Transportation Research Part A 198 (2025) 104500

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Impacts of high-speed rail on new firm formation and economic clustering: Evidence from Suzhou, China

Lan Wang [a], Jia Tao [a], Wenyao Sun [a], Chia-Lin Chen [b,*], Zhenhua Chen [c], Po-Chen Lin [d], Roger Vickerman [e,f]

[a] *College of Architecture and Urban Planning, Tongji University, China*
[b] *Department of Geography and Planning, University of Liverpool, UK*
[c] *The Ohio State University, USA*
[d] *North Carolina State University, USA*
[e] *School of Economics, University of Kent, UK*
[f] *Department of Civil and Environmental Engineering, Imperial College London, UK*

ARTICLE INFO

Keywords:
High-speed rail
Intra-city dynamism
New firms
Economic clustering
Suzhou

ABSTRACT

The arrival of high-speed rail (HSR) generates new economic opportunities and shapes the spatial distribution of economic activities and territorial dynamism. While extensive research examines inter-city phenomena, limited research focuses on intra-city dynamism, particularly how HSR affects new firm formation and their spatial distribution within a city. This paper develops an analytical framework utilising difference-in-difference methods and temporal dynamics to examine new firm registration data in Suzhou, a non-central prefecture-level city in China. The empirical evidence substantiates four key points: First, HSR significantly accelerates new firm formation. Second, there is a time lag in new firm formation; construction firms respond first to HSR services, but the most substantial responses come from the Knowledge Intensive Services and Commerce, Transport and Hospitality Services sectors. Third, there is distinct locational heterogeneity. The most developed urban districts, with their proximity to HSR stations, experience a more pronounced impact on economic clustering in the short term compared to the newly developed areas surrounding peripheral HSR stations. This study provides valuable insights for integrated transport and urban planning strategies and economic development policies by leveraging HSR accessibility to enhance intra-city dynamism.

1. Introduction

Numerous studies have explored the factors influencing business location decisions and the distribution of economic activities. Krugman (1991) highlighted that regional agglomeration of business activities can be stimulated by various factors such as pooled labour markets, the production of non-tradable specialised inputs, and knowledge spillovers. Other factors, such as area-based policies (Anyadike-Danes et al., 2005), cluster strategies (Delgado et al., 2010), and regional embeddedness (Dahl and Sorenson, 2012), also play significant roles in new firm formation.

* Corresponding author.
E-mail addresses: wanglan@tongji.edu.cn (L. Wang), 2330126@tongji.edu.cn (J. Tao), sunwenyao@tongji.edu.cn (W. Sun), chia-lin.chen@liverpool.ac.uk (C.-L. Chen), chen.7172@osu.edu (Z. Chen), pochenlin.tw@gmail.com (P.-C. Lin), r.w.vickerman@kent.ac.uk (R. Vickerman).

https://doi.org/10.1016/j.tra.2025.104500
Received 28 July 2024; Received in revised form 15 April 2025; Accepted 21 April 2025

Additionally, population density (Delfmann et al., 2014; Parajuli and Haynes, 2017), human capital (Davidsson and Honig 2003; Parajuli and Haynes 2017), financial capital (Dahl and Sorenson, 2012), establishment size (Kangasharju, 2000; Armington and Acs, 2002; Lee et al., 2004; Sutaria and Hicks, 2004), unemployment (Sutaria and Hicks, 2004; Cheng and Li, 2010), population growth (Audretsch and Fritsch, 1994; Kangasharju, 2000; Armington and Acs, 2002), and per capita income (Armington and Acs, 2002; Lee et al., 2004) are generally recognised as key determinants for new firm formation.

In addition to these socioeconomic factors, transport infrastructure significantly influences the location of economic activities (Hodgson, 2018). Building on classic location theories (Weber, 1929), New Economic Geography (Krugman, 1991) emphasises that transport costs are critical determinants in the location choice of new firms. Pioneering studies have confirmed that the number of new manufacturing plants tends to grow in areas with better access to major transport infrastructures, such as highways and railways (Smith and Florida, 1994; Coughlin and Segev, 2000; Fotopoulos and Spence, 1999; Melo et al., 2010). For instance, Holl (2016) found that improved transport infrastructure enhances the productivity of manufacturing firms.

Melo et al. (2010) examined the role of transport infrastructure on the location choice of new plant openings in Portugal. Their study found that a 10 % improvement in railway and motorway networks at the local municipality level could increase new plant openings by 0.9 % to 2.7 % and 0.7 % to 2.6 %, respectively, with strong spillover effects.

With major time–space shrinkages and changes in accessibility and connectivity, high-speed rail (HSR) is widely recognised for its potential impacts on economic development effecting across different spatial levels. Much of the existing research and debates focus on inter-city dynamism, examining aggregated economic performance for cities served by HSR. One of the implications of new economic geography is that HSR may accelerate the process of agglomeration and concentration under "imperfect competition" (Krugman and Venables, 1990) among large and small cities, with high value-added firms moving to large cities that offer pooled labour markets and the production of non-tradable specialised inputs when agglomeration forces dominate over dispersion forces (Peeters et al., 2000; Puga, 2002). This perspective emphasises competition rather than collaboration among connected cities, where large cities benefit at the expense of smaller ones, often exhibiting siphon effects (Dong, 2018; Lin and Gan, 2022; Matas et al., 2020).

However, beyond a zero-sum game, HSR can also foster stronger business connections and collaboration between connected places within the expanding HSR network (Jiao et al., 2020). Venables' (2017) integrated framework of "expanding cities and connecting cities" theorises the interrelated economic effects of transport improvements. Intra-city transport facilitates urbanised economies through increased returns from city size, while inter-city transport such as HSR enables city specialisation in specific sectors and tasks, potentially enhancing productivity if economies of localisation exist. Positive outcomes have been observed on the Madrid-Barcelona HSR line (Carbo et al., 2019) and in the rationalisation and advancement of industrial structures in non-central Chinese cities within 100 km of a central city (Li et al., 2023). Tang et al. (2021) demonstrated that HSR impacts urban innovation through both agglomeration and network externalities, with the latter being more influential.

Therefore, HSR can benefit non-central cities connected by HSR beyond large cities, although existing literature suggests that strong policy interventions are crucial to overcoming path dependency obstacles such as existing population scale and economic trajectories (Deng et al., 2020a; Lin et al., 2023), restricted urban hierarchies (Chen et al., 2021), and low HSR frequency (Vickerman, 2015; Willigers and van Wee, 2011).

Regarding economic clustering, HSR, as a major technological innovation, influences how firms and labour markets operate, particularly in knowledge-intensive services (Chen and Vickerman, 2017; Tierney, 2012) and producer services (Shao et al., 2017). Studies have also explored HSR's impact on other economic sectors, including manufacturing agglomeration (Sun et al., 2017) and differential movements between manufacturing and services (Chang et al., 2021). Services often cluster in major urban areas, while manufacturing activities decentralise (Chang et al., 2022; Chang and Zheng, 2022). Zhou and Zhang (2021) found that core cities exhibit faster growth in service activities around HSR stations, whereas manufacturing industrial parks experience spillover effects, indicating differing impacts on service and manufacturing sectors. Zhou and Zhang (2024) explore the impacts of HSR on industrial upgrading, showing that big firms innovate more while being exposed to more competition from small firms and relatively decreased profitability.

Existing studies on HSR dynamics between cities offer limited insights into intra-city changes. While HSR is recognised as a key driver of new economic and development opportunities in both developing and developed countries, few studies have examined its impacts on economic and spatial changes at the disaggregated level within individual cities using firm-level data. Furthermore, there is a lack of longitudinal studies exploring how firms' reactions shift and evolve before and after the introduction of HSR services. Additionally, it remains unclear whether and how new firms from different sectors and types react differently to various HSR lines and stations.

This paper addresses these gaps by exploring the following interrelated questions: First, has the arrival of HSR impacted new firm formation? Second, how have new firms' reactions shifted and evolved over time before and after the introduction of HSR services? Third, whether and how might new firms from different sectors and types react differently to various HSR lines and stations? To answer these questions, we adopted difference-in-difference methods, temporal dynamics analyses, and heterogeneous analyses to examine panel data of approximately 60,000 new firm registrations from 2005 to 2015. This decade covers about 5–6 years before and 4–5 years after the arrival of HSR in Suzhou, a non-central prefecture-level city located between Shanghai and Nanjing in the Yangtze River Delta Area (YRDA), one of the most advanced agglomerations in China.

This paper is organised as follows. Section 2 reviews key concepts and evidence to develop a framework for understanding intra-city dynamism. Section 3 introduces the study's datasets and methods within the research framework. Section 4 presents the empirical results. Section 5 synthesises and discusses the new firm creation patterns in light of existing knowledge. Section 6 concludes with policy implications for HSR-driven urban expansion and future research directions.

2. Understanding intra-city dynamism: High-speed rail and economic clustering

Transport infrastructure plays a pivotal role in shaping the locations of economic activities (Hodgson, 2018). Different types of transport infrastructure attract different economic activities. High-speed rail (HSR), for instance, is particularly appealing to firms with high knowledge content, as it facilitates rapid inter-city communications (Tierney, 2012). Knowledge is a classic Marshallian externality, enhancing productivity in regions with high knowledge intensity, leading to increased rates of innovation. HSR facilitates face-to-face interactions, crucial for developing knowledge-intensive activities, as knowledge creation is more efficient within urban environments (Audretsch, 1998). The range of knowledge-intensive activities has expanded from a narrow focus on science and technology (OECD, 1996) to include professional services such as finance and insurance, business services, real estate, education and health sectors (Brinkley, 2006; Eurostat, 2007; OECD, 2007; Muñiz and Garcia-López, 2010), as well as cultural and creative industries (Jones et al., 2008; Kok, 2004). Knowledge-intensive activities tend to cluster in dense urban areas to gain comparative advantages. Once economic activities agglomerate, enhanced effects of spatial clustering emerge through enhanced agglomeration and network externalities facilitated by HSR (Malmberg et al., 1996).

Empirical studies have demonstrated the growth of knowledge-intensive economies in HSR cities although results vary (Chen and Hall, 2011, 2012; Chen and Vickerman, 2017). While HSR is conducive to developing knowledge-intensive services, it has also encouraged various service industries, including commerce, retail/wholesale, hotel/food industries, and tourism (Dong, 2018; Han et al., 2012; Matas et al., 2020; Shao et al., 2017). However, the influence of HSR on the consumer service and public service industries is less significant (Shao et al., 2017). Matas et al. (2020) stressed that although HSR may promote firm formation, this is not always the case.

Most studies, such as Chen et al. (2016) and Chen (2019), examine HSR's impact on economic development and land use changes at aggregate geographic levels, treating cities as homogeneous units. However, actual changes occur at a more disaggregated level, varying across different areas within a city. This study accordingly investigates the impacts of HSR on new firm formation and their spatial distribution within a city, shedding light on the intra-city dynamism induced by HSR, which is crucial for informing urban development policies aligned with its introduction.

2.1. HSR accessibility and firm location decision

Good accessibility to railway stations, along with service frequency and type, are key factors in firms' location decisions. Willigers (2003) identified that corporate decision-makers consider HSR linkages for different functions, activities, employees, business partners, and customers, both currently and in the future. The demand for high-speed travel is reflected in the types of services associated with externally oriented and international business. Kuang et al. (2021) found that firms in communication-intensive and travel-dependent industries benefit more from HSR. Willigers et al. (2005) noted that HSR accessibility is crucial for firms regularly undertaking international business trips. Distributive effects within urban regions are expected to be larger than relocations between regions. Willigers et al. (2007) found that the accessibility effects of future high-speed train connections are more significant for business travel than for commuting, with the value of time being a dominant factor.

While knowledge flows do not necessarily require proximity or physical transport links, evidence shows that spatial clustering requires both. Studies have shown that geographical proximity to HSR stations matters. Zheng et al. (2019) found a 27 % increase in land use intensity near HSR stations, although spillover effects vary across Chinese cities. Liang et al. (2022) observed significant business-commercial agglomeration effects around HSR stations, along with notable time-lag effects.

2.2. HSR stations' influential ranges

Several studies have attempted to assess the spatial influence of high-speed rail (HSR) using various data and methodologies. One approach is to analyse HSR catchment areas through ridership coverage. Martinez et al. (2016) examined the spatial influence of HSR stations and explored strategies for extending their influence to increase profitability, arguing that additional factors beyond the HSR network should be considered to enhance profits.

Pan et al. (2020) used multi-period night-time light data to estimate the influential range of HSR over a short period, about one year before and after the arrival of HSR. They studied the Nanjing-Shanghai-Hangzhou (NSH) and Nanjing-Hangzhou (NH) lines to determine the extent to which HSR spurs the agglomeration of economic activities around, and at a distance from, the station. Their findings indicate that commercial activities are predominantly attracted to the station area rather than the broader region. Moreover, the investment and construction phases attract more commercial activities pre-HSR than post-HSR. The impacts are most evident within short space–time ranges, specifically within 5 km and three months. They argue that a strong local economic base is crucial for HSR to promote local development. Moreover, the location of HSR stations within cities is also significant, with stations integrated into urban regeneration strategies near city centres generally being more successful (Delaplace, 2012; Hall, 2009). In contrast, peripheral HSR stations, which typically offer poor accessibility, appear less attractive (Facchinetti-Mannone, 2013).

2.3. Different HSR stations within a city

The arrival of HSR has been hailed as a key urban strategy in both developing and developed countries, offering new development opportunities for cities served by HSR. Different HSR stations illustrate different locational advantages for spatial development. Hall (2009) identified three types of locations for HSR stations: Central Business District (CBD), second CBD, and edge city. In Europe, HSR is often used as a core strategy for urban transformation and regeneration (Loukaitou-Sideris and Peters, 2020), with the optimal location generally in or near the city centre. In fast-growing developing countries like China, HSR is widely regarded as a strategy for urban expansion and new town development (Wang et al., 2024; Wang and Gu, 2019a). However, the realisation of this potential varies, reflecting different negotiation powers among cities. Zhu et al. (2015) emphasised that the site selection power for HSR stations is largely beyond local control for medium and small cities, often resulting in HSR stations located far from existing urban cores. The long distance and poor accessibility between new HSR stations and urban centres weaken overall attractiveness for economic growth and increase costs for firms and residents. Diao et al. (2017) argued that improving connections to peripheral HSR stations and integrating them into urban planning are essential to enhance the accessibility and promote desirable urban development outcomes.

