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The Competition Effects of Low-Cost Carriers and High-Speed Rail on the Chinese Aviation Market

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Abstract: Despite the fast growth of the Chinese aviation market in recent years, various legacy regulations remain and a few big airlines dominate the domestic market. This study empirically investigates the competition effects of various passenger carriers on leading airlines' profitability and pricing strategy. Our study suggests that different types of carriers, namely low-cost carriers (LCCs), and the high-speed rail (HSR) operator, all bring effective competition to the aviation market by reducing airlines' profitability and prices. HSR services bring much more significant competition than LCCs, especially on short-distance routes below 1000 km. Chinese airline groups' "dual-brand" strategy did not enhance airlines' profitability. These findings suggest that there can be multiple driving forces to increase the competitiveness of Chinese airlines. Any type of market deregulation could potentially lead to gains in consumer welfare. In addition, much of the market dynamics will be driven by HSR operations beyond the control of aviation regulators. Government authorities should consider coordinating the development of HSR services and new airports, and meanwhile promote competition in all forms.

Keywords: Chinese aviation market; High-speed rail; Low-cost carriers; Profitability; Competition.

1. Introduction

The Chinese aviation market has experienced substantial growth in the past decades, and has been ranked the world's second largest market in terms of scheduled capacity since 2005 (Fu et al., 2012). There is no sign of market slowing down, with passenger volume maintaining a growth rate of 10.9% in 2018 (Civil Aviation Administration of China, 2019). Airlines' productivity and efficiency levels are also improving toward international standards (Wang et al., 2014a; Yan et al., 2019). Despite the remarkable growth and achievements, the Chinese aviation industry still faces many challenges, such as cost cutting and control, managing fluctuating demands, deregulation and liberalization, and meeting quality requirements (Li et al., 2010; Baker, 2013; Adler et al., 2014; Fu et al., 2015a). Many input markets are still under various controls which could have compromised Chinese airlines' cost competitiveness despite low input prices for labor and general costs. For example, the price of jet fuel price was ranked as the second highest in the world (after Mexico) in 2016 (International Air Transport Association 2017), and many important IT systems and services are controlled by one state-owned provider. More importantly, a few large airlines dominate the market, with the four largest carriers controlling more than 80% of the passenger market (Fu et al., 2015b; Civil Aviation Administration of China 2019). Such a high market concentration, together with slot control in many of the hub airports, might limit airline competition and impose entry barriers (Fu et al., 2015a; Wang et al., 2017a). Reduced competition will not only harm users of aviation services such as travelers, logistics companies, and cargo shippers, but also reduce the competitiveness of the Chinese aviation market in the long term. Therefore, it is important for industry practitioners and policy makers to understand the status of and drivers for airline competition, so that appropriate government policies can be designed to promote the sustained growth of the industry. A better understanding of the aviation market also helps companies and stakeholders to review their operation and management strategies, so that informed decisions can be made. In recent years, the emergence of low-cost carriers (LCCs) and the fast expansion of high-speed rail (HSR) systems are having significant impacts on the aviation market in China. Although a number of studies have examined these issues in isolation, few have examined them within one framework. In addition, most previous studies have focused on airlines' fare changes, which are different across different routes, carriers, and market structures. This paper aims to provide an updated view on these two important and inter-related issues using real market data collected for the trunk routes in the Chinese domestic markets.

A number of LCCs have been formed in China since the early 2000s, controlled by either state-owned airlines or private enterprises. Following the strategy of established LCCs in North America and Europe (Connell and Williams, 2005; Fu et al., 2011; Hanaoka et al., 2014; Fageda et al., 2015; Zou et al., 2015; Wang et al., 2017a), these airlines typically provide simple, no-frills services through standardized fleets in order to reduce cost and increase efficiency, thus providing fares significantly lower than rival full-service carriers (FSCs). Many empirical studies have concluded that low fares have been the main tool for LCCs to stimulate market growth as well as capture market share from FSCs (Windle and Dresner, 1995, 1999; Anuwichanont, 2011; Dolnicar et al., 2011; Martínez-Garcia et al., 2012). Studies have found that the entry of competitive LCCs can lead to significant fare reductions and passenger volume growth at the same time. For example, the entry of AirTran and JetBlue into Richmond in 2006 increased traffic volume by 400,000 new passengers, reducing the average fares of virtually all incumbent airlines, while the entry of AirTran into Pittsburgh reduced US Airways fares by 27% and increased passenger volume by more than 76,000 (Detzen et al., 2012). In China, the presence of LCC on a route has reduce the airfare and stimulate the demand for air travel significantly (Wang et al., 2018). Incumbent airlines may also adjust their fares on routes not yet having LCC services, partly due to the desire to deter the threat of LCC entries (Morrison, 2001; Goolsbee and Syverson, 2008; Fu et al., 2019). On the other hand, fares are not the only factor driving customer satisfaction (Forgas et al., 2010). LCCs face a huge challenge of retaining and building a loyal customer base (Rajaguru, 2016), whereas FSCs can differentiate and compete in quality in addition to price responses. Although fare reductions following LCC entry have also been documented in China, an empirical study of Spring Airlines, the most successful LCC, suggested that the carrier was able to achieve fast growth without triggering price wars with incumbent FSCs. This is because the LCC adopted a "cream skimming" strategy to enter high-priced routes, which allowed the carrier to achieve both a high load factor and considerable profitability (Fu et al., 2015a). However, few studies have investigated the issues of product differentiation and service quality issues. Overall, despite findings and evidence suggesting that the Chinese aviation market may have some distinct features compared to fully deregulated markets in developed economies, much remains to be studied regarding the LCC segment in China.

