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Comparing China's urban systems in high-speed railway and airline networks

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ABSTRACT

Although the Chinese high-speed railway (HSR) entered the transportation market at a late stage in 2003, its networks have become the world's largest and are currently even growing faster than airline networks. Using the 2013 origin/destination (O/D) passenger flow data instead of commonly used scheduled data, we compare the spatial configurations of the Chinese national urban system in both high-speed railway and airline networks. The results show that HSR-dominant cities and links are located mainly in the middle and eastern parts of China, offering regional connections, whereas air-dominant cities and links are evenly distributed across the whole of China and predominantly offer interregional connections. This is mainly because HSR networks are more focused on connections to cities with high socio-economic performance and are more restricted by the geographical distance between linked cities than the airline networks. Furthermore, HSR networks promote agglomeration economies within cities located along the trunk lines in specific regions, whereas airline networks contribute to more balanced urban development in China. These dimensions indicate that the configuration of urban systems in HSR networks differ largely from that of air networks when measured in terms of passenger flows.

1. Introduction

Urban systems are made up of city nodes and various kinds of interactions (social, economic, and political) that materialize to some extent through transportation and information flows (Meijers, 2005; Devriendt et al., 2010). Even though information and communication technologies (ICTs) overwhelmingly facilitate instant communication, face-to-face interactions are still important in the contemporary world (Bertolini and Dijst, 2003). High-speed physical means of transportation, such as airlines and high-speed railways (HSR), which can dramatically decrease the geographic and temporal constraints of commuting for business transactions, tourism, post-migratory travel to keep social links with friends and relatives, academic collaborations, and political activities, are all crucial in facilitating the formation of functional urban systems (Hall and Pain, 2006).

Given their important role in linking urban areas,the development of airlines and HSR has been supported with substantial capital and infrastructure investment in China. The development of both systems has been very rapid. The global ranking of China's airline transportation networks, based on scheduled seats, was 37th in 1978, but rose to second place after 2005. The number of civil-certificated schedule airports in mainland China increased from 94 in 1990 to 216 in 2016 and is expected to reach 260 in 2020, according to the 13th five-year plan of China's contemporary transportation system (Fu et al., 2012; NDRC, 2016). Although China's HSR networks entered the transportation market at a late stage in 2003, they have become the largest in the world (a total of 19,000 km by the end of 2015, accounting for over 60% of the global figure), even though HSR length per capita is less spectacular due to the size of the country (Delaplace and Dobruszkes, 2016). This network served > 70% of the population and the cities involved account for 80% of GDP (Wang et al., 2015; NDRC, 2016). It should be noticed that, in 2016 the mode shares of HSR and airlines are 6.4% and 2.6%, respectively, compared to the 81.2% and 1.4% of highways and waterways (NBSC, 2017). These investments have stimulated the integration of the national urban network (Ng and Wang, 2012) and are seen as part of its future integration with Euro-Asian

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urban systems via the by the Belt and Road Initiative (BRI) (Liu and Dunford, 2016).[1]

A great deal of the existing literature exploring the functional relationships within urban systems has relied upon scheduled seat airline data, measuring the capacity of aircraft movements across the world (Smith and Timberlake, 2001; Derudder and Witlox, 2005; Derudder and Witlox, 2009; Van Nuffel et al., 2010). However, HSR travel has received less attention, and also the few available studies on the functional relationships within urban systems in Europe (Hall and Pain, 2006) and China (Zhang et al., 2016) at the regional and sub-regional levels are based on time schedule data not a measure of capacity. In most of the research carried out to date, airline and HSR travel have been studied separately. One exception is the study by Xiao et al. (2013), in which passenger data of conventional railways and airlines are used to estimate a reversed gravity model to identify the attractiveness of a limited number of cities in China. Several studies have used the supply and demand side of airline flow data to understand HSR's impacts on domestic aviation in China (Chen, 2017; Wang et al., 2017). To the best of our knowledge, no study has compared the role of high-speed transportation networks (i.e. HSR and airlines) on one national urban system using the same type of passenger flow data. Our research tries to fill this gap. Thus, the key research question in this paper is: To what extent does the configuration of Chinese cities served by HSR differ from those served by airlines? This is of particular interest for two reasons. First, as we argue in the next section, the understanding of the functional relationships between the cities in an urban system is better reflected by passenger flow data(i.e. the demand side) than by timetable information (i.e. the supply side) (Yang et al., 2018). Second, both HSR and airlines in China mainly carry people from the middle and upper-middle income classes, that is, social groups with travel demands for functional activities such as high-end business, advanced producer services, and tourism (Delaplace and Dobruszkes, 2016; Liu and Kesteloot, 2015). The relevant functional relationships of each the high-speed transportation network will provide precise insight on the working of these activities and so add to our understanding of Chinese regional economic development. The insight on each network will be valuable in future high-speed transportation and urban systems planning.