The different locations of HSR stations within a city offer various functions and advantages for different types of economic activities. For instance, in Reims which is served by two HSR stations, firms near the peripheral station are linked to the region's industrial base, while those near the central station benefit from proximity to final clients and a positive urban environment (Beckerich, Benoit-Bazin, and Delaplace, 2017). This study also shows office availability and good HSR access are crucial for firm location decisions. However, the perception of good HSR accessibility can be more important than actual train usage, as shown by Willigers et al. (2005).

2.4. Formulating the research inquiry

To understand how improved accessibility by HSR impacts the formation and distribution of new economic activities in spatial clustering, we hypothesise that new economic activities are likely to be attracted to areas in proximity to HSR stations, given the importance of HSR accessibility for economic development (Pan et al., 2020; Pol, 2002). Treated groups are defined as those located within a certain distance from HSR stations, while control groups are outside that range. This research explores the most significant spatial influential range in proximity to HSR stations to address the following inter-related questions: Is the arrival of HSR associated with new firm formation? Are there temporal patterns in new firms' reactions to the HSR opportunity? How do new firms from

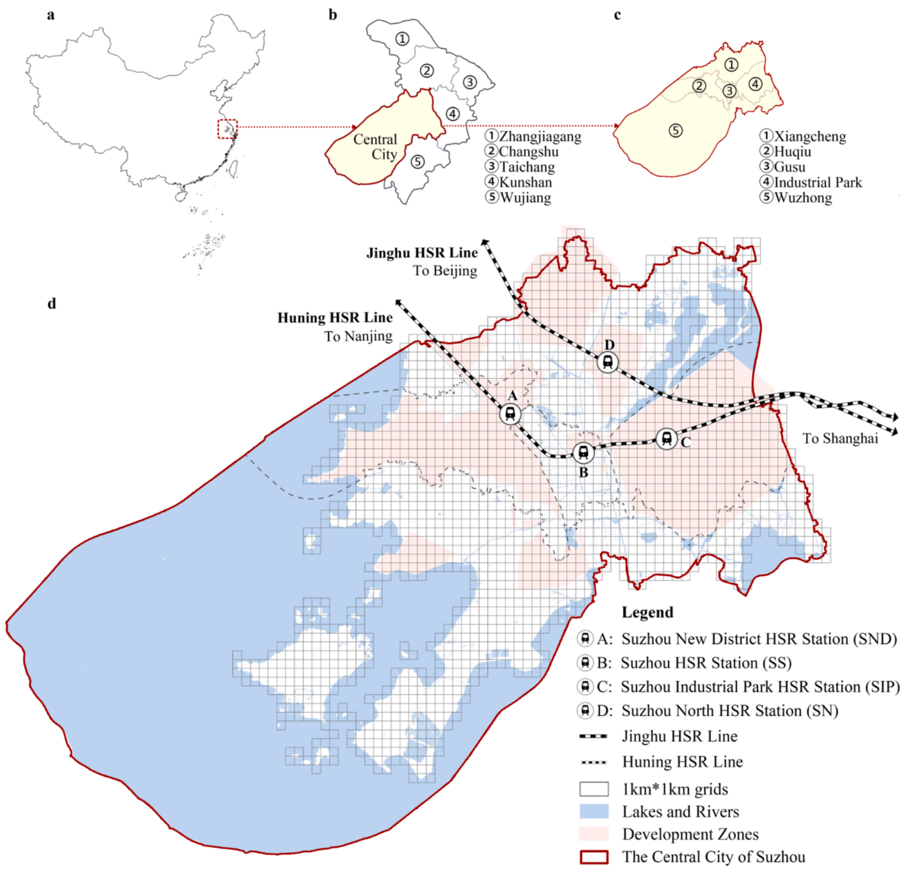

Fig. 1. Research Locations and Units. a. Location of Suzhou City. b. The city of Suzhou. **c.** The central city of Suzhou. **d.** High-speed railway and research units in the central city of Suzhou.

different sectors and types react to different HSR lines and stations? Will the opening of HSR contribute to the sustained enhancement of specific industry clusters? Overall, this paper aims to fill the gap in understanding intra-city dynamism by investigating how HSR impacts firm formation and economic clustering within cities, focusing on longitudinal firm-level data to offer new insights into urban development strategies in the context of HSR.

3. Data and methods

3.1. Study area: The central city of Suzhou

Suzhou provides an ideal setting for examining the impact of HSR on new firm formation. As one of the most dynamic market-driven city economies in China, Suzhou is home to the country's first government-backed development zone, the Suzhou New and Hi-tech Development Zone, as well as the Sino-Singapore Suzhou Industrial Park, a leading example of international collaboration and industrial modernization (Wei et al., 2009). Additionally, Suzhou is a key node on the Beijing–Shanghai High-Speed Railway – China's first world-class, highest-standard, and busiest HSR line – as well as the Shanghai–Nanjing Intercity Railway. Thus, the city's long exposure to HSR and the intensity of its impact make it particularly well-suited for this study. Furthermore, access to ten years of firm registration data, spanning both pre- and post-HSR periods, provides a rare opportunity for conducting the intended longitudinal analysis in this study.

Under China's "city-administering-county" system in place since 1983 (Wang et al., 2015), Suzhou governs five urban districts and five county-level cities before HSR inauguration. However, each county-level city operates substantial autonomy in local economic initiatives benefiting from decentralised fiscal power. This study focuses exclusively on Suzhou's central city, drawing data from five urban districts: Gusu District, at the core, and four newer urban districts—Suzhou Industrial Park (SIP) in the east (established in 1994), Huqiu in the west (2002), Xiangcheng in the north (2001), and Wuzhong in the south (2001). The exclusion of county-level cities is due to the absence of equivalent firm registration data prior to 2011, making their inclusion unfeasible. Nevertheless, this limitation does not undermine the central contribution of this study—analysing the causal impact of HSR on firm dynamism across different HSR station areas within the central city of Suzhou through a robust analytical framework.

Fig. 1 provides a visual representation of the central city of Suzhou. Suzhou features four HSR stations served by two HSR lines. The Regional Intercity *Huning* line, which parallels the conventional rail route, began service in 2010. Operating at 250 kph, it reduced travel time between Shanghai and Nanjing from 2 h to 73 min. This line serves the busy commuting and business corridor, enhancing economic integration among cities along the route. It includes three new HSR stations: Suzhou New District (SND), Suzhou (SS), and Suzhou Industrial Park (SIP). Suzhou SS station was newly rebuilt and expanded on the existing station site. SS and SIP are relatively close to the most developed urban districts, while SND station is at the eastern edge of the SND district, far from its major development zones.

The National Trunk *Jinghu* line, a 1,318 km route connecting Shanghai and Beijing, came into service in June 2011, running through rural areas and connecting with Suzhou North (SN) station, located in Xiangcheng district, 20 km from the city centre. This line, operating at 350 kph, serves as a gateway to Suzhou for passengers from across the nation. The arrivals of the *Jinghu* and *Huning* HSR lines and their station locations reinforce Suzhou's spatial structure as 'one centre, four cities', as outlined in the 2012 city plan following the *Jinghu* line's approval. Among the five districts of Suzhou, Wuzhong is the only one without a HSR station.

Despite similar travel times (30–40 min) between Shanghai and Suzhou across the four HSR stations, differences in city ranking and HSR systems result in varying train frequencies (Chen, 2020). Information on HSR frequencies for selected years is provided in Table A1 of Appendix A1. In the year 2018, on the regional intercity Huning line, Suzhou ranked second after Shanghai and Nanjing. Suzhou (SS) station had 112 trains per day to Shanghai, SIP station had 21, and SND station had only 2. On the national trunk *Jinghu* line, Suzhou ranks third or fourth, with only 30 percent of the nearly 200 daily trains (around 60 trains to Shanghai) stopping at Suzhou North station, compared to 90–100 percent stopping in Nanjing.

Since the economic reform in 1978, Suzhou has emerged as one of the most competitive industrial bases in the Shanghai region, driven by foreign direct investment and trade. Special economic zones offering various incentives, described as 'Zone fever' (Cartier, 2001), have become prevalent in Chinese cities, including Suzhou (Wang et al., 2015). By 2015, Suzhou's urban districts hosted 52 development zones focusing on diverse areas such as retail parks, industrial parks (high-tech, biotechnology, health and medicine, R&D centres, creative industries, finance, etc.), designated at national, provincial, or city levels. The arrival of HSR has spurred significant development ambitions around HSR stations on the city's periphery, notably through the planning and construction of new HSR towns (Chang et al., 2022; Chen and Wei, 2013; Dai, 2015; Wang, 2016). These conditions potentially influence the location decisions of new firms, reflecting different formation patterns between HSR-related and non-HSR-related development zones and policies.

3.2. Data and variables settings

The sample comprises 59,537 new firms registered in Suzhou from 2005 to 2015, based on data provided by the Suzhou Administrative Bureau for Industry and Commerce. Each firm record includes attributes such as name, address, registration year, and economic sector.

Three steps of data treatment were undertaken. First, the initial 20 economic sectors, classified according to the Chinese standard industrial classification (SIC), were grouped into five categories: Manufacturing; Construction; Knowledge Intensive Services; Commerce, Transport and Hospitality Services; and Others.[1] This grouping forms four main economic sector groups, reflecting their distinctive characteristics, particularly for the two services groups. The Knowledge Intensive Services group[2] includes sectors that benefit from agglomeration externalities through face-to-face interaction and knowledge spillover, while the Commerce, Transport and Hospitality Services group[3] potentially benefits from the growing network externalities brought by HSR.

Second, the registered address for each firm, which typically included room numbers, was simplified to the building level before being geocoded to obtain latitude and longitude coordinates for spatial analysis, using the Gaode API. Gaode provides more accurate address identification in Chinese than platforms such as Google or Baidu. Table 1 summarises the business entry patterns across Suzhou's urban districtsand individual municipal districts from 2005 to 2015 for each economic sector group. The comprehensive data reveal that Knowledge Intensive Services, along with Commerce, Transport and Hospitality Services were the primary sectors for new firm entries. At the district level, stark differences in industrial structures are evident. In Gusu District, over half of the new firms (52.944 %) were involved in Commerce, Transport and Hospitality Services, while in the Industrial Park, nearly half of the new firms (49.209 %) belonged to the Knowledge Intensive Services, surpassing entries in Commerce, Transport and Hospitality Services. Huqiu, Xiangcheng, and Wuzhong districts displayed a greater prevalence of Commerce, Transport and Hospitality Services, followed by Knowledge Intensive Services, Construction, and Manufacturing sectors. Notably, Xiangcheng District had the highest proportion of Manufacturing (30.164 %), closely followed by Wuzhong District (22.554 %).

Third, a total of 1,973 grids, each measuring 1 km by 1 km, were generated to cover the non-water land area of Suzhou City, serving as the unified spatial analysis unit for this study. The counts of new firms and related attributes for each year in each grid were recorded, constructing the panel data. The final sample contains 1,973 grids with 21,703 grid-year observations from 2005 to 2015.

Table 2 presents the defined variables and summary statistics. The dependent variable is the count of new firms per year in each grid, and the key explanatory variable is the indicator HSR, which indicates the opening of HSR. In addition, we incorporate the total proportion of various economic sectors over the past three years as control variables to account for underlying trends in the formation of new firms and economic conditions within each spatial grid. The set of lag periods was determined with reference to the study by Andersson and Koster (2011) consideration of the reduced reliability of cumulative calculations as lag periods lengthen. Results based on two- and one-year lags yield consistent findings (see Appendix B2).

3.3. A research analytical framework and methods

To explore the intra-city dynamism of new firm formation and economic clustering rigorously, we have developed a research framework depicted in Fig. 2. Initially, a Difference-in-Differences (DID) model investigates *whether* HSR openings influence the establishment of new firms, with subsequent robustness checks to validate the results. Further analysis using a multistage DID model pinpoints *when* these impacts are most pronounced. Finally, heterogeneity DID analyses elucidate *which* economic sectors and *where* geographically the impacts are most significant, by dissecting the benchmark regression effects into locational and economic sector heterogeneity.

The DID model is a classic method for evaluating the effects of policy interventions by comparing the differences in explanatory variables before and after policy implementation between treatment and control groups (Blundell and Costa Dias, 2000; Deng et al., 2019). Accordingly, this study hypothesises different impact ranges around HSR stations and delineates treatment and control groups within and outside these ranges. The treatment group is assumed to benefit from significant HSR services in proximity to HSR stations, while the control group is assumed not to benefit directly from HSR services beyond a certain range. Sensitivity analyses with varying distance thresholds were conducted to validate the robustness of this assumption. By comparing the changes in the counts of new firms between the treatment and control groups before and after HSR opening, the DID model identifies the net effect of HSR on new firm formation, as shown in Equation (1). Standard errors are clustered at the individual grid level.

$$CFY_{i,t} = \alpha + \beta \times HSR_{i,t} + \gamma \times X_{i,t} + \mu_i + \delta_t + \varepsilon_{i,t} \tag{1}$$

where $CFY_{i,t}$ is the dependent variable, representing the counts of new firms within grid i in year t. HSR_{it}, the key independent variable of this study, is a binary variable which equals 1 if the grid i is served by HSR in the year t, and otherwise 0. The decision to establish near HSR stations hinges on both the externalities from HSR inauguration and the local economic framework. X_{it} consists of a set of control variables calculated from the cumulative share of specific new firm types in the recent years. These variables primarily reflect the historical trends in the geographical concentration of new firms and further capture the territorial network structure within each grid. μ_i and δ_t are fixed effects for time and individual grids respectively in the model to control for both time-invariant and time-varying unobservable grid characteristics that may be correlated with a grid's HSR adoption decision, while ε_{it} represents the random error component.

