varies from city to city, the standard DID method is not suitable when exogenous shock happens inconsistently, we thus use the time-varying DID. Specifically, the time-varying DID regression model is set as follows:

$$G\_Invent_{ij,t} = \alpha_0 + \alpha_1 HSR_{ij,t} + \alpha_2 Controls_{ij,t} + \rho_{ij} + \psi_t + \varepsilon_{ij,t} \tag{1}$$

where $HSR_{ij,t}$ is a dummy variable that equals one after the city i that the firm j located has opened the HSR in year t, and zero otherwise; $G\_Invent_{ij,t}$ refers to the number of invention patents granted by the listed firm j in the city i in year t; $Controls_{ij,t}$ refers to the matrix of control variables. α_0 refers to constant term, and $\varepsilon_{ij,t}$ is the error term. ρ_{ij} and ψ_t are the year and industry fixed effects separately.

4 Regression Results and Robustness Tests

4.1 Regression Results

Table 1 reports the estimation results based on OLS regressions controlling for year and industry fixed effects. Specifically, we use the Eq. (1) to test the impact of the construction of HSR on firm innovation. As shown in M1, the coefficient of HSR is positive and significant at the 1 percent level, which means that the construction of HSR can promote firm's innovation output. More specifically, cities with HSR will increase their firm's innovation output by 12.1 percent compared to those cities without HSR. Therefore, Hypothesis 1 is verified.

4.2 Parallel Test and Year-Dynamic Effects

When using the DID approach, the parallel trend assumption must be met. Inspired by Beck et al. [12], we applied time-varying DID combined with event study approach (ESA). Here we have two motivations to use ESA. Therefore, we set the following equation:

$$G\_Invent_{ij,t} = \pi_0 + \sum \pi_{1,t} event_{ij,t} + \pi_2 Controls_{ij,t} + \mu_{ij} + \sigma_t + \in_{ij,t} \quad (2)$$

where $G\_Invent_{ij,t}$ refers to the invent patent granted by list firms j in the city i in year t; π_0 refers to constant terms; $event_{ij,t}$ is a dummy variable that indicates whether city i has constructed HSR in relative time t; $Controls_{ij,t}$ refers to the matrix of controls variables; μ_{ij} is industry fixed effect, and σ_t is the time fixed effect; $\in_{ij,t}$ is the error term. Figure 1 visualizes the regression results with 90 percent confidential interval, as follows.

Before the relative time 0, the confidential interval of all point estimates include 0 and insignificant, which mean that there is no significance between HSR-listed firms (firms located in the HSR city) and non-HSR-listed firms in firm's innovation output before the construction of HSR. Thus, the parallel trend assumption is satisfied and the estimation result in Eq. (1) is unbiased.

Table 1. Baseline regressions

Variables	G_Invent	
	Coefficient	S.E.
HSR	0.121***	(0.043)
Size	0.437***	(0.046)
ROA	0.024	(0.262)
TOP1	-0.002	(0.001)
Lev	-0.070	(0.074)
lnAge	-0.090*	(0.054)
TobinQ	0.021*	(0.011)
Tang	-0.287***	(0.099)
SOE	0.055	(0.045)
GDP_Gro	-0.007	(0.006)
lnPopu	0.073***	(0.028)
Constant	-9.223***	(0.984)
Year/Industry fixed effect	Yes	
Observations	12,817	
R-squared	0.370	

Note heteroskedasticity-adjusted robust errors reported in parentheses are clustered at prefectural level; *, **, and *** represent statistical significance at the 10%, 5% and 1% level, respectively

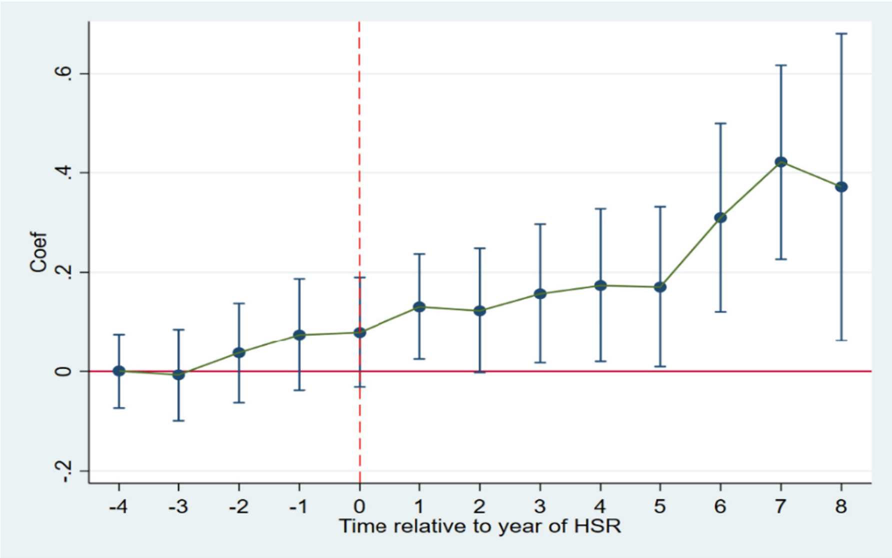

Fig. 1. The result of event study approach

5 Conclusions

In the present article, using a matched patent database from Chinese-listed manufacturing firms and the infrastructure information about high-speed rail construction at the city level, we examined the relationship between transportation improvement and firm innovation. Using high-speed railway construction as an exogenous variation in transportation improvement, our study proves that transportation improvements allow innovative factors to flow freely between regions by reducing barriers between regions and transaction costs in the transaction process, which means that firms are able to use external sources to innovate. The robustness test we conducted show that our conclusions are robust.

However, there is limitation to this study that shed light on future researches. Due to the data of patent citation is not available to us in China, so it prevents us from studying the impact of transportation improvement on the quality of firm innovation, we leave this for future studies.

6 Authors' Contributions

The contribution of this paper is mainly reflected in two aspects. Firstly, prior studies have been conducted to investigate the economic and social effects and its disparity of HSR, while a limited number of studies have directly explored the effect mechanisms of HSR on firm innovation. Using the micro data from Chinese-listed manufacturing firms, we find that HSR can effectively promote firm innovation. Second, unlike most previous studies on the economic effects of HSR, which have mostly used the general regression model or the DID model, we adopted a newly developed method of policy evaluation to identify the spatial relationship in the dynamic of innovation, namely time-varying DID method, which can effectively avoid the bias that the former is prone to in the evaluation of policy effect, thus making our results more effective and robust.

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