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Borrowing Power from Potential Entrants and High-Speed Rail: Entry Pattern of China's Low-Cost Carrier

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Abstract: This paper investigates the impact of market structure and high-speed rail on China's low-cost carrier Spring Airlines' entry patterns during the pre-pandemic period. Dividing the air transport system into discrete distance segments (i.e., short-, medium- and long-haul) helps better reveal critical factors that affect the route entry of Spring. Given the existence of market power in China's airline industry and the capacity constraints at major airports, Spring strives to enter routes that can accommodate more potential entrants without a strong response from incumbents and are connected with more concentrated or lower-capacity airports. The complementary and competition effects of high-speed rail are well-distinguished in different distance ranges.

Keywords: entry pattern; market advantages; high-speed rail; spatial segmentation; low-cost carriers

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1. Introduction

Research on air carriers' route entry patterns has attracted significant attention, especially in an era of widespread deregulation. By modeling the evolution of new routes, researchers can identify factors that influence carriers' decisions to open new markets and probe broader network and competitive implications, which is conducive to the sustainable development of airlines. Such analyses also shed light on carriers' business models and provide insight into the dynamics of industry change.

Low-cost carriers have arguably been one of the most significant drivers of change in air transport over the past few decades, particularly in well-developed and largely deregulated markets in the United States (U.S.), the European Union (EU) and Australasia. However, one of the largest and fastest growing air transport markets in the world, China, differs from both the U.S. and EU in that it has been slower to shed industry regulation and has had only minor impacts from LCCs. In fact, only one low-cost airline—Spring Airlines (referred to as 'Spring' in this paper)—currently has any substantial impact in the Chinese market.

Since beginning flight operations in 2006, Spring has experienced swift expansions in its operations, including available seat capacity, number/frequency of departures, number of routes, and cities served. Although Spring remains a relatively small player in China's air transport scheme (accounting for about 3.2% of seat capacity from Chinese airports in 2019), its growth has been remarkable, and its impact seems poised to rise. For example, between 2007 (Spring's first full year of operation) and 2019, world and Chinese-origin seat capacity grew by 60% and 200%, respectively [1]. Meanwhile, Spring's seat capacity has grown by more than 1800% [1]. The pattern is similar for departures, where Spring has grown by more than 2000% compared to 164% for China and 29% worldwide. Corresponding to the statistics above, other researchers have shown that Spring does not necessarily follow any existing LCC model worldwide [2] and also differs from other carriers in China where LCCs are not yet generally well-developed [3]. This phenomenon can even be well-reflected

by evidence during the post-pandemic period [4]. For instance, compared to the indicator of Revenue Passenger Kilometers (RPKs) for domestic market in 2019, Spring increased by 8.97% in 2020 [5], while the big three carriers (i.e., Air China, China Eastern, China Southern) in China significantly decreased by around 30% [6–8]. The decline extent was even severe for LCCs in other regions, such as Southwest and JetBlue in the U.S., i.e., a decrease of 58.2% and 65.8%, respectively [9].

The uniqueness of Spring has attracted researchers' attentions to investigate its route evolution [10] and entry pattern [11]. However, the period under investigation only covers the initial period from its inauguration year in 2005 until 2012, which cannot provide a comprehensive understanding of factors influencing its route entry decisions. Given the dramatic changes of air transport in China after 2012, several new trends, such as changes in spatial distribution [10], market structure [11] and the development of high-speed rail (HSR) [11–13], have reshaped Spring's route entry pattern, which calls for an updated research. The unstable situation, such as the sporadic outbreak of COVID-19, and the unavailability of data make it difficult to include data in the post-pandemic period after 2019. In order to reveal the "real" route entry pattern of Spring by establishing econometric models, this paper considers data during the period 2011–2019. The post-pandemic route entry pattern of Spring can be separately examined to study its response strategy to COVID-19.