A unique challenge to Chinese airlines is the fast expansion of the HSR network, especially for Origin–Destination (OD) pairs with a trip distance shorter than 1,200 kilometers (Fu et al., 2012). HSR total operational mileage reached 29,904 km by the end of 2018, serving more than 80% of cities with populations exceeding one million. Zhang et al. (2013) highlighted that with the continuous improvement of the HSR network, airlines' market structure and competitive strategy would need to change. Hence it is necessary to analyze the impact of high-speed rail on the civil aviation market. The effect of the competition and complementarity between HSR and air transport has been well studied, as summarized in a comprehensive survey of the recent studies by Zhang et al. (2019a). Studies on developed economies suggest that on short- to medium-distance routes, HSR can impose significant competitive pressure by reducing airlines' market share, traffic volume, and airfares (Gleave, 2006; Park and Ha, 2006; Dobruszkes, 2014; Behrens and Pels, 2012; Clewlow et al., 2014; Fu et al., 2014; Bergantino and Capozza, 2015; Wan et al., 2016). The implications for airlines' frequency can be ambiguous, which may decrease, remain largely stable, or even increase (Bilotkach et al., 2010; Albalate et al., 2015), but generally the overall effects of HSR competition are likely to be welfare-enhancing (Adler et al., 2010; Dobruszkes et al., 2014). The extensive HSR network in China implies that HSR will compete with airlines in many markets, thus placing significant competitive pressure on airlines' yields, market share, and network configurations (Yang and Zhang, 2012; Zhang et al., 2017a).

On the other hand, HSR and airlines services can also be complementary (Givoni and Banister, 2006). For example, HSR could feed traffic on "spoke" route to airlines' "hub-and-spoke" networks. This would lead to inter-modal cooperation (Givoni and Banister, 2006; Jiang and Zhang, 2014), and benefit the environment as HSR services tend to be more environmentally friendly (Fu et al., 2014; D'Alfonso et al., 2015, 2016). Both empirical investigations (e.g. Givoni and Banister, 2006) and modelling studies (e.g. Socorro and Viecens, 2013; Jiang and Zhang, 2014) have suggested that such cooperation and better integrated transport services could improve social welfare, reduce environmental costs, and ease congestion at capacity-constrained airports. However, analytical studies (Xia and Zhang, 2016; Jiang et al., 2017) have noted that the effects of air–HSR cooperation on social welfare are dependent on the types of air–HSR cooperation, and quality differences between inter-modal and air connection services. The quality improvement of HSR services and air–HSR cooperation may either reduce or increase airlines' prices on different markets (Su et al., 2019). In summary, although most studies have concluded that HSR operations are likely to increase market competition and social welfare, it is possible for airlines and HSR operators to cooperate in selected markets and the market outcomes may be dependent on various factors.

Although the effects of LCC and HSR on airline competition have been considered simultaneously in a few studies, they were mostly treated as moderating factors and controlled by non-interacting dummy variables. An implicit assumption of such a specification is that LCC and HSR services are exogenous and independent, and are not influenced by the market structures on the routes under investigation. In addition, most studies on Chinese LCC development have focused on Spring Airlines. For example, Wang et al. (2017b) indicate that HSR expansion on highly populated and developed routes is likely to leave LCCs with little room to sustain operations of large scales. Because Spring Airlines developed its own ticketing and booking system, Chinese LCCs' pricing strategy remain unknown and were indirectly inferred by examining rival FSCs' fare reactions. What is more, some Chinese LCCs are affiliated with dominant FSCs. A number of studies have examined this so-called Airline-in-Airline (AinA) strategy, also referred to in the literature as the "dual-brand" strategy. Under such a strategy, a FSC and an LCC belong to the same airline group, which may allow the airline group to achieve pricing benefits at the expense of rival airlines (see, for example, Morrel, 2005; Lin, 2012; Homsombat et al., 2014; Pearson and Merkert, 2014; Zhang et al., 2017b, 2018). No studies have yet analyzed this important issue for the Chinese aviation market.

To fill such gaps in the research, this study examines competition among FSCs, LCCs, and the HSR operator on the most travelled routes in the Chinese aviation market. Separate econometric estimations are carried out for different market structures (i.e. FSC–HSR competition, FSC–LCC competition, and FSC–HSR–LCC competition, respectively), so that the competitive effects of different types of carriers can be clearly and separately identified. Our study also estimates the profitability of carriers, so that the competitive implications can be analyzed for different types of routes and airlines for which costs may be significantly different. Finally, our study also attempts to control the effects of the AinA/dual-brand strategy in airline competition, which has been adopted by an increasing number of airlines in Asia and Australasia. Our estimations are based on a large amount of pricing data collected from leading travel booking sites, over trunk routes served by different types of carriers including HSR and LCCs. The effects of AinA/dual-brand strategy is also first examined for the Chinese aviation market. These contributions provides an updated and comprehensive view of the Chinese inter-city travel markets, providing some useful references for industry and regulatory decision-makers.

The remainder of the paper is organized as follows. Section 2 describes the data specification and collection process. Sections 3 and 4 introduce the model and present the estimation results, respectively. Section 5 provides the economic implications and summary. Policy suggestions are provided in the last section.

2. Data collection and processing

The Chinese aviation market remains dominated by the four largest FSCs. In 2018, their market shares in the passenger markets were Air China (CA) 22.40%, China Southern Airlines (CZ) 22.89%, China Eastern Airlines (MU) 19.78%, and Hainan Airlines (HU) 17.82%, respectively (Civil Aviation Administration of China, 2019). Understanding these airlines' behavior will provide good guidance in evaluating the overall development of the Chinese aviation market. Therefore, following previous studies that focused on the dominant airlines (Zhang and Round, 2011; Zhang et al., 2014, Su et al., 2019; Zhang et al., 2019b), we will examine the effects of HSR and LCCs on these leading carriers' pricing, frequency, and profitability.

The primary data used in this study were collected from the Qunar website, one of the most popular travel booking websites in China. We examine flights offered on 22 city-pairs between 11 June and September 11 2016, using data collected daily for each flight starting 30 days before its departure. These routes were selected so that the resultant sample meets the following requirements: (1) the sample includes cities with the largest passenger throughputs, so that the sample captures the most important and representative markets. For instance, Beijing, Shanghai, and Guangzhou alone account for 40% of the overall passenger throughput in China; (2) different types of airlines operate on the selected routes. For instance, the sample contains 19 airlines, including state-held airlines, local government-held airlines, private airlines, and a Sino-foreign joint venture. The sample contains 4 LCCs (Spring Airlines, China United Airlines, Lucky Airlines, and West Airlines);[1] (3) the sample covers short-, medium-, and long-distance routes, which is necessary because LCCs and HSRs' effects on airline competition are likely to be distance dependent. Restricting the data to economy fares, a total of more than two million airfare observations were compiled. Data for HSR were mostly collected from the official website of the China Railway Customer Service Center. Average stage lengths and average cost per available kilometer (CASKs) of the four dominant airlines were compiled from their annual reports. The market characteristics and inter-modal competition conditions on these 22 routes are summarized in Table 1 and Figure 1.

