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Effects of high-speed rail and airline cooperation under hub airport capacity constraint

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ABSTRACT

This paper analyzes the effects of cooperation between a hub-and-spoke airline and a high-speed rail (HSR) operator when the hub airport may be capacity-constrained. We find that such cooperation reduces traffic in markets where prior modal competition occurs, but may increase traffic in other markets of the network. The cooperation improves welfare, independent of whether or not the hub capacity is constrained, as long as the modal substitutability in the overlapping markets is low. However, if the modal substitutability is high, then hub capacity plays an important role in assessing the welfare impact: If the hub airports are significantly capacity-constrained, the cooperation improves welfare; otherwise, it is likely welfare reducing. Through simulations we further study the welfare effects of modal asymmetries in the demands and costs, heterogeneous passenger types, and economies of traffic density. Our analysis shows that the economies of traffic density alone cannot justify airline–HSR cooperation.

1. Introduction

Since the first modern high-speed rail (HSR) began operation between Tokyo and Osaka, Japan in 1964, a number of countries including the United Kingdom, France, Spain, Germany, Italy, Belgium, the Netherlands and South Korea have also successfully launched HSR lines. By 2012, China had the world's largest HSR network, amounting to 9300 km of HSR coverage, with speeds between 200 km and 350 km per hour. In the United States, President Barack Obama's (fiscal year) 2012 budget allocated $8 billion for HSR development, representing the first installment of a six-year, $53 billion plan.

As train speeds have increased over the years, HSR has been viewed as a *de facto* substitute and effective competitor of air transport, especially for routes with distances up to 1000 km (e.g., Janic, 1993; Rothengatter, 2011). However, as pointed out by Givoni and Banister (2006), the relationship between HSR and air transport is far more complicated than pure competition alone. In particular, HSR can complement air service by offering connections between airports and nearby cities, and the potential for airline–HSR cooperation exists due to the hub-and-spoke network adopted by most major airlines. Under hub-and-spoke operation, two flights (''legs'') are offered to passengers as one journey from their origin airport to the destination airport through a hub airport. With HSR, however, both these two legs need not be air flights: on legs where HSR service is comparable with flights in terms of (total) journey time and cost, HSR service may also be used in combination with a flight as one journey, with one booking for the entire two-leg trip. Such airline–HSR cooperation may be viewed simply as a special type of ''code sharing'' – i.e. two airlines cooperate to offer a hub-and-spoke operation with each offering one leg of a flight (and a non-operating carrier is allowed to put its code on the operating airline's flight number) – which has been a common practice in the airline industry (e.g. Oum et al., 1996; Brueckner, 2001; Ito and Lee, 2007; Gayle, 2008).

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There are several such airline–HSR cooperations in Europe. The AIRail Service provided by Lufthansa and Deutsche Bahn has connected Frankfurt airport with Stuttgart since March 2001, and with Cologne since May 2003. Passengers purchase a single ticket for the entire trip, and the luggage coordination between the airline and the HSR enables the passengers to pick up their luggage at the final destination without worrying about the transfer problem. Onboard the train, Deutsche Bahn staff provides services comparable to the ones offered onboard European short-haul flights. In France, Air France and SNCF launched TGV AIR in 1994, under which the intermodal passenger transportation between Charles de Gaulle (CDG) and Lille is exclusively operated by TGV (all Air France flights are cancelled). The TGV journey has an associated flight number appearing in the airline's computer reservation system (CRS), but luggage check-in is not included in the intermodal service. Similarly, Thalys International has cooperated with several airlines (Air France, KLM, American Airlines, Lufthansa and SN Brussels) to provide intermodal services to passengers on three Thalys links, namely, Brussels-CDG, Anvers-Schiphol, and Paris (Nord)-Brussels National Airport. These agreements differ from TGV AIR in that travelers check in at the rail stations for the entire journey. In Switzerland, the Swiss railway operator, SBB, cooperates with Swiss Airlines and Finnair to offer an intermodal product, called FlugZug, which covers four destinations (Basel, Bern, Lausanne and Lucerne) beyond Zurich. This product is displayed on the airlines' CRSs such that it looks like a Swiss or Finnair "flight." The traveler is "through checked" and obtains a boarding pass for the train leg of the journey. The service originally offered luggage through-check but the luggage transfer was stopped eventually due to under-utilization (Cokasova, 2006).