Given the staggering growth of Spring as a competitor in the more general context of the rapidly expanding Chinese air transport system, the objective of this paper is to investigate Spring's market entry patterns during the period of pre-pandemic. Specifically, using Probit modeling, we examine the route-level entry patterns of Spring in light of market structure, impacts of high-speed rail (HSR), distance ranges and other regional/city-level correlates. The results provide a reference for low-cost airlines' sustainable development in China from the perspective of route entry. They also contribute to a growing literature on the development of Chinese civil aviation from the perspective of expanding one of its most unique components—the sole successful LCC.

The remainder of this paper is structured as follows. Section 2 provides context for the study by briefly reviewing LCCs, carrier entry patterns and the relevance to Spring in the Chinese context. Section 3 introduces the data and provides background through exploratory data analysis. Section 4 presents the details of the econometric model and variable construction. Section 5 reveals the results of the model, and Section 6 finishes with concluding comments.

2. Literature Review

2.1. LCCs and Spring Airlines

Wang et al. [14] summarize the traditional key characteristics of the LCC strategy, which usually include a simple fleet structure, limited in-flight service, a point-to-point network structure, quick aircraft turnaround, secondary airports and providing competitive fares. This competition has been shown to at least influence [15] or reduce overall market fares [16], generate both immediate and overall travel demand [17] and support tourism [14]. At the same time, as de Wit and Zuidberg [18] point out, parts of the low-cost model appear to be changing in mature markets as LCCs become omnipresent in these regions. Their research suggests that LCCs are increasingly engaging in partnerships and changing their network mixes to include a more significant share of larger airports, among other things. Remarkably, the ongoing hybridization process of LCCs tends to reshape their network architecture and entry strategies by introducing connecting services (Birolini et al. [19] and Morlotti et al. [20]). Ultra-low-cost carriers have further challenged the standard LCC model with even lower costs/fares, more service unbundling and transitional route structures [21]. Furthermore, reflecting on LCCs worldwide, the business models of long-haul LCCs have been discussed at both domestic [22] and international levels [23–26]. Full-service airlines (FSCs) have also adopted the airline-within-airline (AWAs) model and have introduced their own low-cost airlines to enhance their competitiveness, such as Asiana Air [27].

Spring Airlines operates in a relatively unique context. China is one of the fastest-growing air transport markets globally, but Spring is also the only successful LCC in a still significantly regulated China. Although it shares some characteristics of LCCs elsewhere, such as a fleet consisting of a single aircraft (currently, the 180 seat Airbus A320-200), differences are apparent [1,28]. For example, Dobruszkes and Wang [2] showed that Spring has a unique combination of network, traffic density, and route-distance characteristics compared with Southwest, EasyJet, Ryanair, and Jet Blue. For instance, "it could be close to Ryanair and EasyJet in terms of traffic density, to Ryanair, EasyJet, and Southwest (for median distance stage, lack of long-haul services and very few inter-regional services), to EasyJet and JetBlue (rather low share of monopolistic services) or to JetBlue only (intermediate share of international services, comparative average degree)". The authors conclude that one common trait shared with these well-known U.S. and EU carriers is a "small-world, scale-free network" [2]. Since Spring does not mimic the features of these other LCCs, it is apparent that additional research is required to add perspective on the determinants of its route choices.

Fu et al. [11] provide one of the few investigations that empirically focus on Spring and route development of LCCs in China. They concluded that Spring tended to enter routes of relatively longer distance and relatively higher density via its hub in Shanghai. Meanwhile, Spring has avoided routes connecting through airports with larger capacity, focusing instead on secondary airports. Fu et al. [11] also applied a route-level Herfindahl-Hirschman Index (HHI) to their model based on scheduled seats to investigate the concentration index's impact on Spring's entry but found no significant impact. In a later study, Fu et al. [29] suggest the importance of point-to-point networks and multiple airport regions for developing LCC networks in regions such as China. Meanwhile, Jiang et al. [10] examined the temporal and spatial evolution of Spring's network structure from 2005 to 2013 and found that distance plays a significant role in its network construction. Overall, the route distance followed a partial normal distribution, meaning that the number of routes was not evenly distributed across different distance segments (i.e., short-, medium-, and long-haul). They found that Spring tended to add routes of distances between 1200 and 1600 km disproportionately.