Table 1 Summary statistics for the 22 city-pairs

City pairs	Flight/travel time（min）		Average daily frequencies		Direct distance（km）	With LCC presence
	Air	HSR	Air	HSR		
Lanzhou-Chengdu	95	0	7	0	659	No
Changsha-Kunming	120	0	11	0	1078	No
Chengdu-Shenzhen	155	0	19	0	1318	No
Beijing-Urumqi	215	0	18	0	2429	No
Beijing-Taiyuan*	80	180	6	17	407	No
Shenzhen-Xiamen*	80	240	2	1	488	No
Guangzhou-Changsha*	80	160	4	102	531	No
Hangzhou-Changsha*	110	270	5	37	737	No
Wuhan-Guangzhou*	110	240	10	60	824	No
Dalian-Haerbin*	95	270	1	18	835	No
Nanjing-Beijing*	120	270	11	49	947	No
Shanghai-Xiamen**	115	480	26	5	816	Yes
Beijing-Shanghai**	130	330	51	37	1096	Yes
Guangzhou-Shanghai**	145	480	39	4	1201	Yes
Beijing-Chengdu**	190	846	35	1	1557	Yes
Beijing-Guangzhou**	200	600	31	5	1875	Yes
Kunming-Xishuangbanna***	70	0	36	0	412	Yes
Chengdu-Kunming***	95	0	19	0	615	Yes

[1] Chengdu Airlines is not classified as an LCC during the sample period although the airline was recently reportedly as having transformed into an LCC.

Lanzhou-Beijing***	155	0	15	0	1181	Yes
Shenzhen-Shanghai***	155	0	46	0	1231	Yes
Shanghai-Xian***	165	0	29	0	1274	Yes
Beijing-Kunming***	205	0	28	0	2092	Yes

*with FSC and HSR services, **with FSC, HSR and LCC services, ***with FSC and LCC services

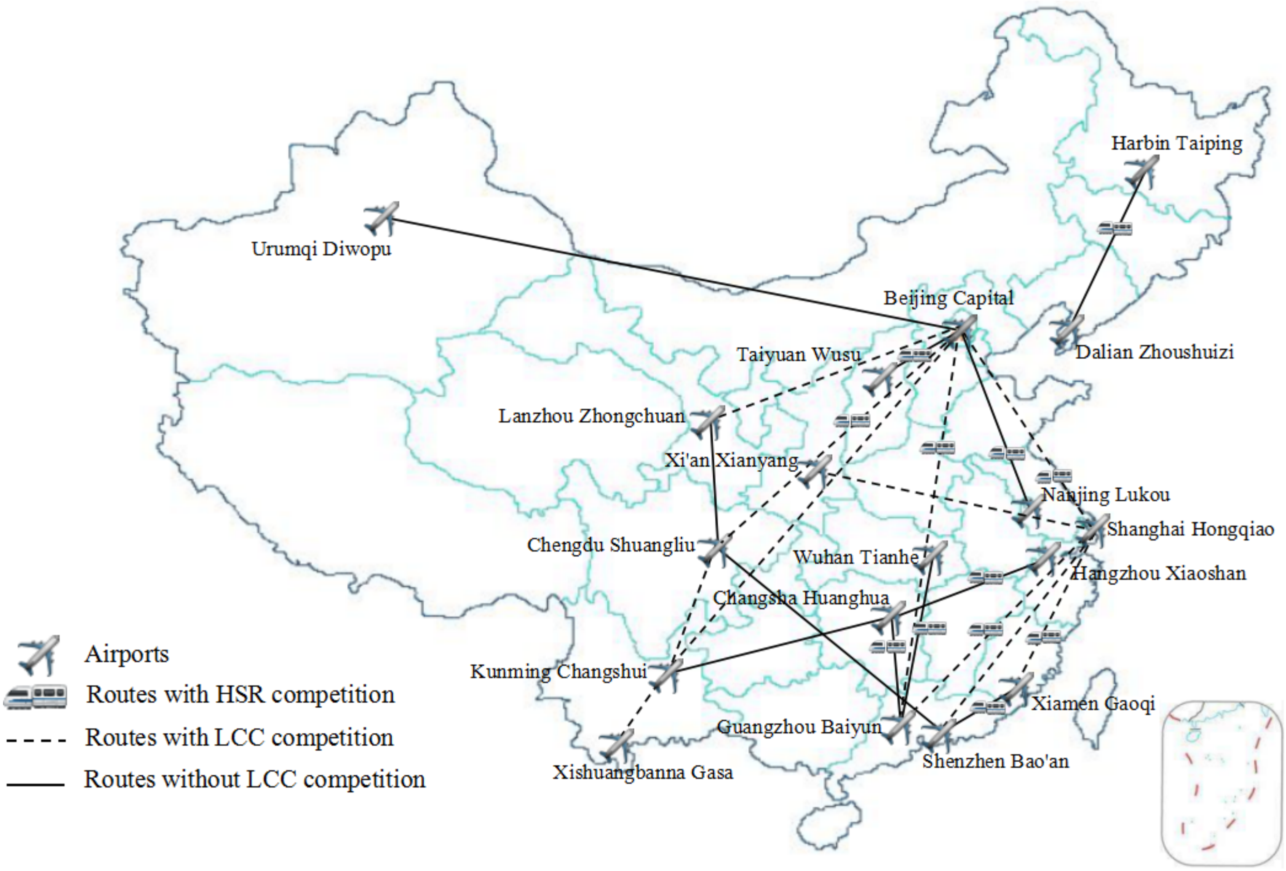

Figure 1. Geographic distribution of the 22 city-pairs

The average prices for the four dominant FSCs on each route were calculated based on the 30 observations collected before departure, which are used in the estimation of these carriers' profitability. After removing flights with incomplete data, a sample of 57,173 observations was used for the econometric estimation.

