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Airline network choice and market coverage under high-speed rail competition

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ABSTRACT

While the existing literature has focused on the short-term impacts, this paper investigates the long-term impacts of high-speed rail (HSR) competition on airlines. An analytical model is developed to study how an airline may change its network and market coverage when facing HSR competition on trunk routes. We show that prior to HSR competition, an airline is more likely to adopt a fully-connected network and cover fewer fringe markets if the trunk market is large. Under HSR competition, the airline will, for a given network structure, have a greater incentive to cover more fringe (regional or foreign) markets if the trunk market is large, or the airline network is close to hub-and-spoke. Further, the airline will, for any given market coverage, move towards a hub-and-spoke network when the trunk market is large, or the number of fringe markets covered by the airline network is large. Both effects are more prominent when the decreasing rate of airline density economies is large. We further show that HSR competition can induce the airline to adopt network structure and market coverage that are closer to the socially optimal ones, thereby suggesting a new source of welfare gain from HSR based on its long-term impacts on airlines. Implications for operators, policy makers and specific countries (such as China) are also discussed.

1. Introduction

Over the past decades, high-speed rail (HSR) has become a growing phenomenon around the world. In countries like Japan, France, Spain, Germany, Italy, Belgium, the Netherlands, United Kingdom, and South Korea, HSR is already a major transport mode for millions of passengers every day. With its first HSR line being introduced in 2007, China has since developed the most extensive and most heavily used HSR network in the world (e.g., Fu et al., 2012). A number of countries including United States, India, Malaysia (and Singapore), Thailand, Russia and Brazil, are seriously considering their HSR development, some of which countries even have a clear plan of construction and financing on the table.

Other than passengers, airlines are another party that are strongly affected by the rapid development of HSR. With increased train speed, HSR has become a *de facto* substitute and effective competitor of air transport, especially for routes with distances less than 1000 km (e.g., Janic, 1993; Rothengatter, 2011). Examples abound where airlines have been forced to withdraw from, or cut back on, short-haul routes. Recent cases of air route cancellations include a number of Chinese

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domestic markets such as Nanjing-Shanghai, Zhengzhou-Xi'an, Changsha-Guangzhou and Wuhan-Nanjing. Deep cuts of airfare after the introduction of HSR service are also very common. For example, the market between Wuhan and Xiamen, two Chinese cities recently linked by HSR, saw an 80% drop in air ticket price (CAPA, 2013b). Due partly to HSR competition, the net profits of the three major Chinese airlines all saw big drops in 2013 (32% for Air China, 25% for China Eastern Airlines, and 24% for China Southern Airlines). In fact, China's HSR now moves twice as many passengers as its airlines (Bradsher, 2013). The Chinese carriers are not alone here: for the first time ever, HSR has outpaced air travel in Spain. Figures released by the National Statistics Institute (INE) in 2014 show that 1.9 million people used the country's extensive HSR (aka "AVE") network in January compared with 1.8 million people who bought plane tickets. These represent a 7.3% year-on-year drop for airplane travel and a 22% rise in high-speed rail journeys.

Capacity reduction and price cuts are both short-term responses by airlines when they confront the direct competition from HSR. Virtually all of the existing literature on air transport–HSR interaction has focused on such short-run impacts (see Givoni and Dobruszkes, 2013, for a recent review). 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. With a simulation model, Ivaldi and Vibes (2008) study the intramodal and intermodal (rail, road, and air) competition with price as the decision variable. Adler et al. (2010) use a game theory setting to analyze aviation-HSR competition in the medium-to-long distance transport markets. With a short-run model focusing on traffic and price, they conclude that the European Union should encourage development of the HSR network across Europe. Yang and Zhang (2012) show that if the objective of an HSR operator is to maximize a weighted sum of welfare and profit, both airfare and HSR fare fall as the weight on welfare rises; furthermore, airfare decreases, but HSR fare increases, in the airport access time.[1] Jiang and Zhang (2014) show that cooperation between airline and HSR reduces traffic in markets where prior modal competition occurs, but may increase traffic in other markets of the network.[2]

However, once established, competition from HSR will likely stay; therefore, airlines need to come up with strategies to compete against HSR in the long run. In this paper we examine, analytically, two long-term airline strategies: (i) network structure, and (ii) market coverage. The network structure, namely a "fully connected" (point to point) network or a hub-and-spoke network, involves a large amount of initial investment and once established, is hard to change (e.g., Oum et al., 1995). In the long run however, airlines can restructure their network structures. Usually, the network structure is relatively constant unless some major events, such as airline deregulation, happen.[3] Many carriers in the world, such as the Chinese airlines, are still using the fully-connected network (Zhang, 2010; Fu et al., 2012), and the fierce competition from HSR is likely to be such a major event that causes the carriers to switch from a fully-connected network to a hub-and-spoke network. As for the decision on market coverage, one of the most important features of air transport is its extensive network coverage. Unlike HSR, which is economically viable only for certain trunk routes due to substantial fixed costs involved in infrastructure building, airlines can serve many smaller markets, hence creating a much more extensive network from which some network-specific benefits (such as higher service frequency and economies of traffic density) are available. One possible competitive strategy by airlines is to target markets that they have previously ignored. These "fringe" markets (small regional markets and/or international markets) may be less profitable to serve than the domestic trunk markets, but they may nevertheless help airlines survive the HSR competition on the trunk routes.[4]

In this paper we study an airline's long-run responses of an airline when it faces the entry of HSR into its domestic trunk market (or when HSR is already in service, it faces an improvement of HSR competitiveness in terms of cost reduction and/or high service quality), with network structure and market coverage being its two potential strategies. Our analysis will specifically incorporate the possible diminishing returns in the benefits from higher traffic density. Academic literature has identified the benefits of higher traffic density on a particular route in terms of reduced cost per passenger (aka "economies of traffic density"). However, the observation that these benefits are likely to diminish as the airline's traffic on the route increases is less explored, a factor that is to be taken into account in the present paper. Our analysis shows that for a given network structure, when HSR enters the trunk route (or improves its competitiveness on the route), the airline will have a greater incentive to cover more fringe (regional, foreign) markets if the trunk market is larger or the airline network is closer to hub-and-spoke. On the other hand, for any given level of market coverage, it would be more likely for the airline to move towards hub-and-spoke network as a response to the HSR entry (or an increase in HSR competitiveness) when the trunk market is larger, or when the airline covers more fringe markets. Both effects are more prominent when the diminishing rate of the benefits from greater air traffic density is higher. We further demonstrate that the socially optimal levels of market coverage and network structure can be higher or lower than the privately optimal levels depending on the size of the trunk market. More importantly, we show that introducing (or enhancing) HSR competition can induce the airline to achieve market-coverage and network-structure levels that are closer to the socially optimal levels. We note that

[1] See Behrens and Pels (2012) and Martin et al. (2014) for recent empirical studies on the role of terminal access (among others) on the competition between HSR and air transport.

[2] For recent empirical work on competition and cooperation/integration between the two modes, see Albalate et al. (2014) and Roman and Martin (2014).

[3] The Airline Deregulation Act of 1978 has led most of major US airlines to shift from a fully-connected network to a hub-and-spoke network (e.g., Levine, 1987; Borenstein, 1992; Zhang et al., 2011). The deregulation of European airlines between 1993 and 1997 had a similar effect.

[4] CAPA (2013a) suggests that for Chinese airlines, international yields are often significantly lower than domestic yields, and international services are often unprofitable. Notice that so far, there is no HSR service between China and other countries.

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