Thus, existing research suggests several key takeaways. First, Spring does not necessarily follow any existing LCC model. Second, China is a unique region where LCCs are not yet generally well developed [3], and the Chinese aviation market differs from that elsewhere. Third, while there is some evidence that Spring prefers less dense routes, relatively longer flights, and smaller airports, route entry characteristics have not been fully revealed. Fourth, existing studies do not include more recent data.

These somewhat limited results leave several gaps in our understanding of Spring and its operations in China. First, how might one choose appropriate variables to better represent the structure of the Chinese airline market with the presence of Spring so that one can examine a more comprehensive set of variables concurrently? Two specific issues are of most concern: market structure and the impact of high-speed rail (HSR).

2.2. The Impact of Market Structure and Presence on Route Entry

Market structure is often a significant factor influencing carriers' entry. One can represent this using several variables, such as the Herfindahl–Hirschman Index (HHI), airport/market presence, market share and the presence of different types of carriers at both route and endpoint levels [22,30,31]. Researchers do not always include all these variables in modeling due to either the strong correlations among them or the inappropriate setting given different air policy environments in varied countries or regions.

In many research efforts, analysts represent market concentration/competition by route/endpoint HHI. As shown in Table 1, the impact of route HHI on LCCs' entry is somewhat mixed, with the possibility of positive, negative or insignificant impacts depending on the circumstances. In most cases, a highly concentrated market deters LCCs' entry since higher route concentration can bring market power to incumbent carriers [23].

One can measure the endpoint HHI in the form of an arithmetic average, maximum or minimum depending on whether there is a need to highlight more concentrated airports/cities. Researchers have found that LCCs generally tend to avoid highly concentrated airports [22,30–32]. It is important to note that interaction terms between endpoint HHI and endpoint size are sometimes applied to test whether the impact of endpoint HHI on entry. The results are often mixed, ranging from no relation for small LCC(s) such as JetBlue [22] to significant causal relations for large LCC(s) such as Southwest [30].

Table 1. Estimation results of different market structure variables.

Paper	Empirical LCC(s)	Market Concentration/Competition Variables				Market Presence Variables			
		Route Level	Results	Airport Level	Results	Route Level	Results	Airport Level	Results
Müller et al. [22]	JetBlue	RouteHHI	+	AirportHHI; An interaction term between AirportHHI and hub status variable (AirportHHI*NonHub)	– NS	Chapter 11 route dummy; Number of other LCCs	– –	Airport presence dummy	–
Homsombat et al. [31]	Jetstar			MinAirportHHI; MaxAirportHHI	– –	Qantas' route dummy; Number of non-Qantas FSAs; Number of non-Jetstar LCCs	– – +		
Boguslaski et al. [30]	Southwest	MarketHHI	+/NS/–	MinCityHHI; An interaction term between MaxCityHHI and airport size (MaxCityHHI*Dsmall); MaxCityHHI*Dbig	NS – NS/–	LCC competition dummy; SWShare;	NS –	Airport non-presence dummy	NS
Fu et al. [11]	Spring	RouteHHI	NS						
Lederman and Januszewski [32]	US LCCs as a group							ServeOneEnd; ServeBothEnds; Maximum of rivals' market share (MaxOwnSHFLT)	+ +

Note: "+" means that the corresponding market structure variable has positive impact on LCCs' route entry; "–" means that the corresponding market structure variable has negative impact on LCCs' route entry; "NS" means that the corresponding market structure variable has no statistically significant impact on LCCs' route entry.

As with market concentration, one can analyze the impacts of market presence on entry from both route and endpoint levels (Table 1). The former indicates direct competition with other carriers, while the latter represents potential competition and the transitive influence from airports to routes. In other words, if a carrier presents at least one of the endpoint airports of a market without providing services between the endpoints, it is identified as a potential entrant to the market [33]. An "entry threat" to incumbents may be created by a potential entrant once it establishes presence at the second endpoint airport of a route. Researchers have found that incumbents may not respond to this as an effective "entry threat" [33,34]. As shown in Table 1, one can specify market presence as indicator (dummy) variables, market share and/or the number of carriers. Further, one can define all these variables for a particular carrier relative to their competition. Overall, LCCs tend to avoid routes with the direct presence of competitors. Exceptions are Southwest's nonsignificant impact from other LCCs and the positive impact of Jetstar [30,31]. For variables representing market presence at the airport level, it appears that indicator variables and the interaction term of indicator/number of carriers yield better estimation results. The presence of the investigated carrier itself or other selected competitors at one or both endpoint(s) can influence entry.

