Transportation Research Part B 46 (2012) 1322–1333

Contents lists available at SciVerse ScienceDirect

Transportation Research Part B

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

Effects of high-speed rail and air transport competition on prices, profits and welfare

Hangjun Yang [a,b,*], Anming Zhang [b,c]

[a] School of International Trade and Economics, University of International Business and Economics (UIBE), 10 Huixindong St., Beijing 100029, China
[b] Sauder School of Business, University of British Columbia, 2053 Main Mall, Vancouver, BC, Canada V6T 1Z2
[c] China Academy for Financial Research (CAFR), Shanghai Jiao Tong University, China

ARTICLE INFO

Article history:
Received 24 June 2011
Received in revised form 3 September 2012
Accepted 3 September 2012

Keywords:
Air transport
High-speed rail
Bertrand competition
Price discrimination

ABSTRACT

This paper investigates the effects of competition between air transport and high-speed rail (HSR). While airlines are assumed to maximize profit, HSR may maximize a weighted sum of profit and social welfare. We show that both airfare and HSR fare fall as the weight of welfare in the HSR's objective function increases, while airfare decreases, and rail fare increases, in the airport access time. Furthermore, airfare decreases in rail speed if the impact of HSR marginal cost with respect to rail speed is not too large. On the other hand, whether rail fare increases in rail speed depends not only on the HSR marginal cost but also on the weight of welfare. We further compare prices, profits and welfare between "with price discrimination" in which airlines price discriminate business from leisure passengers, and "without price discrimination". Welfare in the HSR system can be either higher or lower with price discrimination: In particular, it is higher under price discrimination when the difference of gain from travel is sufficiently larger than the time value difference between business and leisure passengers. Finally, a numerical study on China's markets is conducted in which both price and schedule frequency are considered as decision variables.

1. Introduction

The first modern high-speed rail (HSR) – the route between Tokyo and Osaka with a maximum speed of 210 km/h – went into operation in 1964 in Japan. In 1976, British Railways opened an HSR line between London and Bristol. France commenced the operation of its first HSR between Paris and Lyon in 1981. Since then, many European countries have built HSR lines, including Spain, Germany, Italy, Belgium, and the Netherlands.[1] In Asia, South Korea started its first HSR line between Seoul and Daegu in 2004 (which later was extended to Busan), and Taiwan started its HSR service between Taipei and Kaohsiung in 2007.

Yet, the most ambitious HSR development so far is in China: Its original plan, first elaborated in a National Development Plan in 2003, was to build a 12,000 route-km HSR network by 2020, based on a network of four vertical and four horizontal trunk lines. The stimulus package launched by China in 2008 to mitigate the impact of the global financial crisis has more than doubled the investment funds available for railways for the period 2008–2010, enabling its Ministry of Railways to accelerate the HSR construction. The total investment in the HSR network is about USD 300 billion. As a result, the

* Corresponding author at: School of International Trade and Economics, University of International Business and Economics (UIBE), 10 Huixindong St., Beijing 100029, China.
E-mail addresses: hangjunyang@gmail.com (H. Yang), anming.zhang@sauder.ubc.ca (A. Zhang).

[1] According to a recent report by the World Bank (Amos et al., 2010), the total length of dedicated HSR lines in Europe was about 5500 km as of July 2010.

0191-2615/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.trb.2012.09.001

completion dates of several projects have been brought forward, and it is now planned to complete construction of 42 HSR lines, amounting to 13,000 km HSR coverage, by 2012. This will give China the world's largest and most modern (with a maximum speed of 350 km/h) HSR network.

In this paper we investigate the effects of competition between air transport and HSR, which is an important topic in contemporary transport research. As train speeds become faster, HSR is likely to impose significant competitive pressures on air transport. Janic (1993) argues that HSR can compete with air transport over a relatively large range of distances from 400 to over 2000 km. Rothengatter (2011) finds empirical evidence that fierce competition between air transport and HSR may occur on routes with distance up to 1000 km, mostly likely between 400 and 800 km. In China, routes between 400 and 800 km account for about 30% of domestic airline network (Fu et al., 2012). For example, all the flights between Zhengzhou and Xi'an (505 km) were cancelled by the airlines in March 2010 – 48 days after the opening of HSR service – due to very low demand. Even for the Wuhan–Guangzhou route – a much longer route (1069 km) – daily airline flights were reduced from 15 to 9, 1 year after the HSR entry (Fu et al., 2012).

