Transportation Research Part A 94 (2016) 397–410

Contents lists available at ScienceDirect

Transportation Research Part A

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

Forecasting passenger travel demand for air and high-speed rail integration service: A case study of Beijing-Guangzhou corridor, China

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ARTICLE INFO

Article history:
Received 15 December 2015
Received in revised form 3 June 2016
Accepted 4 October 2016
Available online 14 October 2016

Keywords:
Air and high-speed rail integration service
Modal split
Stated preference survey

ABSTRACT

This paper investigates the mode choice behavior of inter-city passengers among air transport, high-speed rail (HSR), and air and high-speed rail (AH) integration services. Stated preference survey has been conducted for four typical city pairs that are located in the Beijing-Guangzhou corridor, China. Modal split models are proposed and calibrated based on the collected survey data. The proposed models are used to identify the key factors affecting passengers' mode choices and to estimate the modal split of passenger travel demand for some inter-city transportation markets of China. Sensitivity analyses are also performed to reveal the market potential of the AH integration service in China. It has been found: (i) when the inter-city travel distance exceeds a threshold, passengers become less sensitive to the connection time of the AH service, (ii) the most competitive haul distance for the AH service is between 1200 km and 1600 km, and (iii) the en route travel time is the most important factor affecting the market share of the AH service.

1. Introduction

In the past few years, China has experienced a rapid development of high-speed rail (HSR) due to rapid urbanization and economic growth. By the end of 2014, China has already established the largest HSR network in the world, up to a length of 15,000 km with a maximum train speed of 350 km per hour. Some countries, such as Japan, Spain, France, Germany, and South Korea, have also successfully been operating their HSR lines. Introduction of the HSR service has led to some significant impacts on air transport markets, particularly on the short- and medium-haul markets, due to its competitive advantages in network connectivity, journey time and cost (see, e.g., González-Savignat, 2004; Park and Ha, 2006; Roman et al., 2007; Fu et al., 2012; Yang and Zhang, 2012). In China, for instance, all the flights between Zhengzhou and Xi'an (the haul distance is 503 km) were cancelled on March 25, 2010, only 48 days after inauguration of the HSR service between that city pair. For the Wuhan-Guangzhou route with a haul distance of 1039 km, the number of the average daily flights was reduced from 15 to 9 flights after introducing the HSR service in 2010. Empirical evidences from the European markets have also shown that fierce competition between air transport and the HSR service may occur on the routes with a distance of up to 1000 km, mostly between 400 km and 800 km (e.g., Janic, 1993; Rothengatter, 2011).

However, the relationship between the HSR service and air transport is more than pure competition. The European Union ever stated in its White Paper that "...network planning should therefore seek to take advantage of the ability of HSR to

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http://dx.doi.org/10.1016/j.tra.2016.10.002
0965-8564/

replace air transport and encourage rail companies, airlines and airport managers not just to compete, but also to cooperate…" (Commissions of the European Communities, 2001, see p. 53). There are a few cases of cooperation in reality. For instance, the AIRail service, which was jointly developed by Deutsche Bahn (a German railway company), Lufthansa and Fraport in Germany, is one of the most advanced and successful intermodal products available so far in the world. The prominent features of the AIRail service are the integrated ticketing and baggage through-handling services (Grimme, 2007). Passengers, who travel from/to Stuttgart (or Cologne) and transfer at Frankfurt airport, buy an integrated ticket for their entire trips. Their luggage is first checked through the Lufthansa-branded check-in counter in Stuttgart (or Cologne) railway station. The HSR service (with flight numbers on the carriages of the trains) offered by Deutsche Bahn is then provided to feed those passengers to the terminal of the Frankfurt airport, which is directly linked to the HSR lines. Passengers complete their remaining trips by air service and pick up their baggage at the final destination without worrying about their transfers at the Frankfurt airport. Similar intermodal services are also available in some other cities, such as France, London, Switzerland, and China.

Vespermann and Wald (2011) have summarized several advantages of the intermodal service (i.e., using the HSR service to complement and substitute for the existing short-haul flights) as follows: (i) expansion of airport catchment area; (ii) increasing slot availability at congested airport; (iii) alleviating environmental issues; and (iv) meeting customer's potential needs for a seamless transportation chain. Therefore, the air and HSR (AH) integration service can gain strong political support, particularly in Europe and China (Chiambaretto and Decker, 2012).

Despite the advantages of the intermodal service, in practice, however, passengers' demand for such service is rather limited. A study by the French Civil Aviation Authority (Direction Générale de l'Aviation Civile, 2011) found that the number of passengers using the intermodal service accounts only for 5% of the total traffic volume in Charles de Gaulle (CDG) airport. Since the provision of the intermodal service may require substantial investments (e.g., integrated transportation infrastructure, establishment of baggage through-handling facilities, upgraded computer reservation system and so forth), intermodal service providers usually remain cautious when promoting it. For instance, it is roughly estimated that in order to guarantee economically viable (i.e., breakeven), more than 10,000 and 5000 intermodal passengers per month are, respectively, required to use the AIRail service for the cases of Cologne and Stuttgart (Grimme, 2007).

In light of the above, the relevant stakeholders (i.e., airlines, rail companies or airports) should address the following two important issues before launching the AH integration (or intermodal) service: what kind of haul market is appropriate for provision of the intermodal service? What are passengers' preferences for different service attributes (e.g., en route travel time, connection time, integrated ticket price)? This paper aims to quantitatively analyze passengers' demand for the AH integration service. Three alternative modal split models are proposed to forecast the market share of the AH integration service. Several key factors affecting passengers' travel mode choices are then identified. The calibrated models have also been applied to forecast the market share of the AH service for some typical Chinese city pairs. This study can be served as a useful tool for the stakeholders to evaluate the economic viability of the AH integration service. It can also provide some valuable insights into the intermodal service design issues.

The remainder of this paper is organized as follows. The next section provides a brief summary of the related literature, and highlights the contributions of the paper. Section 3 formulates the modal split models. Section 4 presents the calibration of the model parameters with the stated preference (SP) method. In Section 5, several typical Chinese city pairs serves as model illustration and the sensitivity analyses of key factors are carried out. Section 6 concludes the paper and provides recommendations for further studies.

2. Literature review

There are a number of studies involving the competition between air transport and HSR services (see, for example, González-Savignat, 2004; Park and Ha, 2006; Roman et al., 2007; Adler et al., 2010; Fu et al., 2012, 2014; Yang and Zhang, 2012). However, few publications regarding the AH intermodal service can be found. For instance, Givoni and Banister (2006) suggested airlines using HSR to complement and substitute for the existing airplanes as feeder mode between hubs and spokes. Using the case of London Heathrow airport, they concluded that airlines can benefit from the slots that were freed in the hub airports and the society can have a better integrated transport service at a lower environmental cost. Grimme (2007) presented the German experience in providing the AH intermodal service, which was further evaluated from the perspectives of transport providers, passengers and policy makers. He concluded that the decisive prerequisites of successful intermodal products were the availability of the comparable HSR journey time and the integration of airports into the HSR network. In addition, he also reported that in reality very limited slots have been freed for alternative use at Frankfurt airport. Chiambaretto and Decker (2012) discussed some competitive issues associated with the AH intermodal agreements. They suggested that both the parallel and 'behind and beyond' agreements can raise some competition concerns in particular circumstances.[1]

[1] 'Behind and beyond' agreements imply that an airline sells a non-offered route, which is actually operated by the HSR operator. Parallel agreements imply that both airlines and HSR operators compete on a given route. But, they also sign a code-sharing agreement which allows the airlines to sell the HSR tickets (with its own flight number).