2.3. The Substitutability and Complementarity between HSR and Air Transport

It is now impossible to analyze Chinese (domestic) passenger transportation without incorporating the impact of HSR, which connects nearly all major cities and continues to proliferate [35]. Researchers have found that the impact of HSR on China's air transport—both in terms of demand and supply—varies based upon route distance [13,36]. For instance, Chen [36] found that the impacts were the largest when the distance range was limited to 500–800 km, although negative effects on air transport traffic were observable in other segments. Liu et al. [37] emphasized that HSR effects are better analyzed at the airport level, as diverging results can be obtained compared with route-level analysis. For instance, one can observe positive rather than negative HSR impacts for long-haul air routes, air–HSR intermodal transport and international routes.

Several researchers have found substantial substitution impacts between HSR and enplanements [13,36,38], the number of seats [39] and airfare [40], among other things, for shorter-haul routes. However, compared with the big three carriers (i.e., Air China, China Eastern, and China Southern) in China, Spring's reactions to the presence of HSR were much more immediate [12]. The carrier may have avoided markets dominated by HSR (e.g., routes of distances less than 800 km; medium-haul markets). This finding supports other research, such as by Fu et al. [11], that has found that Spring tends to enter routes with relatively longer distances.

Researchers have also captured the complementary effects between HSR and air transport despite such substitution effects, especially for longer-haul domestic markets [13,39]. Zhang et al. [13] attributed this to the diversity of travel modes that can bring much more flexibility for travelers to connect to longer routes. Spring often has advantages for travelers in airfare [11] and frequencies [10]. Thus, a complementary effect may also exist in Spring's decision to adapt to the presence of HSR. More generally, Zhang et al. [13] verified the coexistence of substitutability and complementarity between HSR and air transport. Specifically, the presence of HSR significantly reduced the traffic on the short- and medium-haul (below 1000 km) routes, while traffic on the long-haul markets (over 1000 km) was activated by the presence of HSR services in China.

Market timing may also be important. Fu et al. [11] found that the presence of HSR services did not significantly impose competition pressure on Spring from 2005 to 2012. However, Wang et al. [12] observed several critical metrics of Spring, such as passengers, ASKs (available seat kilometers) and the number of routes that experienced first-time decreases in 2016 when the large-scale expansion of HSR occurred. They suggested that Spring could focus on low-density corridors, especially in central and western China, to avoid the fierce competition from HSR. In other words, if Spring had little room to survive in the short-haul markets, then swiftly transiting to medium- and long-haul markets could bring both economic benefits and welfare for passengers.

In the empirical investigation that follows, we update the analysis of Spring' entry patterns during the period of pre-pandemic. In doing so, we assess both the substitutability and complementarity effects that coexist in Spring's entry decisions, particularly when route distances are split based on the characteristics of Spring's business model. We also consider the presence of HSR at the endpoint(s) of a route, which is critical since the number of airports overlapping with HSR services has increased year by year [41,42].

2.4. Other Potential Factors

2.4.1. Demand and Supply Variables

The relationship between supply and demand is also a key factor affecting airlines' route resource layout. According to the principles of economics, supply and demand determine price together, which then affects supply. When the market demand exceeds supply, the product price will rise, and production will be promoted by enterprises. For one specific route, if the frequency and available seats provided by airlines in this route are insufficient, the ticket price will rise, which will urge airlines to increase production, such as entering and adding resources on this route.

Many scholars have considered the impact of supply and demand variables on route entry from the perspective of cities and airports level. The common variables identifying urban characteristics are GDP, income, population, tourism, etc. Research shows that higher incomes and more population may affect demand by raising the propensity for air travel in a market [34]. Furthermore, the route entry of LCCs has been proved to be significantly and positively influenced by income, GDP and population variables in the case of Hong Kong [14] and New Zealand [43]. The services of LCCs are closely related to the development of tourism [44]. Taking New Zealand [43,45], Malta [46], South Korea [47] and other countries as examples, some researchers have proved that LCCs' entry promotes the development of local tourism. In this paper, we will turn to explore whether the tourism market affects the route entry of low-cost carriers.