While airline–HSR cooperation has become more popular, overall it is still a relatively new phenomenon and so its market outcomes and welfare effects are largely unknown to date. Such cooperation can obviously hurt competition between the two modes in the markets where prior competition between the two occurs. A less obvious question is how such cooperation affects other "secondary" markets, owing to the network nature of a transportation system. The European Union appears to encourage such cooperation, stating in its White Paper that "network planning should therefore seek to take advantage of the ability of HSR to replace air transport and encourage rail companies, airlines and airport managers not just to compete, but also to cooperate" (European Commission, 2001); no rigorous analysis was given however. In the existing literature the two main arguments in favor of airline–HSR cooperation are (1) the relief of congestion at some major airports subject to capacity constraints and (2) the reduction of environmental pollutions (Givoni and Banister, 2006; Socorro and Viecens, 2013), as HSR service can divert airport traffic and is further considered a cleaner mode of transportation than air service, on a per-passenger basis. The arguments are made largely qualitatively with the use of empirical observations.

The present paper investigates analytically air transport–HSR interactions so as to address the impact of airline–HSR cooperation on market outcome and social welfare. Our investigation incorporates some of the most salient features of the two modes: in addition to an explicit examination of potential hub airport capacity constraints, we consider modal asymmetries in the demands and costs, heterogeneous passenger types, and economies of traffic density. Such an exercise is important because airline–HSR cooperation can involve substantial investment in access/connecting facilities and management time and effort. A better understanding of its impact is necessary and timely given that China is developing HSR quite ambitiously and countries like Brazil, India, Russia, Turkey, the UK and the US are evaluating the options of investing in HSR (Fu et al., 2012).

We show that airline–HSR cooperation will, as expected, reduce traffic in the markets where prior competition between the partners occurs, but may increase traffic in other markets of the network. The cooperation would improve social welfare, independent of whether or not the hub capacity is constrained, as long as the substitutability between air service and HSR service in the overlapping markets is low. However, if the modal substitutability is high (and hence the negative effect from dampening competition becomes larger), then hub capacity plays an important role in assessing the welfare impact. If the hub airports are significantly capacity-constrained, then airline–HSR cooperation could help alleviate the constrained capacity and benefit passengers in the non-overlapping markets of the network, leading to a net welfare improvement. Otherwise, the cooperation should be carefully examined, owing to its likely welfare-reducing effect. Through simulations we further find that airline–HSR cooperation is welfare enhancing irrespective of the hub capacity level if any one of the following conditions holds: (1) the unit cost of the HSR operator is sufficiently lower than that of the airline; (2) the HSR service is sufficiently superior to that of the airline; (3) the price sensitivity of HSR demand is higher than that of airline demand; and (4) a sufficiently large proportion of the passengers are business passengers. Our analysis shows that the economies of traffic density alone cannot justify airline–HSR cooperation. Moreover, when the density effect in the air sector is strong, the cooperation is less likely to be welfare enhancing under hub capacity constraints; but when the density effect in the rail sector is strong, this cooperation is more likely to improve welfare.

The existing literature focuses mainly on the competition aspect of the airline–HSR interaction. For example, Gonzalez-Savignat (2004) indicates that HSR service significantly reduces the market share of air transport when the two modes compete head-on. Park and Ha (2006) find that the opening of the first HSR line in South Korea has a significant (negative) impact on the domestic air transport industry. Adler et al. (2010) use a game theory setting to analyze aviation–HSR competition in the medium- to long-distance transport markets. They conclude that the European Union should encourage the development of the HSR network across Europe. With a Hotelling (differentiated Bertrand) model in which the HSR's objective is to maximize a weighted sum of welfare and profit, Yang and Zhang (2012) show that both airfare and HSR fare fall as the weight on welfare rises, and that airfare decreases, and HSR fare increases, in the airport access time. Behrens and Pels (2012) use pooled cross-sectional data from the London-Paris passenger market to identify the degree to and conditions under which HSR is a viable substitute for airline travel. They show empirically that there is fierce competition between aviation and HSR,