[1] e.g. Farming, Forestry, Animal Husbandry and Fishery; Mining and Quarrying; Electric Power, Gas and Water Production and Supply; Water Conservancy, Environment and Public Facility Management; Resident Service and Other Service Industries; as well as Health Care, Social Security and Social Welfare.

[2] e.g. Information Transmission & Computer Service and Software, Finance, Real Estate, Leasing and Business Service, Scientific Research, Technical Service, Education, Culture, Sports, and Entertainment.

[3] e.g. Wholesale and Retail Trade, Transportation, Storage and Post, Hotel and Catering Services.

Table 1
Summary of business entries by sector across Suzhou municipal districts, 2005——2015.

City/District	Economic sectors		Total entries	Percentage of city/district total	
Central City of Suzhou as a whole		Manufacturing	7,853	13.190 %	
		Construction	4,077	6.848 %	
		Commerce, Transport and Hospitality Services	25,046	42.069 %	
		Knowledge Intensive Services	20,967	35.217 %	
		Others	1,593	2.676 %	
	All		59,536		100 %
Gusu District		Manufacturing	203	1.277 %	
		Construction	1,205	7.581 %	
		Commerce, Transport and Hospitality Services	8,416	52.944 %	
		Knowledge Intensive Services	5,717	35.965 %	
		Others	355	2.233 %	
	All		15,896		26.700 %
Huqiu District		Manufacturing	827	11.661 %	
		Construction	416	5.866 %	
		Commerce, Transport and Hospitality Services	3,056	43.091 %	
		Knowledge Intensive Services	2,624	36.999 %	
		Others	169	2.383 %	
	All		7,092		11.912 %
SIP District		Manufacturing	686	5.595 %	
		Construction	834	6.802 %	
		Commerce, Transport and Hospitality Services	4,465	36.413 %	
		Knowledge Intensive Services	6,034	49.209 %	
		Others	243	1.982 %	
	All		12,262		20.596 %
Xiangcheng District		Manufacturing	2,614	30.164 %	
		Construction	507	5.850 %	
		Commerce, Transport and Hospitality Services	3,419	39.453 %	
		Knowledge Intensive Services	1,791	20.667 %	
		Others	335	3.866 %	
	All		8,666		14.556 %
Wuzhong District		Manufacturing	3,523	22.554 %	
		Construction	1,115	7.138 %	
		Commerce, Transport and Hospitality Services	5,690	36.428 %	
		Knowledge Intensive Services	4,801	30.736 %	
		Others	491	3.143 %	
	All		15,620		26.236 %

Table 2
Variable definition and summarised statistics.

Variable	Definition	Mean	Std. Dev
Dependent variable			
CFY	Counts of New Firms Per Year	2.743	15.497
CMF	Counts of New Firms Per Year	0.362	1.315
CCF	Counts of New Construction Firms Per Year	0.188	1.364
CCTHSF	Counts of New Commerce, Transport and Hospitality Services Firms Per Year	1.154	7.125
CKISF	Counts of New Knowledge Intensive Services Firms Per Year	0.967	7.007
COF	Counts of New Other Firms Per Year	0.073	0.448
HSR factors			
HSR	Dummy, 1 for units after operation of HSR, 0 otherwise	0.024	0.152
Control variables			
PMF	Percentage of Manufacturing Firms in the grid over the past three years (%)	13.466	29.046
PCF	Percentage of Construction Firms in the grid over the past three years (%)	1.975	8.849
PKISF	Percentage of Knowledge Intensive Services Firms in the grid over the past three years (%)	9.150	21.696
PCTHSF	Percentage of Commerce, Transport and Hospitality Services Firms in the grid over the past three years (%)	12.155	24.785
POF	Percentage of Other Firms in the grid over the past three years (%)	1.927	10.541
Other variables			
SS	Dummy, 1 for being located within the influence area of Suzhou Station, 0 otherwise	0.012	0.107
SND	Dummy, 1 for being located within the influence area of Suzhou New District Station, 0 otherwise	0.012	0.107
SIP	Dummy, 1 for being located within Suzhou Industrial Park Station, 0 otherwise	0.011	0.103
SN	Dummy, 1 for being located within Suzhou North Station, 0 otherwise	0.012	0.107

The primary focus is on the significance and the sign of coefficient β, which indicates the net effect of HSR operation on new firm formation in spatial grids, after controlling for fixed effects and other control variables. While the partitioning of urban grids can pose challenges in fully capturing variables such as demographic composition and socio-economic factors that might influence the outcomes. Nevertheless, by applying individual grid fixed effects and randomly drawing the grids, it is feasible to mitigate biases asso-

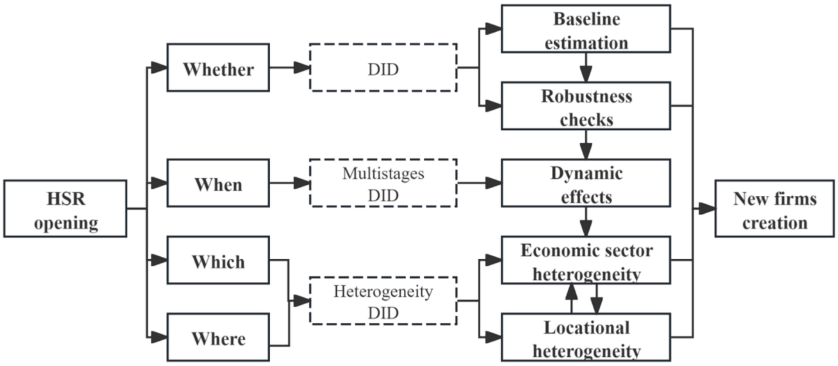

Fig. 2. Research Framework.

ciated with the unique and time-invariant characteristics of each grid, such as disparities in local economic levels, and to reduce potential correlations between the grids and the dependent variables (Yao and Hu, 2020).

3.4. HSR impact range and industrial geography

Before conducting the DID regression, it is necessary to define the impact range of HSR openings as a basis for establishing the treatment and control groups. Previous literature suggests that industries around HSR stations often exhibit a concentric expansion pattern centred on the station (Pol, 2002). Despite the lack of consensus on the exact quantitative extent of this influence, many scholars consider the 2 km radius circular area as the HSR station zone (Wang and Gu, 2019b; Yu, 2020; Zhao and Chen, 2015), which falls within the travel time tolerance range of HSR passengers (Wang et al., 2012; Wang Li et al., 2017). Research by Deng et al. (2020b) traces the guidelines from the National Development and Reform Commission on promoting the rational development and construction of areas around HSR stations, emphasising the importance of prioritising development within a 2 km radius of newly built HSR stations. Fig. 3 illustrates the industrial geography around the four HSR stations in Suzhou, showing that designated HSR new towns and business districts generally lie within a 2 km or 5 km buffer zone. Empirical findings by Pan et al. (2020) indicated that the economic impact of HSR on urban development is strongest near the station, with a pronounced decay effect beyond 5 km, where HSR's influence on business activities becomes negligible. To identify the optimal impact range of HSR openings on new firm formation, we conducted empirical analyses using spatial grids within buffer zones at incremental distances, ranging from 1 km up to 5 km in 1 km intervals. Table B1 in Appendix B presents the descriptive statistics and baseline regression results for each distance setting, revealing that the 2 km buffer zone has the strongest promotional effect on new firm entries. Consequently, spatial grids within the 2 km impact radius were chosen as the treatment group to closely capture the effects of HSR opening on new firm formation.

To better understand the business entry patterns around the four HSR stations, the bar charts in Fig. 4 display the average counts of new firm formation across various economic sectors within the treated grids (within 2 km) before and after HSR openings at each station. Substantial increases in new firm formation were observed at Suzhou Station and Suzhou Industrial Park Station, particularly in the Commerce, Transport and Hospitality Services and Knowledge Intensive Services sectors. In contrast, Suzhou New District (SND) Station, located on the same *Huning* line, exhibited lower HSR frequencies[4] but still experienced an evident rise in total new firm formation. Meanwhile, Suzhou North (SN) Station, located on the *Jinghu* line, saw a minimal increase in new firms despite relatively high HSR frequencies, with a notable decrease in Manufacturing sector firms.

4. Empirical results

4.1. Baseline estimation

Table 3 summarises the results of all DID baseline regressions examining the overall impact of HSR opening on new firm formation, controlling for grid and year fixed effects, with robust standard errors clustered at the individual grid level. Column (1) shows that the counts of new firms increased by approximately 12.552 in the grids intersecting the 2 km buffer zone after the HSR opening, verified at the 1 % significance level. Control variables representing the cumulative share of specific new firm types over the past three years are simultaneously incorporated into the regression analysis in Column (2). The results indicate that, even after controlling for the path dependency of firm entry patterns within the grid, the coefficient of HSR opening remains significantly positive in accounting for the increase in the counts of new firms, with statistical significance at the 1 % level. Furthermore, the coefficients of PCTHSF (Commerce, Transport and Hospitality Service) and PCF (Construction) are consistently greater than zero. In contrast, the coefficients for the historical entry shares of remaining three sectors do not show a promoting effect, with the Manufacturing and other sectors

[4] HSR frequency data for the study period was unavailable; however, the relative frequencies of the four stations remained stable, with the 2018 pattern closely resembling that of 2015. Daily frequencies in the figure are sourced from 12306 China Railway (July 2018)

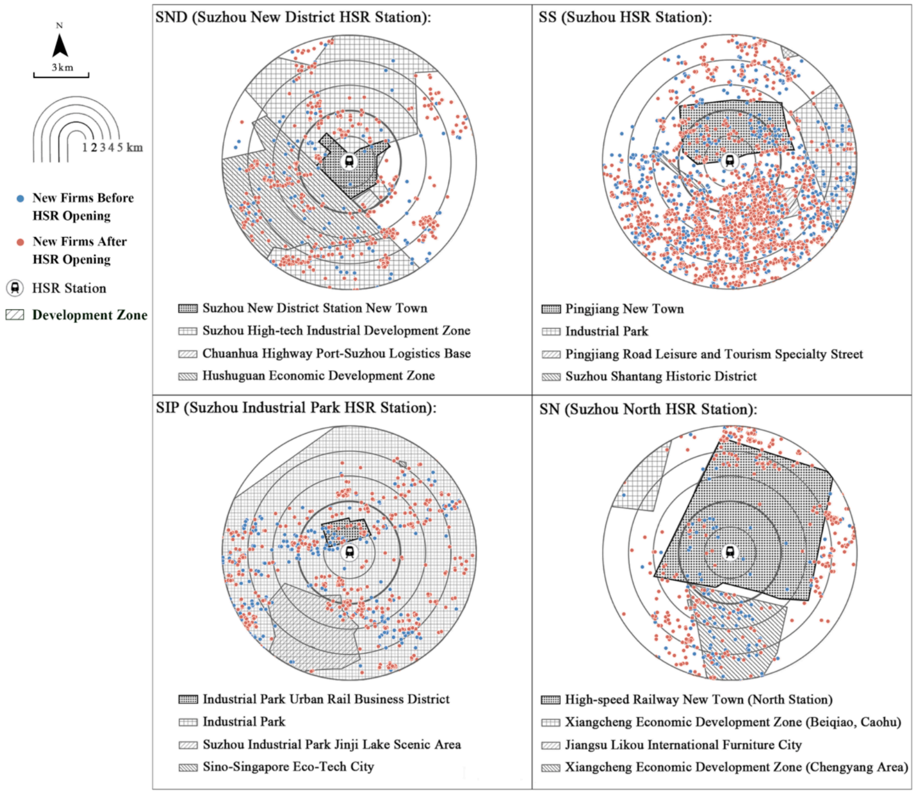

Fig. 3. Industrial geographic distribution around HSR stations before and after HSR inauguration.

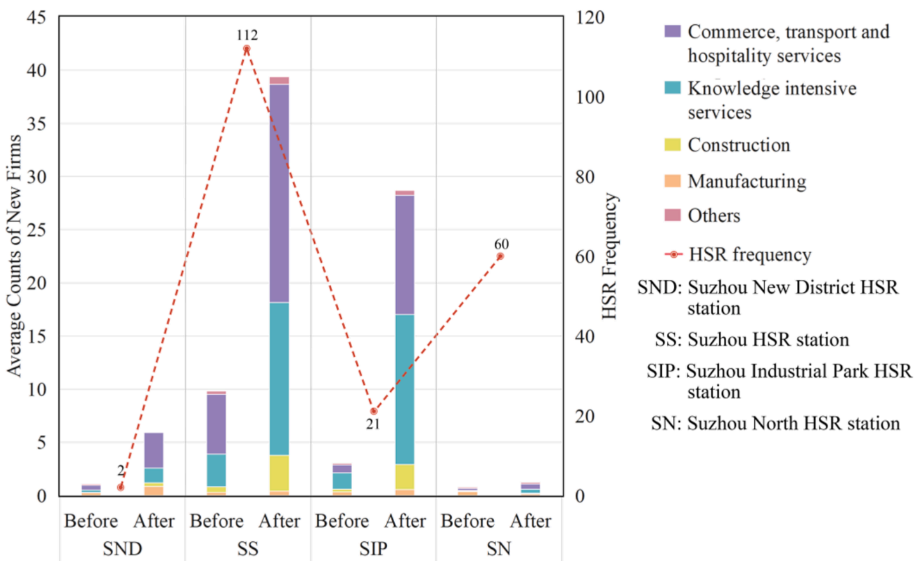

Fig. 4. HSR daily frequencies in 2018 and average counts of new firms within the treated grids by sector before and after HSR inauguration

significantly inhibiting, while the Knowledge Intensive Services remain statistically insignificant.