3. Profitability estimates

3.1 Model specification

Based on the type of services provided, passenger carriers in our sample are classified into three categories: FSCs, LCCs, and one HSR operator that owns the national rail network. We focus on the effects of LCC and HSR competition on FSCs' profitability, because these largest FSCs' dominance and significant influence are key determinants for Chinese domestic market performance. If comparable cost data can be obtained for LCCs and the HSR operator, similar analysis can be carried out on these carriers using the same methods. Following Li et al. (2009) and Zhang et al. (2014), the profitability of airline i on route k during period T can be measured by γ_{iT}^{k} which is specified as follows, where P_{iT}^k and MC_{iT}^k are the airline's price and marginal cost on this route, respectively:

$$\gamma_{iT}^k = \frac{P_{iT}^k - MC_{iT}^k}{P_{iT}^k} \tag{1}$$

Profit margin γ_{it}^k is effectively the Lerner index that has been extensively used in the literature to measure a firm's pricing/market power. Alternative methods have been used to calculate the marginal cost of an airline. One is to estimate the coefficient of a total cost function (Mizutani, 2011). Such an approach requires detailed and extensive data on input prices and quantities for airlines, which is very difficult to compile due to the complex holding structures of the Chinese FSCs. In addition, many airlines are not publicly listed, making it even more difficult to obtain financial and cost data. Another method has been adopted in airline competition studies, such as by Brander and Zhang (1990, 1993), Wang et al. (2014c), and Zhang et al. (2014). This approach utilizes the average cost at airline level as follows:

$$MC_{iT}^k = cpk_{it}(D^k / AFL_{it})^{-\theta} D^k \tag{2}$$

where cpk_{it} is the average cost of airline i during period t; D^k is the flight distance of route k; AFL_{it} is the average flight/stage length; θ is a coefficient that captures the "cost tapering" effect (i.e. average cost declines on longer routes) . Equations (1) and (2) imply that

$$P_{iT}^k = \frac{cpk_{iT}(D^k / AFL_{iT})^{-\theta} D^k}{1-\gamma_{iT}^k} \tag{3}$$

which can be rewritten in logarithm form as

$$\ln(cpk_{iT}) + \ln(D^k) - \ln(P_{iT}^k) = \theta[\ln(D^k) - \ln(AFL_{iT})] + \ln(1-\gamma_{iT}^k) \tag{4}$$

Define $Y_{iT}^k = \ln(cpk_{iT}) + \ln(D^k) - \ln(P_{iT}^k)$, $X_{iT}^k = [\ln(D^k) - \ln(AFL_{iT})]$, $a_{iT}^k = \ln(1-\gamma_{iT}^k)$, $a = mean(a_{iT}^k)$ and $\varepsilon_{iT}^k = a_{iT}^k - a$, then we have:

$$Y_{iT}^k = \theta X_{iT}^k + a + \varepsilon_{iT}^k \tag{5}$$

which can be empirically estimated with a linear regression with a being the constant[2]. This leads to an

[2] With the estimate data obtained using this approach, there is no rigorous proof that the estimated value of θ is

estimation result of θ=0.408 for our sample. It should be noted that these measures of profitability shall be interpreted as the "gross" profitability at route level, as firm level costs such as general administration costs, marketing and sales, and loyalty programs, are not reflected. Oum et al. (1993) obtained θ=0.43 using data from the U.S. market. Murakami (2011) obtained θ=0.374 using data from the civil aviation industry in Japan, whereas Wang et al. (2014c) arrived at an estimate of θ=0.4 using data for the three major airlines in China. All estimations are close to and consistent with our result. Using our own estimate, the dominant FSCs' profitability can be calculated directly as

$$\gamma_{iT}^{k}=\frac{P_{iT}^{k}-cpk_{iT}(D^{k}\ /\ AFL_{iT})^{-0.408}D^{k}}{P_{iT}^{k}} \tag{6}$$

3.2 Empirical results

We first calculate the average value of the four airlines' daily prices before departure on each route (i.e. P_{iT}^{k}), and then use Equation (6) to calculate airlines' profitability. Table 2 summarizes the mean values of the profitability on the 22 city-pairs included in our sample.

Table 2 Four dominant FSCs' average profitability on each route

City pairs	CA	CZ	HU	MU	Route average
Lanzhou-Chengdu	0.510	—	—	0.464	0.487
Changsha-Kunming	—	0.321	—	0.383	0.352
Chengdu-Shenzhen	0.370	0.395	0.409	0.392	0.392
Beijing-Urumqi	0.477	0.486	0.463	—	0.475
Beijing-Taiyuan*	0.065	—	—	0.246	0.156
Shenzhen-Xiamen*	—	—	0.305	—	0.305
Guangzhou-Changsha*	—	0.288	—	—	0.288
Hangzhou-Changsha*	—	—	0.044	—	0.044
Wuhan-Guangzhou*	0.124	0.136	—	0.084	0.115
Dalian-Haerbin*	—	—	—	0.216	0.216
Nanjing-Beijing*	0.222	—	—	0.109	0.166
Shanghai-Xiamen**	—	—	—	0.45	0.450
Beijing-Shanghai**	0.393	0.281	0.273	0.354	0.325
Guangzhou-Shanghai**	0.331	0.370	0.358	0.321	0.345
Beijing-Chengdu**	0.437	0.351	0.366	—	0.385
Beijing-Guangzhou**	0.366	0.379	0.383	0.374	0.376
Kunming-Xishuangbanna***	—	0.639	—	0.610	0.625
Chengdu-Kunming***	0.549	—	—	0.524	0.537
Lanzhou-Beijing***	0.475	—	0.383	0.461	0.440
Shenzhen-Shanghai***	0.196	0.230	0.320	0.274	0.255
Shanghai-Xian***	0.241	0.225	0.266	0.375	0.277
Beijing-Kunming***	0.457	0.384	0.375	0.429	0.411
Total mean	0.348	0.345	0.329	0.357	0.337

*with FSC and HSR services, **with FSC, HSR and LCC services, ***with FSC and LCC services

unbiased and consistent. Therefore, sensitivity tests are carried out by varying the value 10% below and above the estimated value. The results do not change significantly or qualitatively.

