Journal of Transport Geography 73 (2018) 25–40

Contents lists available at ScienceDirect

Journal of Transport Geography

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

High-speed rail impacts on travel times, accessibility, and economic productivity: A benchmarking analysis in city-cluster regions of China

Liwen Liu[a], Ming Zhang[b,c,*]

[a] Jiangxi Normal University, 99 Ziyang Road, Nanchang, Jiangxi 330022, China
[b] Wuhan University, 8 Donghu Road South, Wuhan, Hubei 430072, China
[c] University of Texas at Austin, 310 Inner Campus Dr., B7500, Austin, TX 78717, USA

ARTICLE INFO

Keywords:
High speed rail (HSR)
Travel times
Accessibility
Economic productivity
China

ABSTRACT

The direct and wider impacts of high-speed rail (HSR) have long been the interest of academia and policy makers. Studies on China's experience just began to accumulate but remain inadequate given the size and speed of the country's HSR and regional growth. This paper reports a benchmark analysis of HSR impacts on travel times, accessibility, economic productivity, and regional disparity in the context of China's current growth initiative centered at city-cluster regions. The study utilized data from year 2006 without HSR and 2014 with HSR for 266 prefectural level cities and analyzed HSR's impacts at the spatial scales of nationwide, territorial regions, and city-cluster regions. In the study, travel times measured the city-to-city average travel times by rail, whereas accessibility analysis applied a gravity model of total employment. Three indicators of economic productivity were calculated: Gross Regional Product (GRP) per capita, per worker, and per square kilometer of built-up land. Finally, regression models framed around economics production theory were estimated. The main findings are: HSR contributed to travel times savings, accessibility enhancement, and productivity gain but with limitations. HSR reduced city-to-city travel times at a national average by 45% or 589 min. City-clusters in Western China, where the starting level of travel times were long, enjoyed a greater rail time reduction than other regions. HSR increased accessibility of all cities and regions; a simplified decomposition analysis estimated HSR's contribution being 25–45% of total accessibility change. Access disparity within most city-cluster regions decreased, whereas the between-region gaps remained during the study period. The study estimated HSR elasticity of GRP per capita being 0.28 nationwide. Responses to HSR varied greatly among city-clusters when measured in GRP per worker and per built-up area terms. As China's HSR network continues to expand, optimizing HSR impacts should focus on integrating fully with other transportation modes and fitting well with national and local development initiatives.

1. Introduction

The phenomenal growth of high-speed rail (HSR) network in China has astonished the rest of the world in terms of the speed and size of constructed HSR tracks and stations. By the end of 2015, China operates about 121 thousand kilometers (km) of railway in track length; out of which 19 thousand km are HSR track (NDRC, 2016a). China's HSR network will continue to expand as programmed in the country's new Five-Year Plan for National Economic and Social Development. According to the plan, additional ten thousand km of HSR track will be built by 2030 (NDRC, 2016a).

Investing in HSR is part of China's national development strategy. The central administration aims at a twofold development goal for HSR: improving surface transportation to accommodate fast growing travel demand, especially for intercity/interregional travel; supporting national economic growth and urbanization (Yin et al., 2015). Coupling with the national HSR plan is a national spatial strategy that accentuates the development of city-cluster regions (Chen, 2012). A city-cluster region consist of multiple extra-large (population of over 3 million) or large (population of 1–3 million) cities along with an array of medium- (population of 0.5–1 million) and small- (population below 0.5 million) sized cities or counties and their hinterlands, forming an economic geography similar to the large functional urban region in Europe or the megaregion in the United States (Carbonell and Yaro, 2005). These city-clusters concentrate the nation's population, jobs, and wealth and are anticipated to play a critical role in elevating Chinese citizen's livelihood and strengthening national competitiveness in the globalized world economy.

* Corresponding author at: Wuhan University, 8 Donghu Road South, Wuhan, Hubei 430072, China
E-mail addresses: liuliwen305@163.com (L. Liu), zhangming@whu.edu.cn, zhangm@austin.utexas.edu (M. Zhang).

https://doi.org/10.1016/j.jtrangeo.2018.09.013
Received 24 February 2018; Received in revised form 18 July 2018; Accepted 28 September 2018

Have the HSR investments in China achieved the objectives? Given the high cost of HSR infrastructure (at $7 million to $30 million per km in China; see Albalate and Bel, 2012; Ollivier et al., 2014), the question is of great interest to both HSR advocates and critics. There are numerous studies on the mobility and broad impacts of HSR development in Europe where rail services have a long history (Yin et al., 2015). Japan, being the first country offering HSR services, has provided exemplar experience in many grounds to the rest of the world (Hayashi et al., 2017). There are also extensive studies on HSR's potential in the US where proposals for HSR have been debated since 1970's (Chen and Zhang, 2013). Prior studies on the experience of developed economies may offer valuable references in terms of theories and analytical methods. However, whether the empirical findings and policy solutions from those studies apply to the Chinese practice is subject to further test (Chen and Vickerman, 2017). Recently, studies on China's HSR experience have begun to accumulate. These studies have examined quite a wide range of topics, for instance, on inter-city travel times, costs, and distances (Wang et al., 2013; Shaw et al., 2014), network connectivity and spatial accessibility (Jiao et al., 2014; Jiao et al., 2017), agglomeration effects (The World Bank, 2013; Jia et al., 2017), market integration of mega city-regions (Zheng and Kahn, 2013), and industrial/sectorial transformation (e.g., Shao et al., 2017). Nonetheless, the existing evidence base from China remains too thin to enable adequate evaluation of HSR project performance, especially regarding HSR's broad impacts (The World Bank, 2014). Additional research is absolutely needed, which motivates this study. Furthermore, HSR investments are imminent in other Asian countries such as India, Malaysia, and Thailand. Lessons learned from China will help inform upcoming HSR development decisions not only to Chinese cities but also to other countries, particularly the Asian developing economies.