These findings suggest that the historical shares of new firm entry in sectors such as Construction and Commerce, Transport and Hospitality Services within a grid significantly influences the formation of new firms. The effect is largely because the clustering of these types of firms creates a supportive economic environment, characterised by complementary resources, increased collaboration opportunities, and greater market potential, which together attract new firms to these areas. In contrast, sectors like Manufacturing and others do not contribute to this positive effect; rather, they show a significant inhibitory impact, highlighting the sector-specific

Table 3
Results of benchmark regression.

Variables	Counts of new firms (CFY) (1)	(2)
HSR	12.552***	11.172***
	(3.572)	(3.296)
PMF		−0.008*
		(0.004)
PCF		0.039***
		(0.012)
PCTHSF		0.026***
		(0.008)
PKISF		−0.009
		(0.012)
POF		−0.012*
		(0.007)
_cons	2.444***	2.806***
	(0.085)	(0.134)
Year fixed	Yes	Yes
ID fixed	Yes	Yes
N	21,703	15,784
R-sq	0.334	0.393

Robust standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

dynamics in new firm formation following HSR openings. The lack of significance for the Knowledge Intensive Services may stem from a long-term balance between the benefits of knowledge spillovers and the competitive pressures from market barriers (Sun et al., 2024).

4.2. Dynamic effects

Fig. 5 illustrates the temporal trends of new firms across the five economic sector types, preliminarily revealing that the Commerce, Transport and Hospitality Services, and Knowledge Intensive Services sectors exhibit relatively larger growth magnitudes. In order to rigorously capture the dynamic and diverse effects of HSR opening, multistage DID models were constructed to explore the varying response speeds and degrees of new firm formation across different economic sectors. Specifically, the dummy variable "the 1st year of HSR opening" takes the value of 1 if a spatial grid intersecting the 2 km buffer zone receives HSR service for the first time; otherwise, it is 0. The same setting applies for subsequent years. Columns (1) of Table 4 shows the regression results for the effects of HSR opening on the total counts of new firms for each year starting from the year of HSR inauguration. The result suggests a time-lag effect associated with the opening of HSR, as the significant promotional impact on firm counts becomes evident only in the third year following the opening. Columns (2) to Column (6) in Table 4 show the regression results for new firms across the five economic sector types.

The findings indicate that the Construction sector exhibited the earliest statistically significant response to HSR opening, with new firm growth becoming significant in the third year, earlier than in other sectors. In contrast, the Knowledge Intensive Services and

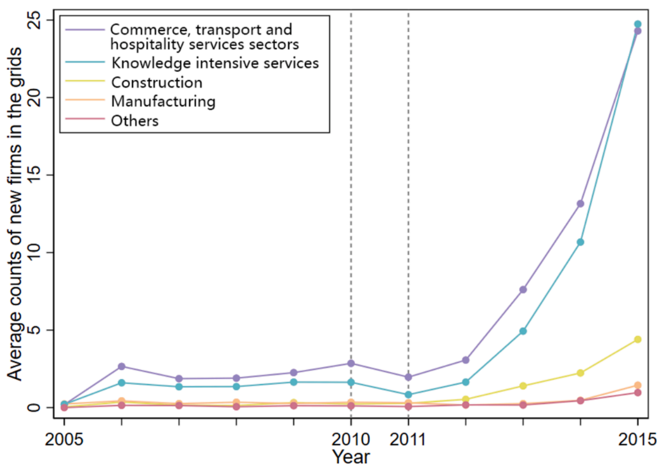

Fig. 5. Temporal trends of the counts of new firms in different economic sectors.

Table 4
Dynamic effects of HSR opening on the counts of new firms in different economic sectors.

Variables	All (1)	Manu-facturing (2)	Construction (3)	Knowledge Intensive Services (4)	Commerce, Transport, and Hospitality Services (5)	Others (6)
The 1st year of HSR opening	0.882	−0.125	0.004	0.229	0.760	0.013
	(2.034)	(0.086)	(0.201)	(0.969)	(0.858)	(0.048)
The 2nd year of HSR opening	−0.354	0.027	0.074	−0.396	−0.023	−0.036
	(2.088)	(0.115)	(0.192)	(0.999)	(0.917)	(0.049)
The 3rd year of HSR opening	1.252	−0.103	0.261*	0.228	0.788	0.078
	(1.816)	(0.072)	(0.150)	(0.901)	(0.796)	(0.066)
The 4th year of HSR opening	8.627***	−0.194**	1.014***	3.038***	4.755***	0.015
	(2.401)	(0.082)	(0.279)	(0.848)	(1.319)	(0.048)
The 5th year of HSR opening	18.753***	−0.262**	1.699***	7.697***	9.345***	0.273***
	(4.315)	(0.113)	(0.404)	(1.808)	(2.117)	(0.090)
The 6th year of HSR opening	60.427***	0.963	4.923***	27.373***	26.218***	0.951***
	(15.332)	(0.601)	(1.367)	(7.673)	(6.169)	(0.299)
_cons	2.436***	0.362***	0.160***	0.837***	1.008***	0.069***
	(0.081)	(0.007)	(0.007)	(0.037)	(0.038)	(0.003)
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes
ID fixed	Yes	Yes	Yes	Yes	Yes	Yes
N	21,703	21,703	21,703	21,703	21,703	21,703
R-sq	0.369	0.431	0.319	0.333	0.385	0.285

Robust standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Commerce, Transport and Hospitality Services sectors displayed generally higher growth magnitudes compared to Manufacturing, Construction, and other sectors, with no significant differences between these two sectors initially. From the fourth year onward, the magnitude of growth in the Commerce, Transport and Hospitality Services sector was significantly higher than that in the other three sectors. By the fifth year, the Knowledge Intensive Services sector also began to show significantly higher growth magnitudes compared to all three other sectors. Wald tests were performed to verify these trends, confirming the statistical significance of the growth discrepancies across sectors over the years following HSR inauguration (see Appendix D1). This progression reflects the differentiated temporal dynamics of HSR-induced opportunities, with knowledge-intensive and consumer-oriented industries benefiting most in the medium to long term. These outcomes may relate to the growing spillover of knowledge in urban innovation (Tang et al., 2021) and the enhancement of economic and trade vitality through network externalities (Liu and Meng, 2024), associated with the gradual expansion of the HSR network in China and the reduction of transport cost.

4.3. Heterogeneity analyses

Analyses based on the complete samples for the whole city could mask potential variations in locations and firm types. Therefore, we explore the heterogeneity of the impact of the HSR opening across different firm types and different HSR stations. As shown in the odd-numbered columns of Table 5, the impact of HSR opening on different economic sectors varies significantly. The counts of new firms in Construction, Knowledge Intensive Services, Commerce, Transport, and Hospitality Services, and other sector types significantly increased following HSR opening, while Manufacturing has not been significantly affected. Robustness checks using logarithmic transformation yield consistent results (see Appendix B4).

Building on this, we further incorporate interactions between HSR dummy variables and dummy variables for four distinct HSR stations, aiming to delineate station-specific impacts. The findings, presented in the even-numbered columns of Table 5, reveal clear heterogeneity in the impacts of HSR opening across different stations and firm types. Overall, the commencement of services at the SS, SIP, and SND stations on the regional HSR line (*Huning*) has markedly increased the counts of new firms in the spatial grids located approximately 2 km from the stations. Among the three HSR stations, SS and SIP show the strongest effects (27.286*** and 23.472**), while SND shows a relatively lower effect (2.735*). In contrast, despite the planned development of Suzhou's high-speed rail new town around the station, the inauguration of the SN station on the national intercity HSR line (*Junghu*) led to a notable decrease in the counts of new firms, with a significant reduction of approximately 2.277, as shown in Column (2) of Table 5. Moreover, it is evident that the opening of SS and SIP stations significantly boosted the counts of new firms in the Construction, Knowledge Intensive Services, Commerce, Transport and Hospitality Services sectors, but not in Manufacturing. Conversely, the opening of SN station exhibits a deterrent effect, while SND station shows no significant impact across any sector type. To further illustrate these distinctions, comparisons between Columns (8) and (10) and other even-numbered columns in Table 5 highlight that the operation of SS and SIP exert a stronger influence in promoting the counts of new firms in Knowledge Intensive Services (10.449*** and 11.652**), and Commerce, Transport and Hospitality Services (13.829*** and 9.461**) relative to the other stations.

4.4. Robustness checks

To establish the credibility of the benchmark results, a series of robustness tests were conducted, namely parallel trend test,

Table 5
Heterogeneity analyses by HSR stations and economic sectors.

Variable	ALL		Manufacturing		Construction		Knowledge Intensive Services		Commerce, Transport, and Hospitality Services		Others	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
HSR	12.552***		0.004		1.141***		5.264***		5.967***		0.177***	
	(3.572)		(0.131)		(0.336)		(1.638)		(1.579)		(0.061)	
HSR*SND		2.735*		0.416		0.138		0.301		1.843		0.037
		(1.606)		(0.424)		(0.098)		(0.320)		(1.263)		(0.038)
HSR*SS		27.286***		−0.042		2.673***		10.449***		13.829***		0.378***
		(7.465)		(0.137)		(0.777)		(2.985)		(3.619)		(0.114)
HSR*SIP		23.472**		0.046		1.965*		11.652**		9.461**		0.348*
		(11.51)		(0.213)		(1.029)		(5.678)		(4.611)		(0.210)
HSR*SN		−2.277***		−0.400***		−0.136***		−0.768***		−0.935***		−0.038*
		(0.485)		(0.090)		(0.038)		(0.285)		(0.171)		(0.021)
_cons	2.444***	2.428***	0.362***	0.361***	0.161***	0.159***	0.841***	0.834***	1.012***	1.004***	0.069***	0.069***
	(0.085)	(0.082)	(0.003)	(0.003)	(0.008)	(0.008)	(0.039)	(0.038)	(0.038)	(0.036)	(0.001)	(0.001)
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ID fixed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	21,703	21,703	21,703	21,703	21,703	21,703	21,703	21,703	21,703	21,703	21,703	21,703
R-sq	0.334	0.341	0.429	0.430	0.290	0.298	0.296	0.304	0.354	0.362	0.274	0.276

Robust standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

propensity score matching, exclusion of geographical factors, and placebo test.

4.4.1. Parallel trend test

To ensure that changes in the treatment and control groups prior to the opening of HSR were approximately the same, a parallel trend test was conducted by replacing the dummy variables in the DID baseline model with dummy variables for each year of the study period. Given the limited sample size in the sixth year preceding policy implementation, tail truncation was applied, setting the time window to [-5, 5], with the year immediately preceding HSR opening used as the baseline year to avoid multiple covariance.

$$CFY_{it} = \alpha_0 + \sum\nolimits_{p=-5}^{5} \beta_0 \times HSR_{it}^{p} + \gamma_0 \times X_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (2)$$

In Equation (2), p identifies the time when HSR services began. p = -5 to p = -2 refers to the fifth to the second year before HSR opening, during which HSR_{it}^{p} is set to 0; p = 1 to p = 5 refers to the first to the fifth year after HSR opening, during which HSR_{it}^{p} is set to 1. No dummy variable is defined for the baseline year (p = -1).

Fig. 6 presents parameter estimates within a 95 % confidence interval spanning 10 years, after controlling for all fixed effects. Prior to HSR opening, the coefficients of HSR opening in each year do not significantly differ from zero, demonstrating no evidence of meaningful differential trends in the counts of new firms before HSR opening. The parallel trend test thus supports the validity of the DID estimation of the promotional effect. Furthermore, the treatment effect of HSR opening gradually increases over the subsequent years following inauguration, with the effect becoming statistically significant from the third year onwards (see Table C1 in Appendix C).

4.4.2. Propensity score matching (PSM-DID) test

Considering that the opening of HSR may be non-random, there may be bias in sample selection. Propensity score matching (PSM) can effectively address sample selection bias by matching the treatment group with a control group that satisfies the “parallel trend” assumption, using a probabilistic regression model to calculate the propensity score based on the core explanatory variables and covariates (Austin, 2011). Specifically, the 1:1 nearest-neighbor matching method with a matching radius of 0.001 was utilised to pair grids in the control group with their closest counterparts in the treatment group. All control variables from the benchmark regression were used as covariates to estimate the propensity scores via a logit model, which calculated the conditional probability that a grid would be assigned to the treatment group. The PSM-DID estimation was then performed to compute the average treatment effect.

$$CFY_{it}^{PSM} = \alpha_1 + \beta_1 \times HSR_{it} + \gamma_1 \times X_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (3)$$

where CFY_{it}^{PSM} denotes the counts of new firms per year in each grid after matching; the other variables are defined similarly to those in Equation (1).

The balance test results, shown in Fig. 7, indicate that most feature covariates between the treatment and control groups were significantly different before matching, whereas the absolute values of standard deviation fell below 20 after matching, suggesting that these differences were no longer significant. Therefore, it can reasonably be inferred that the covariates used for matching were appropriate, and that the outcomes derived from the nearest neighbor matching method are robust. The regression results based on PSM-DID, shown in Column (1) of Table 6, further support the main conclusion of baseline regression. That is, after accounting for sample endogeneity, the opening of HSR still significantly boosts the counts of new firms within a 2 km radius.

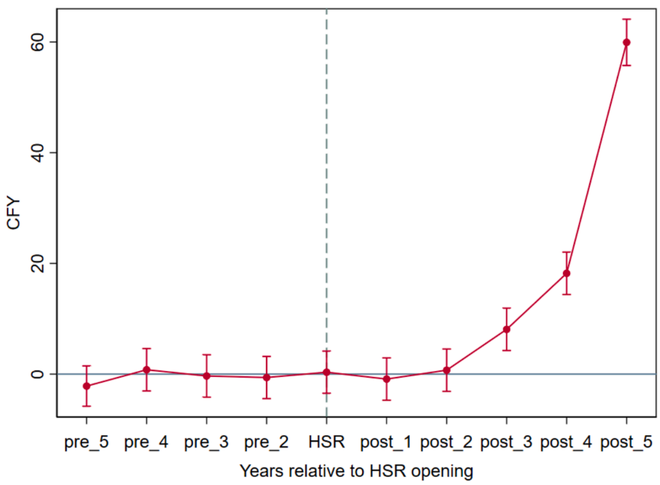

Fig. 6. Regression coefficients for the parallel trend test before and after high-speed rail opening.