To separately identify the effects of LCC and HSR competition on FSCs' fares, the 22 routes are classified into four types: (1) FSC services only; (2) FSCs with the presence of the HSR operator; (3) FSCs and LCCs; and (4) routes with all three types of carriers (i.e. FSCs, LCCs, and the HSR operator). Summary statistics for these four types are given in Table 3, which reveal the following patterns:

(1) There were four routes with FSC services only, where FSCs achieved high profitability. The route level average profitability ranged between 0.352 (Changsha-Kunming) to 0.487(Lanzhou-Chengdu). The result indicates that FSC has strong profitability on routes without HSR and LCC competition.

(2) There were seven routes on which the only substitutable service for FSCs is provided by the HSR operator, most of which had a travel distance of 1,000 km or less. The minimum profitability was merely 0.044 (Hangzhou-Changsha), which suggests that airlines on these routes barely made any profit. Route level profitability was 0.288 on the Guangzhou-Changsha route with only a China Southern Airlines service, and route level profitability was 0.305 on the Shenzhen-Xiamen route with only one daily HSR service. On other routes with higher HSR and airline service frequencies, the mean values of γ_i^k were maintained at a low level. The number of operating airlines on these seven routes was quite small, likely due to the fact that on these short distance routes (average distance being 681km, with virtually all routes below 1000 km) HSR service is so competitive that airlines can barely maintain their services at minimum profitability. On short-distance routes, airlines either reduce output and frequency, or expand to routes with low HSR frequency, to maintain more resilient passenger networks.

(3) On the five routes where FSCs face competition from both HSR and LCCs, the mean values of γ_i^k were at medium levels. For example, the profitability was 0.325 on the Beijing-Shanghai route where HSR daily service frequency was the highest (i.e. 37 daily services). Beijing-Shanghai is China's busiest passenger route, with nearly 3 million passengers, exceeding Shanghai-Shenzhen, which ranks second. On the four other routes where HSR service frequency was much lower (1–5 daily), the range of γ_i^k was between 0.345 and 0.450. The competition effects of HSR and LCCs on FSCs' profitability are moderate on these relatively long routes (average distance being 1309 km), where HSR's competitiveness is not as strong as on the shorter distance routes. It appears that these are heavily travelled routes linking major aviation destinations, where FSCs have substantial market power.

(4) On the six routes where FSCs faced LCC competition only, γ_i^k showed significant volatility. The minimum mean value of γ_i^k was 0.233 and maximum was 0.625. On the two routes (i.e. Shanghai-Xi'an and Shenzhen-Shanghai) that Spring Airlines operates, the mean values of γ_i^k were relatively low compared to the other three routes on which FSC-affiliated LCCs operated. Compared to the state-owned LCCs that are affiliated with FSCs, the privately owned LCC imposed more significant pressure on the profitability of the four dominant airlines.

Table 3 Summary statistics of dominant airlines' profitability on different type of routes

Type of routes	Average Distance (km)	Average Profitability	Avg. Traffic Vol. of the smaller airport (Passengers)	Avg traffic vol. of the larger airport (Passengers)
FSCs only	1371.000	0.454	23592389	57112966

FSC, HSR	681.286	0.235	19080938	56869768
FSC, HSR, LCC	1309.000	0.402	50848671	83037038
FSC, LCC	1134.167	0.450	29693773	68135185

4.Econometric analysis

4.1 Models

In order to further study the impact of HSR and LCCs on the four major airlines, we define the following regression specifications (7) – (9). The first model we estimated is as follows,

$$\overline{\gamma}_{ijt}^{k} = \beta_0 + \beta_1 HSR\_only_t^k + \beta_2 LCC\_only_t^k + \beta_3 HSR\_LCC_t^k + \beta_4 \ln Distance_t^k + \beta_5 \ln(T^O T^D)^k$$
$$+\beta_6 FrequencyShare_{it}^k + \delta_1 Departime_{ijt}^k + \delta_2 Month_t + \delta_3 Weekday_t + \delta_4 Route^k + \varepsilon_{ijt}^k \quad (7)$$

Where γ measures the profitability of the observe flight *j* on route *k* operated by airline *i* for the departure date *t*; $HSR\_only_t^k$ is a dummy variable indicating that on route *k* there was only HSR competition (no LCC service); $HSR\_LCC_t^k$ is a dummy variable taking value 1 if on route *k* FSCs face competition from both HSR and LCCs; $LCC\_only_t^k$ is a dummy variable if FSCs face LCC competition only; *lndistance* is the log of distance of route *k*; T^O and T^D are the traffic volumes of the origin/destination airports in 2016. They are used to control for market potential[3]; *FrequencyShare* is the frequency share of airline *i* on route *k* at departure date *t*; *Departime* is divided into four dummy variables, namely morning (6:01-10:00), midday (10:01-14:00), afternoon (14:01-18:00) and evening (after 18:01). *Month* is a set of monthly dummy variables to control for seasonal effects. *Weekday* represents a set of weekly dummies. The base case refers to routes with FSCs only. *Route* is a route-specific dummy, to control for common factors that might influence all the fares on the same route

To control for possible dual-brand effects when an LCC belongs to a major FSC, we further estimated the following specification

$$\overline{\gamma}_{ijt}^{k} = \beta_0 + \beta_1 DualBrand_{it}^k + \beta_2 \ln Distance_t^k + \beta_4 HSR_t^k + \beta_3 NLCCN_t^k + \beta_4 \ln(T^O T^D)^k$$
$$+\beta_5 FrequencyShare_{it}^k + \delta_1 Departime_{ijt}^k + \delta_2 Month_t + \delta_3 Weekday_t + \delta_4 Route^k + \varepsilon_{ijt}^k \quad (8)$$

where the *Dualbrand* is a dummy variable that takes the value 1 if at least one LCC is affiliated to FSC *i*. *NLCCN* is the number of LCCs, which does not include LCCs with a dual-brand strategy. Because profitability is calculated

