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Effects of train speed on airline demand and price: Theory and empirical evidence from a natural experiment

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ABSTRACT

This study investigates, both theoretically and empirically, the effects of high-speed rail (HSR) speed on airline traffic and price, taking into account the degree of substitutability between the two services. Our model incorporates two countervailing effects of HSR speed, namely the "travel time" effect and the "safety" effect: while increasing HSR speed reduces HSR travel time, it may bring about a safety concern especially in emerging HSR markets such as China. Our theoretical analysis suggests that HSR speed impact on airline traffic and price depends on the relative dominance of the travel-time and safety effects, and air-HSR substitutability may reinforce the HSR speed effect. Furthermore, HSR speed has a larger impact on airline traffic than on airline price. Our empirical results from a rare natural experiment of HSR speed reduction in China show that HSR speed reduction raises both airline traffic and price, suggesting the dominance of travel-time effect. More importantly, consistent with the theoretical prediction, the HSR speed effect is empirically stronger on short-haul routes where the airline and HSR services are more substitutable.

1. Introduction

With a significantly increased train speed, high-speed rail (HSR) has become an effective competitor of air transport. Studies on intermodal competition show mixed results on the competitive distance of HSR. Adler et al. (2010) find that HSR is most competitive on routes with 750 km (kilometers) or less distance. Chen (2017) finds that the impact of HSR on airlines is the greatest on routes with distance between 500 km and 800 km. Wan et al. (2016) show that in China, HSR services with a maximum speed of 300 km/h (kilometers/hour) produce much stronger negative impacts on routes over 800 km than those with a maximum speed of 200 km/h. Therefore, HSR speed plays a critical role in shaping HSR's service substitutability with airlines. In fact, HSR speed is an important service quality that contributes to the vertical differentiation between HSR and air transport (Xia and Zhang, 2016). Furthermore, vertical differentiation in speed may co-exist with passengers' heterogeneous taste in mode preference (i.e., horizontal differentiation). More specifically, given the quality factor (e.g., speed), passengers may not reach consensus on the modal choice. The perceptions and attitudes, habitual behaviors, lifestyle choices, and cultural factors can affect travel mode choice over airlines or HSR (Bennett et al., 1957; Thøgersen, 2006; Blainey et al., 2012). For instance, passengers may have divergent perceptions on airlines and HSR in terms of safety concern, comfort level, and in-vehicle service (Li et al., 2015).

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The heterogeneous tastes may lead to different substitutability between airlines and HSR. When route distance increases, passengers spend longer time in traveling. As a result, their personal tastes on service characteristics of different modes can be amplified, and they may increasingly regard airline and HSR services as different and less substitutable. On the other hand, airline and HSR services become more substitutable on short-haul routes. For instance, by using survey data from Taiwan's HSR market, Li and Schmöcker (2017) found that airline and HSR services are more substitutable on the short-haul routes with HSR travel time between one to two hours.

When the two modes are more substitutable and thus compete more fiercely, HSR speed, as a quality attribute, may have different effects on airlines in terms of price and traffic volume. An increasing number of analytical studies have investigated the intermodal competition between airlines and HSR (Yang and Zhang, 2012; D'Alfonso et al., 2015, 2016; Jiang and Zhang 2016; Talebian and Zou, 2016), but there are no studies, to our best knowledge, that explore how the air-HSR substitutability can moderate the HSR speed impacts on airline traffic and price.

Furthermore, while an increased HSR speed reduces travel time it may, on the other hand, raise safety concern as the existing trains are already at a very high level. This appears the case especially in emerging HSR markets such as China, where experience of HSR operation and management is still being accumulated and technologies are being fast developed. The speed increase can cause suspicion over the railway safety among travellers, especially after China's "7.23 rear-ending" crash accident in July 2011 (the details of the accident will be discussed in Section 3 below). This safety concern may be ongoing, affecting negatively HSR demand.

This paper develops an analytical model to study HSR speed effects on airline traffic and price, explicitly accounting for the potential impact of intermodal substitutability. Our model will, following the above discussion, incorporate two countervailing effects of HSR speed, namely the "travel time" and "safety" effects, where an increase in HSR speed reduces HSR travel time but may harm public confidence in HSR safety. Apart from investigating whether and how the air-HSR service substitutability can moderate the HSR speed effect, the present paper is also the first study to analytically incorporate the safety effect of HSR speed in air-rail competition.

As a natural and important extension of the analytical model, we empirically test, and quantify, the HSR speed effects on airlines using an event of HSR speed reduction in China. The exercise allows us to verify our theoretical findings. As will be elaborated in Section 3, this HSR speed reduction in China in 2011 largely alleviates the endogeneity concern over HSR speed-effect estimation. Briefly, this is because the reduction was enforced by the government rather than being a market competition outcome, and it was implemented system-wide (independent of any route heterogeneity). A difference-in-differences (DID) method is employed to estimate equations of airline traffic and price.[1] In line with theoretical analysis, we identify varying HSR speed effects when airline and HSR services are differently substitutable.

Our theoretical model shows that the air-HSR substitutability reinforces the HSR speed effect on airlines, and that the speed effect depends further on the relative dominance of the travel-time and safety effects. A train-speed reduction increases airline traffic and price when the travel-time effect dominates, while it reduces airline traffic and price when the safety effect dominates. Moreover, HSR speed has a larger impact on airline traffic than on airline price. Finally, our analysis suggests that the speed effect can be moderated by the intensity of inter-airlines competition.

Furthermore, our empirical results are largely consistent with the theoretical findings. Specifically, the HSR speed reduction increased both airline traffic and price, implying that in the Chinese market we examined, the travel-time effect dominates the safety effect of a HSR speed change. More importantly, the estimation shows that the HSR speed effect on airlines is much stronger on short-haul routes than on long-haul routes. This result is robust with alternative econometric specifications. By conducting model selection tests, we find that the HSR speed effect on airlines declines with route distance but increases with HSR speed in a square relation. The HSR speed effect is thus very responsive to air-HSR substitutability (as noted above, airlines and HSR are more substitutable on short-haul routes than on long-haul routes).

The paper is organized as follows. Literature review is provided in Section 2. Section 3 discusses HSR development in China and the system-wide HSR speed reduction in 2011, which is used as a natural experiment to estimate HSR speed effects. Section 4 develops a theoretical model, and Section 5 specifies the econometric model and describes data sources and variables. Estimation results are presented in Section 6. Finally, Section 7 contains concluding remarks.

2. Literature review

This section reviews major studies on air-HSR competition, focusing on the travel time and safety issues. One stream of the literature investigates, analytically, the effects of air-HSR competition. Yang and Zhang (2012), using an adapted Hoteling model, find that both airfare and rail fare fall as HSR puts more weight on social welfare in its objective function. D'Alfonso et al. (2015) analyze the environmental impact of air-HSR competition and show that the introduction of HSR may have a negative effect on the environment. Jiang and Zhang (2016) investigate the long-term impacts of HSR competition on airlines and find that the airline, faced with stronger competition from HSR, may move towards the

[1] See Ashenfelter and Card (1985) for the details on the DID estimation method and application.