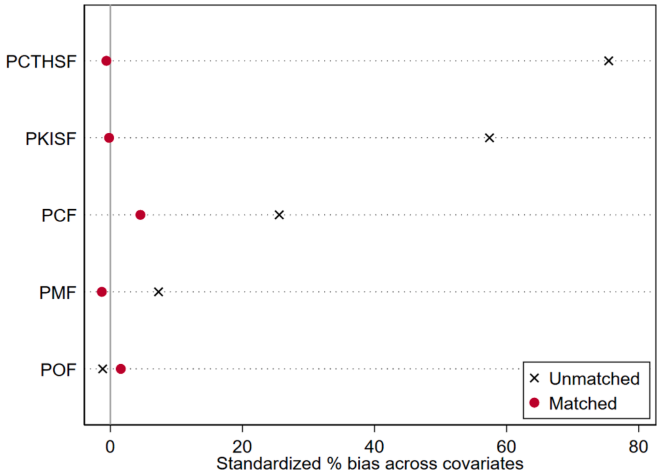

Fig. 7. Deviation diagram of PSM treatment results.

Table 6
Robustness test results.

Variables	PSM-DID (1)	Excluding development zones (2)	Excluding old town centre (3)	Keeping control groups within 5 km buffers (4)	Excluding non-HSR district (Wuzhong) (5)
HSR	11.168***	45.120***	10.099**	7.665**	11.776***
	(3.296)	(10.742)	(4.242)	(3.636)	(3.572)
_cons	2.997***	1.898***	1.889***	6.589***	3.285***
	(0.108)	(0.027)	(0.079)	(0.444)	(0.160)
Year fixed	Yes	Yes	Yes	Yes	Yes
ID fixed	Yes	Yes	Yes	Yes	Yes
N	15,784	11,814	21,010	4235	11,517
R-sq	0.392	0.407	0.298	0.345	0.329

Robust standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

4.4.3. *Exclusion of geographical factors*

The robustness of the treatment effect of HSR opening is further enhanced by examining samples excluding four geographical factors to mitigate confounding effects on new firm formation. These factors are development zones, the old town centre, 5 km buffers, and non-HSR urban district. Development zones in China are designated areas targeted by state investments and incentives (both central and local) to foster economic growth, providing specific policy supports to attract new firms before spatial spillovers occur.

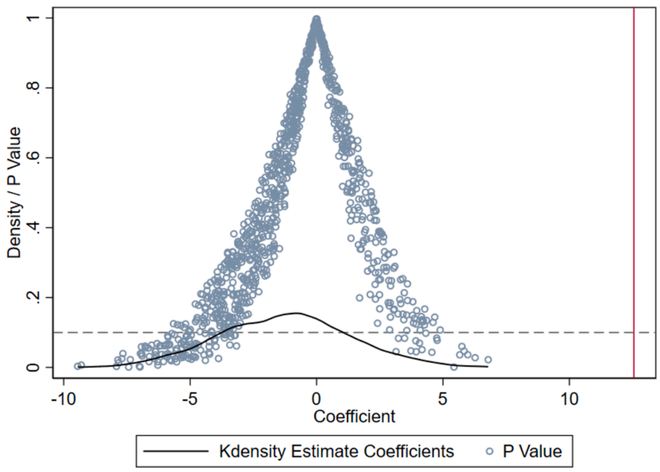

Fig. 8. Placebo test results.

Column (2) of Table 6 shows the regression results excluding samples located within development zones. Additionally, the economy of old urban districts in Suzhou is likely to be more developed, which could bias the spatial distribution of new firm samples. Column (3) excludes samples from the old town (Gusu district). Moreover, to mitigate the confounding effects of broader spatial disparities, this study restricts the control group to grids within a 5 km radius of an HSR station, as shown in Column (4), ensuring a more accurate assessment. Furthermore, since Wuzhong District in Suzhou does not have an HSR station, Column (5) presents DID regression results after excluding samples from this area. These sub-sample regression results demonstrate that the coefficient of HSR opening remains significantly positive after controlling for geographically relevant factors, thereby underscoring the reliability of the baseline regression findings.

4.4.4. Placebo tests

In order to eliminate the possibility of spurious estimates, placebo tests were conducted by randomly generating dummy variables (Jia et al., 2021). Specifically, the original treatment groups were randomly permuted to create placebo treatment groups. The dummy variables were incorporated into a DID regression analysis, and key statistics such as regression coefficients and p-values were recorded through 1,000 repetitions of the procedure. Fig. 8 illustrates the kernel density distribution of the estimated coefficients, along with the corresponding distribution of p-values.

The placebo results show that the true estimated coefficient from the DID benchmark (indicated by the vertical line) significantly exceeds the maximum of the randomised estimates, and that most p-values are above 0.1 (indicated by the horizontal dashed line), suggesting that the baseline regressions results are robust against randomness and not unduly influenced by omitted variables.

5. Discussion

This paper examines the intra-city dynamism introduced by the opening of HSR and its impact on new firm formation and economic clustering. We investigate several inter-related questions: whether HSR induces new firm formation, the timing of these effects, the specific sectors impacted (with a focus on the Knowledge Intensive Services, Commerce, Transport, and Hospitality Services, Manufacturing, Construction) and locational heterogeneity.

Using a natural quasi-experimental design, our findings illustrate the causal effects of HSR operation. DID estimation reveals that HSR significantly boosts new firm formation around HSR stations. This effect persists after controlling for historical agglomeration and conducting robustness tests. Baseline regression analysis highlights that historical accumulation in Construction, Commerce, Transport and Hospitality Services, as well as Knowledge Intensive Services, significantly enhancing new firm formation. Dynamic models further confirm two sectors—Commerce, Transport, and Hospitality Services, as well as Knowledge Intensive Services—benefit most from the inauguration of HSR, while Construction firms show an earlier but weaker response. Additionally, heterogeneity analyses confirm that on the *Huning* line, HSR particularly supports growth in new firms in these two sectors near Suzhou Station (SS) and Suzhou Industrial Park (SIP) station, both located close to well-developed urban districts with frequent HSR services. In contrast, Suzhou New District (SND) station, which has a relatively lower HSR frequency, does not exhibit a similarly significant response. On the national *Jinghu* line, the newly constructed Suzhou North (SN) station has not triggered the expected economic growth within five years of HSR integration. Synthesising these findings suggests that HSR arrival in Suzhou catalyses growth and clustering in specific industries, accelerates new firm formation and optimises local economic restructuring. The most pronounced effects are observed near HSR stations close to developed urban districts.

The following interpretations can be drawn from the findings. First, the enhanced connectivity and reduced travel times associated with HSR services lower the transaction costs and facilitate quicker access to expanding markets and resources, strengthening Suzhou's capacity to cultivate an environment conducive to the development of agglomeration economies. The reinforced clustering of industries around HSR stations located near the most developed urban districts tends to create a dynamic business environment that fosters knowledge spillover and innovation. Such agglomeration effects are known to generate substantial positive externalities and further benefit from HSR-related network externalities, which in turn attract a higher concentration of firms seeking to capitalise on these advantages. Consequently, the presence of HSR catalyses a virtuous cycle of growth and development, significantly enhancing both the local and wider regional economic landscape. Moreover, the opening of HSR effectively reduces communication costs between firms, optimises resource allocation efficiency (Li et al., 2020), and is accompanied by improvements and investments in infrastructure and logistics, illustrating the early reaction observed in the Construction industries. While the impact on the Manufacturing sector was not significant, this finding aligns with previous research (Matas et al., 2020). Specifically, Manufacturing firms rely more on stable production bases and freight services, and the increased personnel mobility brought by HSR have limited impact on this sector.

Second, the regression results on location heterogeneity confirm that the impact of HSR opening varies across different HSR station locations and lines. This variation could be attributed to differences in HSR station characteristics, such as train frequency, geographic location, connectivity, and surrounding land use. The enhanced positive effects, particularly observed in areas with higher train service frequency and stronger economic foundations and infrastructure (Deng et al., 2020a), suggest that HSR stations should not be located too far from city centres. In our study, the stronger economic impacts observed at SS and SIP stations support this argument. SS, located in the city centre, has the highest train frequency and is well-connected to public transport (Wu et al., 2021), likely enhancing its attractiveness to surrounding businesses. Similarly, SIP, situated in the city's primary development zone to the east (Wei et al., 2009) and planned as a new urban center, exhibits a stronger economic impact compared to SND, another development zone station. The relatively weak impact observed at SND could potentially be attributed to the lack of connectivity between high-speed rail station and the rail transit network (Chen, 2018). HSR stations with transit connections experienced a significant increase in new firm formation following HSR opening while no such effect was observed at HSR stations without these connections (See Appendix E for details). Another key consideration is that for existing industrial clusters (various development zones created before HSR), new firms tend to emerge within or near these areas, favouring established business locations. HSR arrival does not appear to drive relocation to new station areas. Instead, factors like talent pools, existing firm networks, and good overall transport connectivity are more decisive. This is supported by insights from a start-up founder in Suzhou Industrial Park's Creative Industrial Parks (Chen, 2020) and our statistically significant results showing enhanced economic clustering for both Knowledge Intensive and Commerce, Transport, and Hospitality Services. This finding also echoes the findings of Artz et al. (2016), who observed that new firms tend to agglomerate in existing clusters from the perspective of intra-city dynamism.

In contrast, newly developed areas around HSR stations outside existing agglomerations have not yet demonstrated such capability, as exemplified by Suzhou North (SN) station. Often, government-led initiatives or investments are created to stimulate new firm formation. For instance, the locational advantage of access to wider markets and clients from the HSR network externalities attracted new start-up firms to register within the government-led incubator in the SN station zone (Chen, 2020). A potential explanation for the subdued effect is that rural villages, agricultural land, and ecological areas to the north of Suzhou North Station constrain economic development around the station, making it difficult to integrate and sustain growth across both the northern and southern built-up areas. Existing studies indicate that the location and accessibility of HSR stations are crucial prerequisites influencing new firm site selection (Ureña et al., 2009). A travel satisfaction study conducted at three HSR stations, including Suzhou North Station (Hickman et al., 2015), indicates that, due to the absence of integrated metro services when the HSR services first commenced, reliance solely on buses, taxis, and private cars for transfers, coupled with a lack of supporting infrastructure, led to a higher rate of dissatisfaction with the travel experience and a noticeable lack of urban vitality at Suzhou North Station compared to other stations. This issue of urban vitality is also captured in Wang et al. (2022). Although this accessibility issue could be addressed to some extent following the availability of metro services linking the station with wider urban districts, as Zhu et al. (2015) argue, this poor accessibility location of out-of-town new HSR stations reflects the weaker negotiation power of non-central prefectural-level cities, such as Suzhou, compared to larger regional cities like Nanjing or Shanghai. Moreover, the variations in new firm formation across the two HSR lines suggest differing economic impacts between regional and national networks. The *Jinghu* line, serving a national network, may require longer timeframes and more strategic infrastructure development for Suzhou North station to realise its full economic potential. This implies that, at least initially, national HSR lines such as *Jinghu* are less effective in attracting new firms compared to regional lines such as *Huning*.

The methodology developed in this study is not restricted to the specific attributes of Suzhou, and the observed patterns are likely applicable to other cities with similar conditions. The opening of HSR stations in Chinese cities has led to two main development models, including urban expansion represented by new town development, and reinforcement of the original city centre through urban redevelopment (Yin et al., 2015). Suzhou North HSR Station, as discussed in this study, exemplifies the former model, as it is located outside the existing built-up area. Similarly, along the *Jinghu* HSR Line, Wuxi East and Cangzhou West HSR stations follow the new town development model, positioned on the outskirts and facing challenges such as limited initial infrastructure and significant development potential (Su and Yu, 2022). Additionally, the suppressive effect of HSR on new firm formation around Suzhou North Station aligns with the findings of Wang and Gu (2019a), highlighting how remote location and limited accessibility have hindered local development. A parallel situation is observed in Changzhou, where the slow pace of development around North Station reflects a misalignment with the city's southeastern economic strategies (Wang and Gu, 2019c). Echoing these observations, Diao et al. (2017) found that suburban HSR stations in Guangzhou failed to significantly boost property values, suggesting that poor accessibility and greater distances can diminish the anticipated benefits of intercity HSR travel. Collectively, these cases illustrate that HSR's effectiveness in stimulating economic growth depends crucially on its integration with urban planning and alignment with city development strategies.

6. Conclusion and policy implications

This study offers new empirical evidence to shed light on the intra-city dynamism of new firm formation and economic clustering brought about by HSR. Our comprehensive analysis confirms that the inauguration of HSR significantly promotes the increase in the counts of new firms, and that its effects exhibit time lags, as well as locational and sectoral heterogeneity. Firstly, among all sectors, Knowledge Intensive Services as well as Commerce, Transport and Hospitality Services firms show the highest responsiveness to the inauguration of HSR. Conversely, although the Construction sector exhibits slower growth rates, it demonstrates a quicker response to HSR access. Secondly, HSR stations located near the city centre and Industrial Park district demonstrate a significantly greater positive impact on the establishment of new firms compared to the other stations along the same HSR line. However, the inauguration of the national trunk line station located in a peripheral area of the city, despite connections to national core cities like Beijing and Shanghai, significantly inhibits new firm birth there.