[3] Other commonly used control variables for market potential in the literature are GDP and population. We chose to use airport traffic volumes as proxy variables because there are various types of regulation and airport capacity restrictions on these large hub airports in China. In addition, major airport hubs can often attract passengers from nearby cities (e.g. airports in Shanghai and Beijing are likely to attract passengers from adjacent cities). Therefore, actual traffic volume at airport level is expected to serve as a good proxy that controlled for such effects. Because traffic on individual routes only accounts for a small proportion of the traffic volume at large airports, there should be minimum endogeneity problem in the estimation.

based on the estimated costs, we further test the robustness of our estimations by using dominant FSCs' average fare directly. The specification is as that given in Model 9.

$$\overline{P}_{ijt}^{k} = \beta_0 + \beta_1 DualBrand_{it}^{k} + \beta_2 \ln Distance_t^{k} + \beta_4 HSR_t^{k} + \beta_3 NLCCN_t^{k} + \beta_4 \ln(T^O T^D)^k$$
$$+\beta_5 FrequencyShare_{it}^{k} + \delta_1 Departime_{ijt}^{k} + \delta_2 Month_t + \delta_3 Weekday_t + \delta_4 Route^k + \varepsilon_{ijt}^{k} \quad (9)$$

4.2 Regression results

To control for the effects of unobservable route-related factors, all estimation results are obtained with the Least Square Dummy Variable Model (LSDV). The slightly different specifications of Model 7, referred to as Model 7-1 to Model 7-4, were estimated to examine the robustness of estimation. Overall, the estimation results are fairly consistent across the specifications. Notably, virtually all competition-related variables such as *HSR_only, LCC_only,* and *HSR_LCC* are negative and statistically significant. These results suggest that competition, no matter whether from LCCs, or the HSR operator, reduces dominant airlines' profitability. The coefficient of lnT^OT^D and *FrequencyShare* is positive, suggesting that profitability increases as the traffic volume and frequency share increase. The coefficient of *lnDistance* is negative, meaning that, as the distance increases, airlines' marginal cost increases faster than their fare.

Table 4 Regression estimation results of Model 7

Profitability	Model 7-1	Model 7-2	Model 7-3	Model 7-4
HSR_only	-0.338*** (-20.7)			-0.429*** (-24.33)
LCC_only		-0.121*** (-12.29)		-0.121*** (-12.29)
HSR_LCC			-0.013 (-0.77)	-0.293*** (-16.93)
lnDistance	-0.182*** (-16.58)	0.011* (1.77)	-0.002 (-0.41)	-0.217*** (-19.21)
FrequencyShare	0.089*** (11.12)	0.165*** (16.36)	0.161*** (15.87)	0.074*** (9.13)
$\ln T^O T^D$	0.139*** (5.46)	0.137*** (5.41)	0.139*** (5.46)	0.137*** (5.41)
Morning	0.042*** (4.46)	0.042*** (4.46)	0.042*** (4.46)	0.042*** (4.46)
Midday	0.088*** (10.87)	0.088*** (10.88)	0.088*** (10.87)	0.088*** (10.88)
Afternoon	0.093*** (10.23)	0.093*** (10.24)	0.093*** (10.23)	0.093*** (10.24)
June	0.048*** (7.83)	0.052*** (8.57)	0.048*** (7.83)	0.052*** (8.57)
July	0.168*** (28.72)	0.17*** (29.34)	0.168*** (28.72)	0.17*** (29.34)

August	0.119*** (25.6)	0.119*** (25.62)	0.119*** (25.6)	0.119*** (25.62)
Monday	-0.028*** (-6.94)	-0.028*** (-6.91)	-0.028*** (-6.94)	-0.028*** (-6.91)
Tuesday	-0.029*** (-7.49)	-0.029*** (-7.46)	-0.029*** (-7.49)	-0.029*** (-7.46)
Wednesday	-0.014*** (-3.7)	-0.015*** (-3.9)	-0.014*** (-3.7)	-0.015*** (-3.9)
Thursday	0.005 (1.23)	0.005 (1.41)	0.005 (1.23)	0.005 (1.41)
Friday	0.042*** (11.46)	0.043*** (11.71)	0.042*** (11.46)	0.043*** (11.71)
Saturday	-0.045*** (-12.99)	-0.046*** (-13.25)	-0.045*** (-12.99)	-0.046*** (-13.25)
Constant	-1.419*** (-6.2)	-5.585*** (-16.55)	-5.342*** (-15.8)	-0.612** (-2.53)
R^2	0.471	0.474	0.471	0.474
Observation	57173	57173	57173	57173

Note: ***significant at 1%, **at 5%, *at 10%; t-statistics in parentheses.

The estimation results of Model 8 and Model 9 are summarized in Table 5 and Table 6. Overall, consistent patterns have been identified. Regression results using full data show that the coefficients of *HSR* on the profitability and average airfares of airlines are very significant. When there is competition from the HSR operator on a route, the average profitability and airfares of airlines are lower. This conclusion is different from Zhang et al.'s (2020) conclusion that the Lerner Index of routes with HSR competition are consistently higher than those of the routes without HSR competition, probably due to sample differences. *NLCCN* has a negative impact on FSCs' profitability and average airfares. As this variables captures the number of LCCs that are not affiliated with the FSC, it again confirms the effects of LCC competition. It is notable that, according to the regression results of Model 8 and Model 9, the coefficient of variable *DualBrand* is negative and statistically significant, which is different from the findings of previous studies on other airlines that adopted airline-within-airline strategies, notably the Australian aviation market (Homsombat et al., 2014; Zhang et al., 2018). In the Australian market, airline groups such as Qantas and Virgin established or acquired their low-cost subsidiaries (i.e. Jetstar and Tiger Airways) as rival airlines of their main competitors. In comparison, the "big four" Chinese FSCs established their LCC subsidiaries in partnership with local governments, as a way to extend their fleets and networks. The mixed ownership of LCC subsidiaries likely prevented its close coordination with the parent FSC, as suggested by the small negative effects on profitability and fares. An alternative explanation is that the AinA strategy allows airlines involved to achieve some cost savings economies of scale, which enables airlines to cut prices. Further analysis is needed to identify the overall effects of the AinA strategy in the Chinese aviation market. However, it is clear that the strategy has not increased airlines' profitability, and thus causes no anti-competition concerns.