Adler et al. (2010) use a game theoretic setting to analyze competition between air transport and HSR in the medium- to long-distance transport market. They assume that both airlines and HSR maximize their own profits. From a European case study, the authors conclude that the European Union (EU) should encourage the development of the HSR network across Europe. In addition to the empirical finding of competition between air transport and HSR in the EU, Rothengatter (2011) points out various ways to increase the competitive power of HSR. Park and Ha (2006) show, using the stated-preference survey method, that the opening of South Korea's first HSR line imposes significant competitive pressures on airlines in the domestic market. By applying experimental techniques to an analysis of air transport–HSR competition, Gonzalez-Savignat (2004) finds that HSR has a significant impact on the market share of air transport. The simulations further reveal that total journey time is the most important determinant of market share. Roman et al. (2007) analyze air transport–HSR competition based on a mixed set of revealed-preference and stated-preference data on the Madrid–Barcelona link, and obtain different willingness-to-pay measures for service quality improvement. Hsu et al. (2010) investigate the competition between HSR and conventional rail in Taiwan, and develop a theoretical model to describe the rail systems' pricing strategy. However, they solve the model with heuristics. Dobruszkes (2011) studies the HSR and air transport competition in Western Europe from a supply-oriented perspective, and examines empirically five city-pairs. He finds that in addition to travel time, some other variables also affect competition between the two modes, e.g., frequencies, fares, airlines' hubs, geographical structures of urban regions. Chiambaretto and Decker (2012) consider the intermodal agreements between rail and air transport, examine the factors relevant to any competition assessment of the agreements, and raise the question whether environmental benefits should be considered as part of the assessment. Behrens and Pels (2012) examine the HSR and air transport competition in the London–Paris passenger market, and show that travel time and frequency are the two main determinants of travel behavior.

While all the above papers utilize empirical or survey data to study the impact of HSR on air transport, our paper is analytical with the use of an adapted Hotelling (differentiated Bertrand) model, supplemented with a Chinese case study. In this sense our paper is closest in spirit to Adler et al. (2010). An important feature of our analysis which is distinct from Adler et al. is that air and rail operators can have different objective functions. With worldwide deregulation and privatization in the airline industry, airlines are, not surprisingly, profit maximizers. In China, however, HSR operators are owned by the Ministry of Railway of Chinese central government and hence, are interested in both consumer surplus and HSR profit (Economy & Nation Weekly, 2011). Even in Europe and Japan where HSR operators are often private companies, HSR objectives are not necessarily pure profit maximization. Due to the huge capital requirement, HSR networks around the world are typically invested or co-invested by governments. While governments may want to maximize social welfare, HSR operators typically want to recover costs or maximize profits. Unlike airlines, therefore, the objective of HSR operators is likely to be a weighted sum of welfare and profit, especially in the case of China.

By first assuming homogeneous passengers we find, as expected, that both airfare and HSR fare fall as the weight of welfare in the objective function of HSR (referred to as the "weight of welfare" below) increases. On the one hand, airfare decreases, and rail fare increases, in the airport access time. We further show that airfare decreases in rail speed if the marginal cost of HSR with respect to rail speed is not too large. On the other hand, whether rail fare increases in rail speed depends not only on the marginal cost of HSR with respect to rail speed but also on the weight of welfare. In particular, the only constellation where rail fare decreases in rail speed is when the marginal cost of HSR with respect to rail speed is sufficiently small and the weight of welfare is sufficiently large.

We then extend the analysis to the case of heterogeneous passengers. In practice, passengers can be divided into two groups: business and leisure travelers, with each group of passengers having different (gross) travel benefits and different values of time. Specifically, business travelers are expected to have higher travel benefit and higher time value than leisure travelers. It is shown that if airlines do not price discriminate business passengers against leisure passengers, then our main results obtained with homogenous passengers continue to hold. Next, we compare prices, profits and welfare between "with price discrimination," in which airlines engage in price discrimination between business and leisure passengers, and "without price discrimination". We find that the profit of air transport is higher with price discrimination than without price discrimination, whilst the HSR profit remains unchanged. Furthermore, welfare in the HSR system can be either higher or lower with price discrimination: In particular, it is higher under price discrimination when the ratio of (gross) travel benefit difference over time value difference is larger than a critical value. Finally, we extend the model by incorporating schedule frequency as another decision variable. Since it becomes too complicated to solve the model analytically, we solve the