This paper makes several contributions. First, to our best knowledge, it is the first study to comprehensively examine the causal impact of HSR on intra-city firm dynamism, utilising a robust analytical framework that disaggregates data by firm type and geographical location of new firm formation, thereby addressing underexplored aspects in the existing literature. Second, this paper contributes to the literature on agglomeration economies by offering a finer lens into different locations within cities served by HSR. Our study confirms the overall positive impact of HSR on the entry of new firms and highlights the variation in these effects across different economic sectors. Firms in Commerce, Transport and Hospitality Services, and Knowledge Intensive Services benefit and react most evidently to HSR. Third, our findings also contribute to a deeper understanding of the varied temporal dynamism among different groups of firms in response to the arrival of HSR, collectively strengthening the evidence for agglomeration effects. Fourth, this study contributes to the literature and urban strategy discussions concerning the role of HSR in driving new urban development around new HSR station areas. Our results show that, although there is an overall causal impact of HSR on new firm formation within the 2 km buffer zone around stations, the proximity benefits are significant only for new firms located near the most developed urban districts rather than in newly built areas. Finally, this paper contributes to the winner–loser debate between central and non-central cities connected by HSR. A study focused on Suzhou North Station from 2015 to 2019 (Zhou and Zhang, 2021) reveals that, influenced by the development of manufacturing in Shanghai, the station has positively impacted the surrounding area's Manufacturing sector. However, the Services sectors have not experienced similar growth but have faced setbacks. This underscores that the effects of HSR are dynamic and multi-dimensional, influenced not only by the local economic structure but also by the economic dynamics of neighbouring regional centers.

Care needs to be taken in trying to transfer the results from this study to other cities as they are conditioned by the specific geographical, spatial and industrial structures. Nevertheless, the findings highlight key parameters that need to be taken into account when attempting to replicate such a study elsewhere. They also offer several policy implications that could be applied beyond the city examined here. First, the arrival of HSR further stimulates the development of services within an HSR city, particularly in Knowledge Intensive Services, as well as in Commerce, Transport, and Hospitality Services sectors. Urban industrial policy leveraging HSR accessibility should therefore strategically support these sectors while mitigating competitive displacement across established economic clusters. Second, for non-central prefectural cities considering the development of integrated station-city areas in peripheral locations, it is crucial to address the inherent challenges such as weaker initial development, limited accessibility, and lower negotiation power. In this context, policies should prioritise careful station-site selection and spatial planning, ensuring the surrounding land is suitable for development. Special attention should be given to attracting specific economic clusters — such as Construction, Commerce, Transport, and Hospitality Services — to stimulate early-stage economic growth. At the same time, to support the growth of these emerging firms, it is advisable to direct manufacturing and other industries less dependent on HSR to areas beyond the immediate station vicinity, thereby minimising potential land-use conflicts. Third, for HSR stations located in newly developed zones, effective integration with public transport systems—especially rail-based modes such as the subways and trams—is critical to fully realise the economic potential of these areas. The frequency of train services and its impact on surrounding economic activities must also be considered. Integrated and strategic planning should address these factors to ensure that the HSR station serve as a true anchor for driving spatial and economic development.

Lastly, this paper also has some limitations. This study covers the period from 2005 to 2015, with the inauguration of HSR occurring in 2010 and 2011. Given the relatively short timeframe after the commencement of HSR, the analysis primarily captures short-term effects rather than providing a comprehensive assessment of long-term impacts. Patience and strategic intervention would be required to realise realistic long-term effects. Furthermore, the lack of annual HSR frequency data for each station limits our ability to analyse how variations in service frequency might affect the spatial distribution of new firms. Moreover, our current data do not allow us to determine whether the clustering of new firms around HSR stations is driven by reduced debt financing barriers, relocation from non-station areas, or other unaccounted factors. These limitations highlight areas that warrant further investigation in future research.

CRediT authorship contribution statement

Lan Wang: Supervision, Methodology. **Jia Tao:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Formal analysis. **Wenyao Sun:** Validation, Software, Methodology. **Chia-Lin Chen:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Zhenhua Chen:** Writing – review & editing, Writing – original draft. **Po-Chen Lin:** Software, Data curation. **Roger Vickerman:** Writing – review & editing, Writing – original draft, Methodology.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Apart from the RDF (Research Development Fund) granted by Xian Jiaotong-Liverpool University (XJTLU), China to the corresponding author, this paper also received a small grant awarded by Research Institute of Future Cities, XJTLU (Grant number: RIFC-2018-01). In addition, the authors would like to thank a number of people who kindly helped during the process of producing this paper over the past few years, including the local government officer who provided the raw datasets and two research assistants, namely Danny Hartono and Huiyao Dai.

Appendix A. Data and methods

A1. HSR frequency

Table A1 shows that Suzhou HSR Stations consistently hold the highest train frequency, while Suzhou North HSR Station has seen a gradual increase in its service frequency in recent years.

Table A1
Inter-city HSR frequency between Suzhou and Shanghai on a typical weekday.

HSR station	HSR frequency in 2018	HSR frequency in 2024
Suzhou New District HSR Station (SND)	2	8
Suzhou HSR Station (SS)	112	149
Suzhou Industrial Park HSR Station (SIP)	21	21
Suzhou North HSR Station (SN)	60	81

Source: 12306 China Railway (July 2018 and December 2024).
Note: Both D-trains (conventional high-speed trains) and GC trains (high-speed rail/intercity trains) are included.

A2. Classification Description

The SIC category specifies the classification and codes of economic activities of the whole society. In this study:

The "Manufacturing" sector refers to group C (Manufacturing).

The "Construction" sector refers to group E (Construction).

The "Knowledge Intensive Services" sector includes groups I (Information Transmission, Computer Service and Software), J (Financial Industries), K (Real Estate Industries), L (Leasing and Business Service Industries), M (Scientific Research, Technical Service and Geologic Prospecting), P (Education), and R (Culture, Sports and Entertainment).

The "Commerce, Transport and Hospitality Services" sector includes groups F (Wholesale and Retail Trade), G (Transportation, Storage and Post), and H (Hotel and Catering Services).

The "others" sector consists of groups A (Farming, Forestry, Animal Husbandry and Fishery), B (Mining and Quarrying), D (Electric Power, Gas and Water Production and Supply), N (Water Conservancy, Environment and Public Facility Management), O (Resident Service and Other Service Industries), and Q (Health Care, Social Security and Social Welfare).

The distinction between the different industry groupings is based on the understanding that HSR does not affect all economic activities with the same intensity.

Appendix B. Baseline regression

B1. HSR impact radius test

We began the study with a 1 km buffer around HSR stations, increasing the radius by 1 km in each iteration. Each buffer zone, representing specific spatial grids, served as the treatment group. Statistical analysis within each zone assessed the average count of new firms and the impact of HSR. Table B1 shows that HSR's impact on new firm formation follows an inverted U-shape, with the 2 km buffer zone exhibiting the highest average CFY.

Table B1
Statistics on average CFY and treatment effects divided with each buffer zone.

Variables		1 km	2 km	3 km	4 km	5 km
DID Regression	HSR(1 km)	5.777*				
		(2.970)				
	HSR(2 km)		12.552***			
			(3.572)			
	HSR(3 km)			8.873***		
				(2.161)		
	HSR(4 km)				8.170***	
					(1.504)	
	HSR(5 km)					7.012***
						(1.125)
	_cons	2.693***	2.444***	2.358***	2.161***	2.029***
		(0.026)	(0.085)	(0.094)	(0.107)	(0.115)
	Year fixed	Yes	Yes	Yes	Yes	Yes
	ID fixed	Yes	Yes	Yes	Yes	Yes
	N	21,703	21,703	21,703	21,703	21,703
	R-sq	0.327	0.334	0.333	0.335	0.335
Average CFY	Treated	7.080	11.768	9.360	8.484	7.525
		(23.093)	(46.283)	(38.180)	(34.289)	(30.555)
	Control	2.669	2.312	2.143	1.837	1.584
		(15.325)	(12.053)	(11.203)	(9.300)	(8.074)
Counts of grids	Treated	33	90	164	269	385
	Control	1940	1883	1809	1704	1588

Robust standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

B2. Lag periods setting of control variables

Table B2 presents results controlling for lagged (1-, 2-, and 3-year) historical industry shares, with consistent findings across specifications. The impact of HSR remains significant.

Table B2
Results of benchmark regression under different lag period settings for control variables.

Variables	**Counts of new firms per year (CFY)**			
	Baseline	n = 1	n = 2	n = 3
	(1)	(2)	(3)	(4)
HSR_t	**12.552*****	**11.459*****	**11.686*****	**11.172*****
	(3.572)	(3.444)	(3.422)	(3.296)
PMF_{t-1}^{t-n}		0.001	−0.006	**−0.008***
		(0.003)	(0.004)	(0.004)
PCF_{t-1}^{t-n}		**0.048*****	**0.037*****	**0.039*****
		(0.009)	(0.010)	(0.012)
$PCHTSF_{t-1}^{t-n}$		**0.033*****	**0.027*****	**0.026*****
		(0.006)	(0.007)	(0.008)
$PKISF_{t-1}^{t-n}$		**0.029*****	0.004	−0.009
		(0.006)	(0.010)	(0.012)
POF_{t-1}^{t-n}		−0.003	−0.010	**−0.012***
		(0.006)	(0.006)	(0.007)
_cons	2.444***	2.060***	2.449***	2.806***
	(0.085)	(0.133)	(0.139)	(0.134)
Year fixed	Yes	Yes	Yes	Yes
ID fixed	Yes	Yes	Yes	Yes
N	21,703	19,730	17,757	15,784
R-sq	0.334	0.356	0.370	0.393

Robust standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

B3. Supplementary validation by accounting for historical agglomeration effects

The two-step system GMM regression accounts for time-series dependencies and autocorrelation, using the core explanatory variable, its lags, and the lagged dependent variable as instruments. A significant HSR effect, independent of historical agglomeration dynamics, suggests a lasting boost to new firm growth. The equation is as follows:

$$CFY_{i,t} = \alpha + \beta \times CFY_{i,t-1} + \sum_{k=0}^{1} \gamma_k HSR_{i,t-k} + \tau_i + \varphi_t + \sigma_{i,t}$$

Where φ_t and τ_i represent the fixed effect for time and individual grids, respectively.

Table B3 shows that both lagged new firm counts and HSR introductions significantly impact current firm formation, highlighting the persistent influence of HSR.

Table B3
Results of GMM regression.

Variables	CFY
Lag.CFY	1.895***
	(0.096)
HSR	20.594*
	(10.740)
Lag.HSR	4.721***
	(1.672)
_cons	−34.161**
	(15.537)
Year fixed	Yes
ID fixed	Yes
N	19,730
AR(1)	0.000
AR(2)	0.229
Sargan	0.000
Hanse	0.996

Robust standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

B4. Elasticity Interpretation of coefficients via logarithmic Transformations

The results in Table B4 confirm robustness and are consistent with those of the untransformed model. Column (1) shows a 35.1 % increase in new firm counts following HSR opening. Columns (2) to (6) highlight the robust impact of HSR on sector-specific development.

Table B4
DID regression results with logarithmic transformation.

Variables	Ln(CFY) (1)	Ln(CMF) (2)	Ln(CCF) (3)	Ln(CKISF) (4)	Ln(CCTHSF) (5)	Ln(COF) (6)
HSR	0.351***	−0.027	0.221***	0.294***	0.358***	0.078***
	(0.094)	(0.035)	(0.050)	(0.066)	(0.082)	(0.021)
_cons	0.458***	0.163***	0.068***	0.202***	0.239***	0.039***
	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.000)
Year fixed	Yes	Yes	Yes	Yes	Yes	Yes
ID fixed	Yes	Yes	Yes	Yes	Yes	Yes
N	21,703	21,703	21,703	21,703	21,703	21,703
R-sq	0.718	0.550	0.437	0.626	0.646	0.304

Robust standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Appendix C. Robustness checks of DID baseline regression

C1. Parallel trend test

Fig. C1 demonstrates parallel trends in average CFY prior to HSR inauguration, with minimal pre-treatment differences and clear post-inauguration divergence. Table C1 indicates that HSR openings had no significant effects until Year 3, after which steady growth is observed.

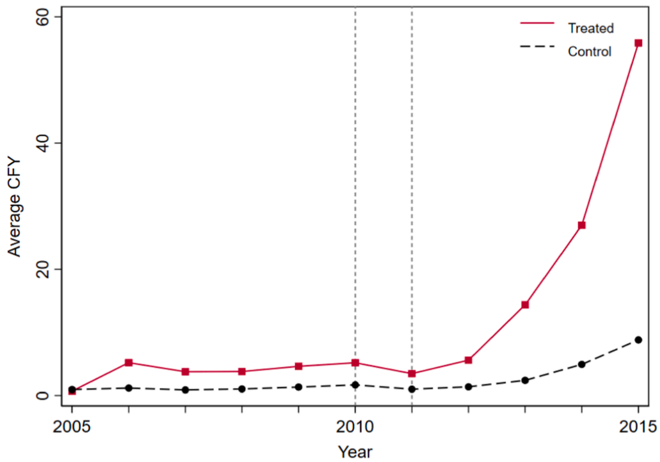

Fig. C1. Trends in Average CFY before and after HSR opening.

Table C1
Parallel trend test results.

Variables	CFY
pre_5	−2.158
	(2.676)
pre_4	0.790
	(2.723)
pre_3	−0.334
	(2.745)
pre_2	−0.612
	(2.689)
post_0	0.348
	(2.610)
post_1	−0.893
	(2.659)
post_2	0.713
	(2.450)
post_3	8.089***
	(2.914)
post_4	18.214***
	(4.630)
post_5	59.929***
	(15.418)
_cons	2.460***
	(0.110)
Year fixed	Yes
ID fixed	Yes
N	21,703
R-sq	0.370

Robust standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

C2. PSM-DID estimation

Table C2 reports the results of the matching balance test. The results show that the p values of all control variables after matching are much greater than 0.01, indicating no marked differences between the matched samples in the treatment and control groups.

Table C2
PSM processing results.