Table 5 Regression estimation results of Model 8

Profitability	Full Date		Route with HSR	Route with other LCC	Route with HSR and other LCC
DualBrand	-0.037*** (-2.71)	-0.141*** (-8.85)	-0.046** (-2.29)	-0.06*** (-2.77)	-0.047** (-2.41)
HSR		-0.522*** (-20.27)			
NLCCN		-0.105*** (-10.82)			
lnDistance	-0.004 (-0.73)	-0.24*** (-17.34)	0.164*** (3.01)	-0.055*** (-4.45)	-0.46*** (-4.49)
FrequencyShare	0.17*** (6.17)	0.167*** (6.08)	0.193*** (3.98)	0.206*** (8.89)	0.197*** (5.32)
$\ln T^{O}T^{D}$	0.171*** (15.94)	0.076*** (9.1)	0.062*** (3.52)	-0.031*** (-3.01)	0.002 (0.07)
Morning	0.042*** (4.51)	0.042*** (4.51)	0.066*** (4.47)	0.039*** (3.72)	0.064*** (4.41)
Midday	0.089*** (11.1)	0.089*** (11.1)	0.101*** (8.37)	0.091*** (9.93)	0.097*** (8.03)
Afternoon	0.093*** (10.36)	0.093*** (10.36)	0.119*** (8.5)	0.079*** (8.76)	0.101*** (8.53)
June	0.047*** (7.67)	0.05*** (8.32)	0.065*** (8.68)	0.041*** (6.2)	0.024*** (3.94)
July	0.167*** (28.55)	0.169*** (29.16)	0.15*** (19.9)	0.162*** (25.93)	0.102*** (21.84)
August	0.118*** (25.7)	0.119*** (25.76)	0.082*** (13.6)	0.119*** (22.58)	0.056*** (11.88)
Monday	-0.021*** (-6.95)	-0.021*** (-6.8)	-0.033*** (-6.17)	-0.018*** (-5.77)	-0.042*** (-6.92)
Tuesday	-0.022*** (-8.98)	-0.022*** (-8.79)	-0.02*** (-5.14)	-0.025*** (-8.7)	-0.021*** (-4.82)
Wednesday	0.012*** (5.11)	0.012*** (5.55)	0.024*** (7.17)	0.008*** (3.08)	0.029*** (7.89)
Thursday	0.049*** (14.88)	0.05*** (15.24)	0.07*** (14.32)	0.052*** (13.06)	0.075*** (13.58)
Friday	-0.038*** (-11.15)	-0.039*** (-11.48)	-0.06*** (-10.89)	-0.043*** (-11.4)	-0.078*** (-12.64)
Saturday	-0.037*** (-2.71)	-0.141*** (-8.85)	-0.046** (-2.29)	-0.06*** (-2.77)	-0.047** (-2.41)
Constant	-5.716*** (-15.82)	-0.451* (-1.78)	-3.315*** (-7.88)	1.721*** (5.87)	3.354*** (4.58)
R^2	0.472	0.475	0.400	0.463	0.282
Observation	57173	57173	29798	39051	23786

Note: ***significant at 1%, **at 5%, *at 10%; t-statistics in parentheses; LCCN is LCC dummy variable, which not include LCC with dual-brand strategy.

Table 6 Regression estimation results of Model 9

MeanPrice	Full Date		Route with HSR	Route with other LCC	Route with HSR and other LCC
DualBrand	-119.496*** (-4.9)	-417.35*** (-12.92)	-136.279*** (-4.86)	-170.135** (-2.31)	-152.754*** (-5)
HSR		-1175.562*** (-19.79)			
NLCCN		-301.488*** (-12.65)			
lnDistance	645.311*** (49.55)	188.981*** (6.6)	481.802*** (8.85)	530.338*** (19.51)	-235.774 (-1.53)
FrequencyShare	270.836*** (7.4)	263.898*** (7.25)	353.863*** (6.17)	350.141*** (8.78)	433.182*** (6.4)
$\ln T^O T^D$	298.165*** (19.08)	113.494*** (7.79)	178.431*** (10.01)	-104.15*** (-5.03)	53.355 (1.36)
Morning	54.353*** (3.74)	54.352*** (3.74)	87.724*** (4.33)	51.099*** (2.73)	89.956*** (3.91)
Midday	126.384*** (8.63)	126.339*** (8.62)	124.049*** (7.12)	139.437*** (7.64)	135.268*** (6.84)
Afternoon	128.219*** (9.02)	128.399*** (9.03)	152.318*** (7.94)	115.997*** (6.79)	141.755*** (7.57)
June	30.218*** (3.77)	39.354*** (5.38)	54.785*** (8.04)	45.258*** (5.42)	34.978*** (4.71)
July	227.327*** (26.74)	232.713*** (27.99)	175.302*** (23.15)	258.705*** (25.91)	166.328*** (18.95)
August	163.258*** (24.69)	164.345*** (24.73)	94.755*** (13.83)	177.22*** (21.14)	94.346*** (11.67)
Monday	-30.467*** (-7.11)	-29.205*** (-6.82)	-42.781*** (-5.83)	-27.011*** (-5.64)	-55.417*** (-6.39)
Tuesday	-33.779*** (-9.07)	-32.513*** (-8.77)	-26.38*** (-4.61)	-38.627*** (-8.54)	-30.983*** (-4.57)
Wednesday	12.641*** (3.57)	15.333*** (4.39)	33.013*** (6.53)	7.748* (1.91)	39.595*** (6.7)
Thursday	79.672*** (13.17)	82.517*** (13.76)	115.674*** (12.72)	89.296*** (12.15)	130.892*** (13.02)
Friday	-47.615*** (-9.97)	-50.455*** (-10.7)	-80.224*** (-10.86)	-56.139*** (-10.09)	-103.041*** (-12.42)
Saturday	-119.496*** (-4.9)	-417.35*** (-12.92)	-136.279*** (-4.86)	-170.135** (-2.31)	-152.754*** (-5)
Constant	-14000*** (-26.19)	-3680.956*** (-6.66)	-9140.443*** (-18.45)	768.531 (1.2)	364.457 (0.3)
R^2	0.661	0.667	0.624	0.562	0.500
Observation	57173	57173	29798	39051	23786

Note: ***significant at 1%, **at 5%, *at 10%; t-statistics in parentheses.