This paper is structured as follows. Section 2 presents the literature review. Section 3 explains our analytical framework, after which we introduce both HSR and airline O/D flow data. In Section 4, we discuss the results of our analyses, which consist of a general overview of HSR and airline passenger flows on a national scale. This section is followed by a comparison between them. The final section concludes the paper and offers an overview on future research issues.

2. Literature review

To understand the functional relationships between cities, studies on transportation networks have explored the space of flows of information, people and capital proposed by Castells (1996) at different spatial scales. The “space of flows” of people incorporates three layers. The first layer is the infrastructure providing material support for the flows. The second layer contains different nodes and hubs, which are connected and organized by the infrastructure layer. The third layer is the directional movements of each function (Derudder and Taylor, 2005).

Two types of empirical approaches have emerged to assess the flows between cities. The first approach is based on the derived flows of advanced tele-information contacts (Devriendt et al., 2010), advanced producer services (APS) (Zhao et al., 2015), and business elite contacts (Beaverstock, 2004) within the three layers. However, there have been strong criticisms of the ‘derived flow approach’. The main argument is that it cannot reflect the extent to which the internal characteristics of nodes can be translated into external interaction (Robinson, 2005), which means the derived linkages of people, information, and service from node attributes cannot reflect the direction in which flows are actually produced by people or the extent of these flows (Neal, 2010). Therefore, a better approach is based on actual physical flows in the first transport infrastructure layer by means of either schedule data (the supply side) or actual passenger data (the demand side). Airline scheduled seats have been used to investigate the network structure of world cities on a global scale (e.g. Smith and Timberlake, 2001; Choi et al., 2006; Derudder and Witlox, 2005) and inter-regional airline transport linkages in Europe (Derudder and Witlox, 2009; Van Nuffel et al., 2010), the USA (Derudder et al., 2013), and China (Lao et al., 2016; Ma and Timberlake, 2008). In contrast, only a few scholars have considered HSR travel to investigate interactions between cities. For instance, Zhang et al. (2016) used HSR time schedule data to approximate actual passenger flows to uncover the relationships among cities in the Yangzi River Delta (YRD) region in China, Hall and Pain (2006) used scheduled train services to identify polycentric urban regions in Europe, and Jiao et al. (2017) used scheduled train services to explore the impacts of HSR on the city network of China.

However, this form of both airline and HSR data raise several issues. First, it is common to consider supply-related data (typically the number of seats offered between two cities, or sometimes train frequencies or seat-kms). The rationale for supply-side data is that carriers' strategies are expected to draw passengers according to existing and potential interactions between places served. However, the supply is by definition larger or equal to the demand satisfied by each transportation mode, so at best it can be considered just a proxy for the actual flows of people (Neal, 2014).[2] Second, supply or demand data are usually given regarding the individual legs of trips rather than for the trip as a whole. For instance, if air or rail passengers travel from A to B where they connect to C, usual figures would count the number of seats or passengers between A and B and between B and C, but not between A and C via B. As a result, transfers distort the picture of actual intercity relationships (Derudder et al., 2010; Derudder and Witlox, 2008; Derudder and Witlox, 2005). Some researchers have addressed this issue regarding airline travel by using the so-called Marketing Information Data Transfer (MIDT) dataset, which is based on the actual origins/destinations of airline travellers (Derudder et al., 2007). However, information is based on bookings made through global distribution systems (GDS). This means that those travellers who book directly on airlines' websites are not included, which could arguably lead to biases, for instance, an underestimation of people flying on low-cost airlines.[3]

Finally, HSR timetables are difficult to convert to the number of seats available for two reasons. First, many HSR routes are served by heterogeneous rolling stock (e.g., shorter vs. longer trains or single- vs. double-deck trains). This means that, if a train operator pursues a high-frequency strategy (that is, operating frequent services but likely with less capacity per train), the estimated interactions between cities derived from HSR frequency would be biased. Second, one still needs to consider that most high-speed trains call at several intermediate stations. This involves uncertainties about how seats are split between the various city-pairs thus served. For instance, if a Beijing (A) to Shanghai (D) HSR service calls at Jinan (B) and Nanjing (C), then seats are potentially sold for A-B, A-C, A-D, B-C, B-D, and C-D city pairs. Either the train operator pre-allocates seats to all pairs or the actual bookings

[1] China's BRI is a call for an open and inclusive (mutually beneficial) model of cooperative economic, political and cultural exchange (globalization) that draws on the deep-seated meanings of the ancient Silk Roads.

[2] The number of passengers carried by transportation modes between cities is basically equal to or smaller than the number of seats.

[3] In Europe, for instance, European low-cost airlines have long kept out of GDS to avoid extra costs.