Variable		Mean Treated	Control	% bias	% reduct |bias|	t-test t	p>|t|
PMF	U	15.487	13.369	7.3	82.3	1.91	0.056
	M	15.487	15.862	−1.3		−0.25	0.806
PCF	U	4.359	1.861	25.6	82.2	7.41	0.000
	M	4.359	3.914	4.6		0.80	0.425
PCTHSF	U	32.837	11.166	75.5	99.2	23.31	0.000
	M	32.837	33.009	−0.6		−0.10	0.921
PKISF	U	22.719	8.501	57.4	99.7	17.34	0.000
	M	22.719	22.766	−0.2		−0.03	0.974
POF	U	1.821	1.932	−1.2	−35.7	−0.28	0.783
	M	1.821	1.671	1.6		0.35	0.728

C3. Excluding real estate industry from knowledge intensive sector

Table C3 highlights the consistent statistical significance of the HSR variable and all control variables after reclassifying the real estate sector from "Knowledge Intensive Services" to the "Other" sector.

Table C3
Results of Benchmark regression after sectoral reclassification.

Variables	CFY
HSR	11.149***
	(3.296)
PMF	−0.008*
	(0.004)
PCF	0.039***
	(0.012)
PCTHSF	0.027***
	(0.008)
PKISF	−0.003
	(0.012)
POF	−0.022**
	(0.009)
_cons	2.785***
	(0.138)
Year fixed	Yes
ID fixed	Yes
N	15,784
R-sq	0.393

Robust standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Appendix D. Dynamic regression

D1. Wald test

Wald test statistics evaluate the sector-specific impacts of HSR openings, with results detailed in Table D1. Fig. D1 visualises these findings by year, illustrating the dynamic effects across sectors. These analyses confirm our conclusions regarding the varying impacts of HSR openings.

Table D1
Coefficient comparisons between economic sectors across different years following HSR opening.

Coefficient Comparison		1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
Knowledge Intensive Services	Manufacturing	0.13	0.18	0.13	7.69**	19.31***	11.77***
	Construction	0.05	0.21	0.05	2.10	10.49***	8.29**
	Commerce, Transport and Hospitality Services	0.17	0.08	0.17	0.76	0.35	0.01
	Others	0.05	0.13	0.05	5.34**	16.83***	11.84***
Commerce, Transport and Hospitality Services	Manufacturing	1.05	0.00	1.24	6.85**	20.56***	16.61***
	Construction	0.73	0.01	0.23	3.95*	12.60***	11.36***
	Others	0.76	0.00	0.76	6.12**	18.35***	16.74***
Construction	Manufacturing	0.35	0.04	4.78*	5.09**	21.81***	7.03**
	Others	0.00	0.31	0.02	2.88	11.85***	8.05**
Manufacturing	Others	1.94	0.26	3.42	0.01	13.63***	0.00

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

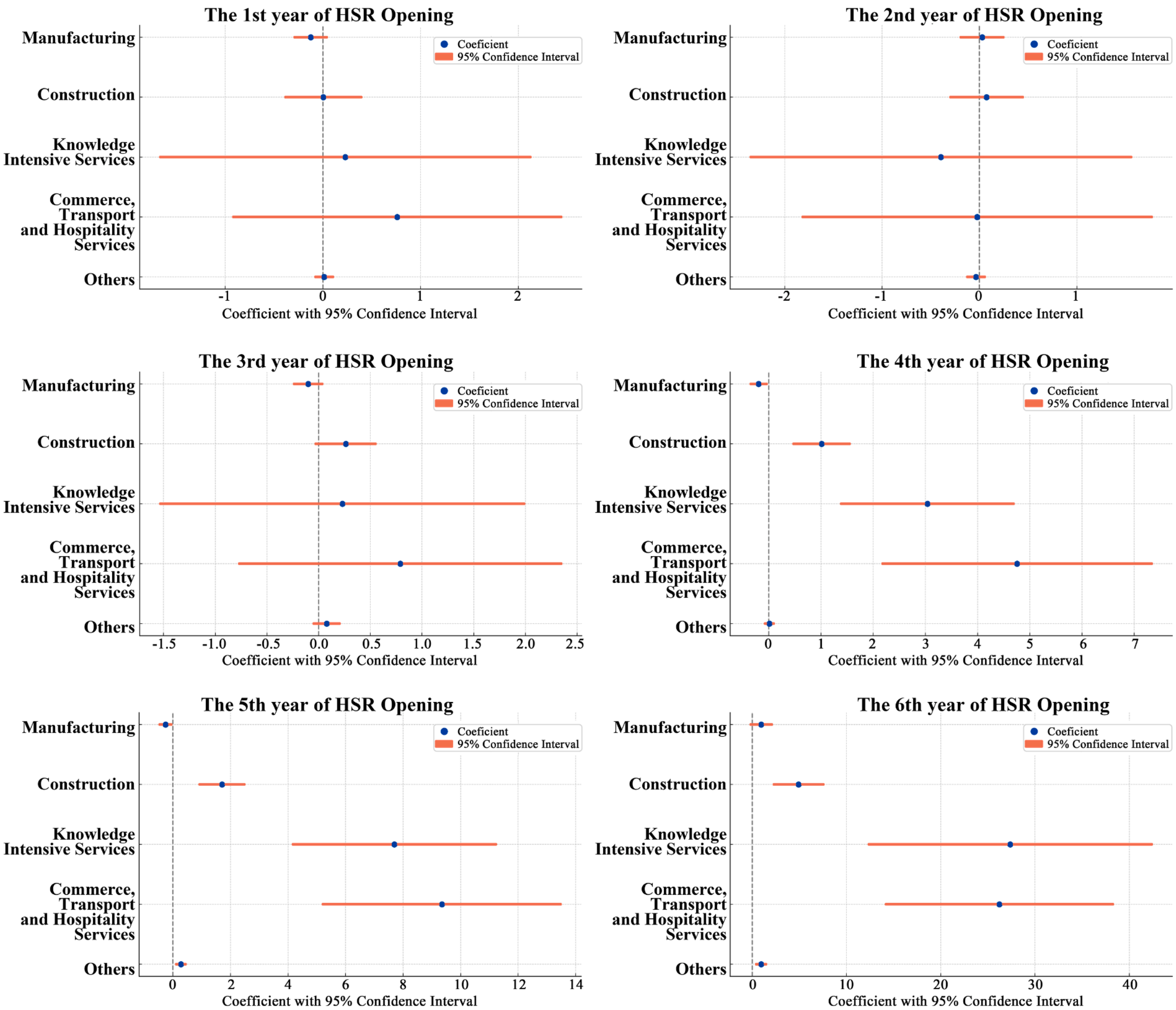

Fig. D1. Coefficients characterising the dynamic effects of HSR opening on new firms of different economic sectors.

D2. Dynamic validation considering historical agglomeration effects in each sector

Table D2 shows significant lagged effects of HSR opening across sectors, except for manufacturing, where the effects are insignificant in the current effects. A generalised least squares estimation was used, accounting for heteroscedasticity across panels and autocorrelation within panels.

Table D2
Results of dynamic equations for each economic sector.

Variables	CMF (1)	CCF (2)	CCTHSF (3)	CKISF (4)	COF (5)
HSR	−0.156**	−0.180	−0.015	−0.674	−0.012
	(0.078)	(0.110)	(0.393)	(0.419)	(0.033)
L.HSR	0.178	0.797***	2.655***	2.361***	0.176**
	(0.134)	(0.204)	(0.821)	(0.729)	(0.069)
L.CMF	0.292***				
	(0.044)				
L.CCF		1.057***			
		(0.149)			
L.CCTHSF			1.180***		
			(0.131)		
L.CKISF				1.808***	
				(0.196)	
L.COF					0.332***
					(0.078)
_cons	0.276***	0.052**	0.204*	−0.076	0.055***
	(0.015)	(0.021)	(0.111)	(0.119)	(0.005)
N	19,730	19,730	19,730	19,730	19,730
R-sq	0.477	0.578	0.672	0.766	0.342

Robust standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Appendix E. Supplemental heterogeneity regression

Two dummy variables, TA and TN, were created to interact with the HSR variable, indicating whether the HSR station is within walking distance of rail transit. When a station is accessible, TA = 1 and TN = 0; otherwise, TA = 0 and TN = 1. Table E1 shows that stations with convenient transit connections experienced a significant increase in new firm formation following the inauguration of HSR (Column 1), whereas no such effect was observed at stations without these connections (Column 2).

Table E1
Results of supplemental heterogeneity regression.

Variables	Counts of new firms (CFY)	
	(1)	(2)
HSR_TA	**15.900*** **	
	(4.694)	
HSR_TN		**2.183**
		(1.615)
_cons	2.466***	2.729***
	(0.082)	(0.010)
Year fixed	Yes	Yes
ID fixed	Yes	Yes
N	21,703	21,703
R-sq	0.335	0.327

Robust standard errors are in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

References

Andersson, M., Koster, S., 2011. Sources of persistence in regional start-up rates—evidence from Sweden. *Journal of Economic Geography* 11, 179–201.
Anyadike-Danes, M., Hart, M., O'Reilly, M., 2005. Watch that space! The county hierarchy in firm births and deaths in the UK, 1980-1999. *Small Business Economics*, Group 25, 273–292.
Armington, C., Acs, Z.J., 2002. The Determinants of Regional Variation in New Firm Formation. *Regional Studies* 36, 33–45.