This study extends from existing studies on China's HSR impacts in three aspects. First, it offers assessments on four topics of most concerns: travel times, accessibility, economic productivity, and regional disparity pertaining to HSR-led changes in travel times and accessibility. Second, it utilizes two years data, before- and after-HSR in 2006 and 2014, respectively, for prefecture level cities. Third, most importantly, it ties analyses directly to China's spatial development initiative targeting city-cluster regions.

The paper includes four parts. After this introduction, Part 2 reviews related studies. Part 3 provides an overview of China's spatial development polices, followed by the description of data and analytical methods used for the study. Part 4 presents analysis results and findings. Finally, the paper ends with concluding remarks and discussions on future research.

2. Review of related studies

Studies on HSR and urban/regional development have built a rich knowledge base, mostly from the experience in Europe, Japan, and South Korea. Chen and de Abreu E Silva (2013) and Yin et al. (2015) provided a comprehensive review of the literature. The review presented below focuses on the studies of the Chinese case while referring to the European or Asian experience when needed. The reviewed studies touched upon a wide range of topical issues addressing both the direct and the wider impacts of HSR in Chinese cities and regions.

2.1. HSR impacts on travel times

The direct impact of HSR concerns the extent to which HSR improves mobility for travel. While mobility may refer to multiple aspects of travel, for instance, travel time, speed, flow volume, distance, and travel means, travel time has been used widely to examine HSR's direct impacts. Currently HSR operations in China serve for passenger travel only. The travel time savings brought by HSR is apparent from citizen's daily life experience and can be quantified straightforwardly using changes in travel times by HSR (e.g., Wang et al., 2013). Empirical evidence has shown that HSR has reduced inter-city, inter-regional travel times dramatically and shrunk time-spaces across the continent of China. For major HSR corridors, for instance, Beijing-Shanghai, Beijing-Wuhan, and Guangzhou-Wuhan, travel time for a distance of 1100–1300-km has decreased from 10–12 h by conventional rail in the 1990s or earlier to 3–5 h by HSR (Shaw et al., 2014). The reported magnitude of HSR-led travel time reductions in China was similar to those reported in European countries, Japan, and South Korea in the range of 30–60% (Sands, 1993; Bonnafous, 1987; Cascetta et al., 2011; De Rus and Inglada, 1997; Froidh, 2005; Chang and Lee, 2008).

The mobility benefits of HSR go beyond direct time reduction between origins and destinations. As the national HSR network reaches a critical size, the system network effects materialize, augmenting the time reduction benefits of individual station nodes and line corridors. Such network effects could lead to changes in the hierarchical structure of settlements and yield new patterns of transport geographies, for example, shifted centrality of cities in regions, (re)formation of corridor and center-diffusion patterns of mobility supply (Cao et al., 2013; Jiao et al., 2014; Shaw et al., 2014). Nevertheless, the realized travel time savings, as reported by Shaw et al. (2014), are sensitive to HSR service performance and operating policies, for instance, the upper limits of cruise speeds, fare rates, train schedules and stop frequencies.

China-focused studies on HSR impacts on other aspects of mobility, for instance, travel modal share, distance, and volume are also emerging (e.g., Wang et al., 2017; Zhang et al., 2017). Since this paper focuses on travel times concerning HSR's mobility impacts, we defer to future work for detailed review of the studies on HSR impacts on other aspects of mobility.

2.2. HSR impacts on accessibility

In most cases people travel for utilitarian purposes: they travel in order to reach opportunities at destinations (Domencich and McFadden, 1975). This notion of travel demand being a derived demand suggests that bringing spatial attributes into HSR impact study offers a perspective beyond the travel time-only assessment. Accessibility, which denotes the ease to reach opportunities (e.g., jobs, labor market, services, et al.) serves well the purpose; it provides a composite measure capturing the combined effects of modifying time geography and redistributing opportunities through infrastructure investments and land use changes. The fact that HSR stations and lines do not distribute uniformly across the national geography raises questions concerning the distributional impacts of HSR. HSR modifies time-distance geography and thus alters spatial access to opportunities. European studies indicate that HSR may generate polarization effects that likely increase inequality and disparity in multiple dimensions, for example, between HSR- and non-HSR cities, among different socioeconomic and demographic groups, between cities of different sizes, and between different parts of territorial regions (e.g., Chen and Hall, 2012; Ureña et al., 2009).

Researchers have applied accessibility to examine efficiency or economic gain and inequality or disparity in HSR impact studies in the China case. In these studies accessibility served as both an outcome indicator and input factor. Jiao et al. (2014) analyzed the accessibility effects by HSR and conventional ground transport in prefecture or above level cities. They found increased inequality of nodal accessibility in three spatial dimensions: between the Eastern, Central, and Western regions of China, between extra-large, large, and small to medium cities, and between cities that differ in the shortest distance to HSR stations. The HSR network enlarges internal disparities in each of the regions and the five types of cities. The authors warned likely trend of increased inequality resulting from continuing expansion of HSR network across the nation. Zhu et al. (2015) expressed similar concerns to that of Jiao et al. (2014) over HSR-increased regional inequality. They calculated the accessibility effects of HSR for 2009 and 2013 and reported greater benefits enjoyed by the cities with HSR access and cities in the prosperous eastern region than that of non-HSR cities and the cities in the hinterland did.