5. Discussion and Conclusions

Despite the fast growth of the Chinese aviation market and a series of deregulation efforts in recent years, a number of studies (Chen and Jiang, 2008; Xu et al., 2011; Zhang and Round, 2011; Wang et al., 2014c; Zhang et al., 2014) show that significant price premiums are present on a large number of routes. Strict controls in the input markets kept costs high for fuel, materials and other inputs, reducing airlines' competitiveness in the international market (Zhang, 1998; Zhang and Chen, 2003).

Introducing more competition, such as allowing LCCs to serve profitable routes linking major hubs, could be a promising way to improve consumer welfare (Wang et al., 2014b; Fu et al., 2015b). However, previous studies on Chinese LCCs such as Spring Airlines suggested that their presence has not led to dramatic price reductions as witnessed in deregulated markets in North America and Europe (Fu et al. 2015a). Our study thus offers an updated view on this important topic. Compared to previous studies that focused mainly on airline competition's effects on airfares, our study offers some fresh insights with the following aspects of our research design: (a) we analyze the competition effects brought by LCCs, and an HSR operator; (b) in addition to airfare changes, we investigate the effects on airlines' profitability, which allows us to control for possible variations caused by cost differentials across airlines; (c) we empirically test the effects of the dual-band strategy adopted by Chinese airlines, a strategy that has been found to significantly influence market competition.

Our empirical investigation has brought some fresh insights into the Chinese aviation market as well as finding updated supporting evidence for findings in the existing literature. First, our study suggest that all types of carriers, namely LCCs, and the HSR operator, bring effective competition to the aviation market by reducing airlines' profitability and airfares. This suggests that any type of market deregulation in China could potentially lead to gains in consumer welfare and industry competitiveness. Second, our study suggests HSR service can bring much more significant competition than LCCs, especially on short-distance routes below 1000 km. This is a distinctive feature for China, where HSR network has been extensively expanded in recent years. Finally, while Chinese airline groups' "dual-brand" strategy reduced FSCs' profitability and prices in the sampled routes. Such a pattern is different from those observed in deregulated markets such as Australia, probably due to the mixed ownership of LCC subsidiaries. This suggests that the Chinese government should not worry about airlines' AinA strategy, and may rely more on LCCs to increase airline competition and stimulate growth in the years to come.

These findings suggest that there can be multiple driving forces to increase the competitiveness of Chinese airlines. On the one hand, any further market liberalization could improve the development and performance of the Chinese aviation market. The Civil Aviation Administration of China (CAAC) should facilitate the entry of all types of carriers, such as FSCs and their subsidiaries, especially private LCCs. On the other hand, much of the market dynamics will be driven by HSR operations beyond the control of the CAAC. This is an area calling for more in-depth investigation. In fact, HSR's impact on the aviation market may be more significant in years to come. Jiang and Zhang (2014) showed that aviation and HSR integration at capacity-saturated airports can improve the level of social welfare. In 2010, 60 airports in China were saturated (Zhang and Qi, 2010), resulting in high levels of flight congestion and frequent delays, and thereby illustrating a high demand for the implementation of integrated aviation and HSR services. With a large number of new airports being planned, the government authorities should consider coordinating the construction of HSR stations and new airports. Under the model of aviation and HSR integration, HSR takes over short-distance services so that airport capacity can be released, and airlines can use the released capacity to develop long-distance domestic and international services. Indeed, Zhang et al. (2020) pointed out that HSR can have a traffic redistribution effect on airport traffic. To mitigate congestion at hub airports, policy makers may consider diverting some traffic to regional airports by promoting air-HSR intermodal services. Our results suggest that HSR can impose significant competitive pressure especially on relatively short routes. FSCs may have strong incentive to cooperate instead of compete aggressively with HSRs on those routes. For example, HSR can provide feeder traffic to FSCs' long distance and international flight services, if convenient inter-modal connection services are available. Airports in Shanghai and Beijing now have quite good HSR connectivity, thus that their respective hub carriers are well positioned to leverage such growth opportunities. Our estimation results also suggest that Chinese LCCs, whether independent or affiliated to FSCs, introduce competition effects at route level. The cooperation between HSR and FSCs thus should not raise significant collusion concerns. On the other hand, In China there is only one monopoly railway operator whereas civil aviation industry is competitive. Therefore, it is still possible for certain market failure to take place. For example, HSR can afford to compete without paying attention to profitability on specific routes. Wang et al. (2017b) pointed out that with significant investment over the past decade, the Chinese HSR network has become very extensive. The dramatic growth of HSR imposes great competitive pressure on LCCs and may hinder the sector's future development. Regulatory review should be conducted periodically on both HSR and aviation sectors, and in the long term it may be helpful to introduce competition into HSR industry too.

Although we tried to validate the robustness of our study by estimating alternative models, one potential limitation of our study is the endogeneity of market structures as airline entry is likely to be dependent on the profitability and fare levels on the routes under consideration. Therefore, the relatively moderate competition effects of LCCs on short-distance routes may be explained by the fact that LCCs could not compete with HSR effectively on these routes in the first place, or airlines only enter those routes where they can compete effectively and sustain sizeable operations (i.e. "self-selection" in route entry). Indeed, Table 3 suggests that the average profitability of dominant FSCs is higher on routes with both HSR and LCCs than that with HSR only. Whereas our model attempted to control for route-specific effects, our sample included some of the largest routes only. Alternative estimation using a large sample may offer more solid and comprehensive estimation results. Where more comprehensive data are available, alternative estimation methods, such as a difference-in-differences (DID) estimation using all routes in the market, or paired routes with propensity score matching, is likely to offer more conclusive estimation results.[4] Furthermore, dynamic structure models that characterize airlines' dynamic network route entry and network configuration strategies may offer fresh insights on competition mechanism among airlines and HSR operators. Such an approach would have more explanatory power than simple reduced form estimations. We hope our study can lead to more advanced studies on this important topic.

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[4] For related discussions and estimation applications, see for example Wang et al. (2020).

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