Artz, G.M., Kim, Y., Orazem, P.F., 2016. Does Agglomeration Matter Everywhere?: New Firm Location Decisions in Rural and Urban Markets. *Journal of Regional Science* 56, 72–95.
Audretsch, B., 1998. Agglomeration and the location of innovative activity. *Oxford Review of Economic Policy* 14, 18–29.
Audretsch, D., Fritsch, M., 1994. The Geography of Firm Births in Germany. *Regional Studies* 28, 359–365.
Austin, P.C., 2011. An Introduction to Propensity Score Methods for Reducing the Effects of Confounding in Observational Studies. *Multivariate Behavioral Research* 46 (3), 399–424.
Beckerich, C., Benoit-Bazin, S., Delaplace, M., 2017. Does High Speed Rail Affect the Behaviour of Firms Located in Districts around Central Stations? The Results of Two Surveys Conducted in Reims in 2008 and 2014. *Transportation Research Procedia* 25, 3017–3034.
Blundell, R., Costa Dias, M., 2000. Evaluation Methods for Non-Experimental Data. *Fiscal Studies* 21, 427–468.
Brinkley, I., 2006. Defining the knowledge economy. The Work Foundation, London.
Carbo, J.M., Graham, D.J., Anupriya, C., D., Melo, P.C.,, 2019. Evaluating the causal economic impacts of transport investments: evidence from the Madrid–Barcelona high speed rail corridor. *Journal of Applied Statistics* 46, 1714–1723.
Cartier, C., 2001. "Zone Fever", the Arable Land Debate, and Real Estate Speculation: China's evolving land use regime and its geographical contradictions. *Journal of Contemporary China* 10, 445–469.
Chang, Z., Diao, M., Jing, K., Li, W., 2021. High-speed rail and industrial movement: Evidence from China's Greater Bay Area. *Transport Policy* 112, 22–31.
Chang, Z., Zheng, L., 2022. High-speed rail and the spatial pattern of new firm births: Evidence from China. Transportation Research Part A: Policy and Practice 155, 373–386.
Chang, Z., Zheng, L., Yang, T., Long, F., 2022. High-speed rail, new town development, and the spatial mismatch of land leases in China. *Land Use Policy* 115, 106014.
Chen, C.-L., 2018. Tram development and urban transport integration in Chinese cities: A case study of Suzhou. *Economics of Transportation* 15, 16–31.
Chen, C.-L., 2020. High-speed rail and its wider spatial-economic impact on transformation of Chinese cities and regions: A multi-level analysis. In: Chen, C.-.-L., Pan, H., Shen, Q., Wang, J. (Eds.), Handbook on Transport and Urban Transformation in China. Edward Elgar Publishing (Book Series of Handbook of Research on Contemporary China), London, pp. 60–82.
Chen, C.-L., Hall, P., 2012. The wider spatial-economic impacts of high-speed trains: a comparative case study of Manchester and Lille sub-regions. *Journal of Transport Geography* 24, 89–110.
Chen, C.-L., Hall, P., 2011. The impacts of high-speed trains on British economic geography: a study of the UK's InterCity 125/225 and its effects. *Journal of Transport Geography* 19 (4), 689–704.
Chen, C.-L., Vickerman, R., 2017. Can transport infrastructure change regions' economic fortunes? Some evidence from Europe and China. *Regional Studies* 51, 144–160.
Chen, C.-L., Wei, B., 2013. High-Speed Rail and Urban Transformation in China: The Case of Hangzhou East Rail Station. *Built Environment* 39 (3), 385–398.
Chen, Z., Xue, J., Rose, A.Z., Haynes, K.E., 2016. The impact of high-speed rail investment on economic and environmental change in China: A dynamic CGE analysis. Transportation Research Part A: Policy and Practice 92, 232–245.
Chen, Z., 2019. Measuring the regional economic impacts of high-speed rail using a dynamic SCGE model: the case of China. *European Planning Studies* 27 (3), 483–512.
Chen, Z., Zhou, Y., Haynes, K.E., 2021. Change in land use structure in urban China: Does the development of high-speed rail make a difference. *Land Use Policy* 111, 104962.
Cheng, S., Li, H., 2010. The effects of unemployment on new firm formation revisited: Does space matter? *Regional Science Policy & Practice* 2, 97–120.
Coughlin, C.C., Segev, E., 2000. Location determinants of new foreign-owned manufacturing plants. *Journal of Regional Science* 40, 323–351.
Dahl, M.S., Sorenson, O., 2012. Home Sweet Home: Entrepreneurs' Location Choices and the Performance of Their Ventures. *Management Science* 58 (6), 1059–1071.
Dai, G., 2015. The impact of policy networks on the urbanisation around High-Speed Railway stations in China: the case of Wuhan. *Environment and Planning c: Government and Policy* 33 (3), 533–551.
Davidsson, P., Honig, B., 2003. The role of social and human capital among nascent entrepreneurs. *Journal of Business Venturing* 18 (3), 301–331.
Delaplace, M., 2012. TGV, local economic development and city size: an analysis in terms of service innovations. *Revue Dècconomie Régionale & Urbaine* 2, 265–292.
Delfmann, H., Koster, S., McCann, P., Van Dijk, J., 2014. Population Change and New Firm Formation in Urban and Rural Regions. *Regional Studies* 48, 1034–1050.
Delgado, M., Porter, M.E., Stern, S., 2010. Clusters and entrepreneurship. *Journal of Economic Geography* 10, 495–518.
Deng, T., Gan, C., Perl, A., Wang, D., 2020a. What caused differential impacts on high-speed railway station area development? Evidence from global nighttime light data. *Cities* 97, 102568.
Deng, T., Wang, D., Hu, Y., Liu, S., 2020b. Did high-speed railway cause urban space expansion? ——Empirical evidence from China's prefecture-level cities. *Research in Transportation Economics* 80, 100840.
Deng, T., Wang, D., Yang, Y., Yang, H., 2019. Shrinking cities in growing China: Did high speed rail further aggravate urban shrinkage? *Cities* 86, 210–219.
Diao, M., Zhu, Y., Zhu, J., 2017. Intra-city access to inter-city transport nodes: The implications of high-speed-rail station locations for the urban development of Chinese cities. *Urban Studies* 54, 2249–2267.
Dong, X., 2018. High-speed railway and urban sectoral employment in China. Transportation Research Part A: Policy and Practice 116, 603–621.
Eurostat, 2007. High-tech industry and knowledge-intensive services (htec). Retrieved July 15, 2024, from. http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/EN/htec_base.htm.
Facchinetti-Mannone, V., 2013. Les nouvelles gares TGV périphériques: des instruments au service du développement économique des territoires? *Géotransports* 1–2, 51–66.
Fotopoulos, G., Spence, N., 1999. Spatial Variations in New Manufacturing Plant Openings: Some Empirical Evidence from Greece. *Regional Studies* 33, 219–229.
Hall, P., 2009. Magic Carpets and Seamless Webs: Opportunities and Constraints for High-Speed Trains in Europe. *Built Environment* 35, 59–69.
Han, J., Hayashi, Y., Jia, P., Yuan, Q., 2012. Economic Effect of High-Speed Rail: Empirical Analysis of Shinkansen's Impact on Industrial Location. *Journal of Transportation Engineering* 138, 1551–1557.
Hickman, R., Chen, C.-L., Chow, A., Saxena, S., 2015. Improving interchanges in China: the experiential phenomenon. *Journal of Transport Geography* 42, 175–186.
Hodgson, C., 2018. The effect of transport infrastructure on the location of economic activity: Railroads and post offices in the American West. *Journal of Urban Economics* 104, 59–76.
Holl, A., 2016. Highways and productivity in manufacturing firms. *Journal of Urban Economics* 93, 131–151.
Jia, R., Shao, S., Yang, L., 2021. High-speed rail and CO emissions in urban China: A spatial difference-in-differences approach. *Energy Economics* 99, 105271.
Jiao, J., Wang, J., Zhang, F., Jin, F., Liu, W., 2020. Roles of accessibility, connectivity and spatial interdependence in realizing the economic impact of high-speed rail: Evidence from China. *Transport Policy* 91, 1–15.
Jones, A., Lee, N., Williams, L., Clayton, N., Morris, K., 2008. How can cities thrive in the changing economy: Ideopolis II Final Report. The Work Foundation, London.
Kangasharju, A., 2000. Regional variations in firm formation: Panel and cross-section data evidence from Finland. *Papers in Regional Science* 79, 355–373.
Kok, W., 2004. Facing the challenge: the Lisbon strategy for growth and employment. Office for Official Publications of the European Communities, Luxembourg.
Krugman, P., 1991. Increasing Returns and Economic Geography. Journal of Political Economy 99 (3), 483–499.
Krugman, P., Venables, A.J., 1990. Integration and the competitiveness of peripheral industry. *Unity with Diversity in the European Community* 56–77.
Kuang, C., Liu, Z., Zhu, W., 2021. Need for speed: High-speed rail and firm performance. *Journal of Corporate Finance* 66, 101830.
Lee, S.Y., Florida, R., Acs, Z.J., 2004. Creativity and entrepreneurship: A regional analysis of new firm formation. *Regional Studies* 38, 879–891.
Li, Y., Chen, Z., Wang, P., 2020. Impact of high-speed rail on urban economic efficiency in China. *Transport Policy* 97, 220–231.
Li, Z., Wang, Q., Cai, M., Wong, W.-K., 2023. Impacts of high-speed rail on the industrial developments of non-central cities in China. *Transport Policy* 134, 203–216.
Liang, P., Cui, X., Lin, M., Yang, T., Wu, B., 2022. High-speed rail effects on station area-level business commercial agglomeration: Evidence from 110 stations in China. *Frontiers in Environmental Science* 10, 1045959.

Lin, C., Liu, J., Li, W., 2023. Influence of the high-speed railway (HSR) construction on industrial structure transformation. Enterprise Information Systems 17 (2), 1942998.
Lin, S., Gan, T., 2022. Does High-Speed Rail Promote Agglomeration in China? *Wireless Communications and Mobile Computing* 2022, 6443204.
Liu, J., Meng, H., 2024. Can China railway express enhance the economic-trade vitality of cities? A spatial empirical evidence from China. *Transport Policy* 150, 121–138.
Loukaitou-Sideris, A., Peters, D., 2020. What is Good Station Area Planning - Lessons from Experts and Case Studies. *Built Environment* 46, 422–439.
Malmberg, A., Sölvell, Ö., Zander, I., 1996. Spatial Clustering, Local Accumulation of Knowledge and Firm Competitiveness. Geografiska Annaler: Series b, *Human Geography* 78, 85–97.
Martinez, H.S., Moyano, A., Ma Coronado, J., Garmendia, M., 2016. Catchment areas of high-speed rail stations: a model based on spatial analysis using ridership surveys. *European Journal of Transport and Infrastructure Research* 16, 364–384.
Matas, A., Raymond, J.L., Roig, J.L., 2020. Evaluating the impacts of HSR stations on the creation of firms. *Transport Policy* 99, 396–404.
Melo, P.C., Graham, D.J., Noland, R.B., 2010. Impact of Transport Infrastructure on Firm Formation Evidence from Portuguese Municipalities. *Transportation Research Record* 2163 (1), 133–143.
Muñiz, I., Garcia-López, M.-À., 2010. The Polycentric Knowledge Economy in Barcelona. *Urban Geography* 31 (6), 774–799.
OECD, 2007. OECD Science, Technology and Industry Scoreboard 2007. Organisation for Economic Co-operation and Development, Paris.
OECD, 1996. The Knowledge-Based Economy (general Distribution. OCDE/GD 96, 102.
Pan, H., Cong, C., Zhang, X., Zhang, Y., 2020. How do high-speed rail projects affect the agglomeration in cities and regions? Transportation Research Part D: Transport and Environment 88, 102561.
Parajuli, J., Haynes, K.E., 2017. Panel Data Models of New Firm Formation in New England. *Region* 4, 65–76.
Peeters, D., Thisse, J.F., Thomas, I., 2000. On high-speed connections and the location of activities. *Environment and Planning A* 32, 2097–2112.
Pol, P., 2002. A renaissance of stations, railways and cities: Economic effects, development strategies and organisational issues of European high-speed-train stations. Delft University Press, Delft.
Puga, D., 2002. European regional policies in light of recent location theories. *Journal of Economic Geography* 2 (4), 373–406.
Shao, S., Tian, Z., Yang, L., 2017. High speed rail and urban service industry agglomeration: Evidence from China's Yangtze River Delta region. *Journal of Transport Geography* 64, 174–183.
Smith, D., Florida, R., 1994. Agglomeration and Industrial-Location - an Econometric-Analysis of Japanese-Affiliated Manufacturing Establishments in Automotive-Related Industries. *Journal of Urban Economics* 36 (1), 23–41.
Su, J., Yu, T., 2022. Research on characteristics of spatial evolution of high-speed railway new town: A case study of Beijing-Shanghai High-Speed Railway Line. *Modern Urban Research* 09, 68–74.
Sun, B., Yu, H., Peng, Z.-R., Gao, Y., 2017. High-Speed Rail and Manufacturing Agglomeration Evidence from Beijing-Guangzhou High-Speed Rail in China. *Transportation Research Record* 2606 (1), 86–95.
Sun, H., Ma, L., Jin, F., Huang, Y., 2024. Path dependence or path creation of mature resource-based cities: A new firm entry perspective. *Journal of Geographical Sciences* 34 (3), 499–526.
Sutaria, V., Hicks, D.A., 2004. New firm formation: Dynamics and determinants. *The Annals of Regional Science* 38, 241–262.
Tang, C., Guan, M., Dou, J., 2021. Understanding the impact of High Speed Railway on urban innovation performance from the perspective of agglomeration externalities and network externalities. *Technology in Society* 67, 101760.
Tierney, S., 2012. High-speed rail, the knowledge economy and the next growth wave. *Journal of Transport Geography* 22 (C), 285–287.
Ureña, J.M., Menerault, P., Garmendia, M., 2009. The high-speed rail challenge for big intermediate cities: A national, regional and local perspective. *Cities* 26, 266–279.
Venables, A.J., 2017. Expanding Cities and Connecting Cities Appraising the Effects of Transport Improvements. *Journal of Transport Economics and Policy* 51 (1), 1–19.
Vickerman, R., 2015. High-speed rail and regional development: the case of intermediate stations. *Journal of Transport Geography* 42, 157–165.
Wang, B., de Jong, M., van Bueren, E., Ersoy, A., Song, Y., 2024. Planning and developing a high-speed railway new town under state entrepreneurialism in China. *Urban Geography* 45 (2), 115–136.
Wang, L., 2016. Studies on HSR New Town Planning and Development. Tongji University Press.
Wang, L., Cao, Y.-H., Liu, K.-W., Wang, C., 2012. Spatial distribution and clusters of industry nearby high-speed rail station: The case of Nanjing station, Shanghai-Nanjing motor train. *Scientia Geographica Sinica/dili Kexue* 32 (3), 301–307.
Wang, L., Gu, H., 2019a. Studies on China's High-Speed Rail New Town Planning and Development. Springer, Singapore.
Wang, L., Gu, H., 2019b. Comparative Analysis of Planning and Development of HSR New Towns. In: Wang, L., Gu, H. (Eds.), Studies on China's High-Speed Rail New Town Planning and Development. Springer, Singapore, pp. 165–243.
Wang, L., Gu, H., 2019c. Site Selection and Urban Development of HSR, in: Wang, L., Gu, H. (Eds.), Studies on China's High-Speed Rail New Town Planning and Development. Springer, Singapore, pp. 21–86.
Wang, L., Shen, J., Chung, C.K.L., 2015. City profile: Suzhou - a Chinese city under transformation. *Cities* 44, 60–72.
Wang, L., Zheng, W., He, S., Wei, S., 2022. Assessing urban vitality and its determinants in high-speed rail station areas in the Yangtze River Delta, China. *Journal of Transport and Land Use* 15 (1), 333–354.
Weber, A., 1929. *Alfred Weber's Theory of the Location of Industries (Translated by C.J.Freidrich)*. Chicago University Press, Chicago.
Wei, Y.H.D., Lu, Y., Chen, W., 2009. Globalizing Regional Development in Sunan, China: Does Suzhou Industrial Park Fit a Neo-Marshallian District Model? *Regional Studies* 43, 409–427.
Willigers, J., 2003. High-speed railway developments and corporate location decisions. *European Regional Science Association; ERSA: Louvain-la-Neuve, Belgium.*
Willigers, J., Floor, H., van Wee, B., 2007. Accessibility Indicators for Location Choices of Offices: An Application to the Intraregional Distributive Effects of High-Speed Rail in the Netherlands. *Environment and Planning A* 39 (9), 2086–2898.
Willigers, J., Floor, H., van Wee, B., 2005. High-speed rail's impact on the location of office employment within the Dutch Randstad area. European Regional Science Association (ERSA), Louvain-la-Neuve.
Willigers, J., van Wee, B., 2011. High-speed rail and office location choices. A stated choice experiment for the Netherlands. *Journal of Transport Geography* 19 (4), 745–754.
Wu, C., Kim, I., Chung, H., 2021. The effects of built environment spatial variation on bike-sharing usage: A case study of Suzhou. China. *Cities* 110, 103063.
Yao, L., Hu, Y., 2020. The impact of urban transit on nearby startup firms: Evidence from Hangzhou. China. *Habitat International* 99, 102155.
Yin, M., Bertolini, L., Duan, J., 2015. The effects of the high-speed railway on urban development: International experience and potential implications for China. *Progress in Planning* 98, 1–52.
Yu, L., 2020. Spatial evolution of high-speed railway station areas and planning response. City Planning Review. In press. Retrieved January 7, 2025, from https://orca.cardiff.ac.uk/id/eprint/137723.
Zhao, Q., Chen, G.-W., 2015. Influence of HSR station location on the development of surrounding areas: A case study of Beijing-Shanghai HSR and Wuhan-Guangzhou HSR. *Urban Planning* 07, 50–55.
Zheng, L., Long, F., Chang, Z., Ye, J., 2019. Ghost town or city of hope? The spatial spillover effects of high-speed railway stations in China. *Transport Policy* 81, 230–241.
Zhou, Z., Zhang, A., 2024. Transportation Infrastructure and Industrial Upgrading: Evidence from High Speed Rail. Available at SSRN 4825822.
Zhou, Z., Zhang, A., 2021. High-speed rail and industrial developments: Evidence from house prices and city-level GDP in China. Transportation Research Part A: Policy and Practice 149, 98–113.
Zhu, P., Yu, T., Chen, Z., 2015. High-Speed Rail and Urban Decentralization in China. *Transportation Research Record* 2475 (1), 16–26.