Indicators at airport level often include airport passenger volume and available seats number. The number of airport seats is often used as a proxy for market potential. Greater scheduled seat capacity implies greater potential passenger demand. Fu et al. [11] found that the sign of this variable was significant and negative, meaning that Spring had a lower probability of entering routes with greater potential demand between 2005 and 2013. They attributed this to Spring's choice of secondary cities with more leisure and price-sensitive travelers, less congestion, and more attractive economic incentives from local governments. We test whether the same strategy persists during the period of pre-pandemic.

2.4.2. Route Structure Variables

Hub variable is tested to be one of the key factors that affect route entry. When discussing the factors influenced route entry of Spring, Fu et al. [11] sets hub variables to evaluate the impact of Spring' own hubs and other airlines' hubs. The result shows that Spring prefers to add routes that operate out of its base at Shanghai to use the existing infrastructure effectively and avoids operating in Guangzhou and Beijing, which are the hubs of China Southern and Air China. We will check this result later.

In combining more recent data with market structure and HSR effects along with demographic variables and a tourism measure, we present a fully comprehensive analysis of Spring's recent market patterns.

3. Data and Exploratory Analysis

3.1. Data Sources

The primary dataset used in this paper is the "schedule analyser module" provided by the Official Airlines Guide (OAG), which includes information on scheduled flights offered by Spring for the year between 2011 and 2019. The OAG database provides the required data for our analysis of Spring's entry decision, including information on origin and destination airports, route distance, flight frequencies, and the number of available seats at the route level. These data permit the identification of newly entered and non-entered routes by Spring by year. Data for city GDP and population were collected from CEIC (https://www.ceicdata.com/en, accessed on 20 April 2021) and supplemented with Wanfang Data (https://www.wanfangdata.com.cn/index.html, accessed on 20 April 2021) as well as annual statistical reports of social and economic development (in the case of small cities). We collected data on the total revenue of regional tourism from the annual statistical report of social and economic development for each city.

3.2. Construction of the Sample

We confine our study to China domestic air transport markets connected by airport-pairs with non-stop services. As transfer services are still scarce in China domestic market and only restricted to international markets via three big hub airports, i.e., Beijing Capital, Shanghai Pudong and Guangzhou Baiyun [48], we did not consider connecting services in the current analysis. Although Civil Aviation Administration of China (CAAC) intends to promote the development of connecting service in domestic market after COVID-19, it is difficult to observe the trend for connecting service during 2011–2019.

A complete sample set should include both entered and non-entered routes for Spring by selecting airports and carriers. First, airports located within China and served by Spring during 2011–2019 are collected, resulting in 88 airports in total. Second, we define "potential routes" that can be theoretically operated by Spring as all the routes between these 88 airports and served by any Chinese carriers, leading to 1684 routes in total. A complete sample set with 13,472 (i.e., 1684 × 8 years) observations is then constructed. Third, an entry event is recognized if Spring serves the route in the current year and did not serve the route in the previous year. Here, a route is considered "served" by Spring only if its market share in available seats is larger than 1%, which has covered more than 97% of Spring's routes in all years. In this way, all observations in 2011 are excluded, as we cannot observe its services in the previous year. Drawing on these definitions, we identified 242 entry events of Spring. In particular, routes exited but re-entered by Spring are not considered valid entry events.

Our sample also includes a redefinition of route distance bands. Most research investigating China's aviation market has applied 500 km and 800 km as the threshold of short-, medium- and long-haul markets [36] and found that those with distances of less than 800 km were the dominant market of HSR. Because we use an updated period during which Chinese carriers have recognized the competition from HSR and taken actions to respond, the upper boundary of the short-haul market is stretching. We base this dynamic on the work of Wang et al. [49], who concluded that air transport still dominates city pairs with a distance over 1500 km in a study of parallel air service and HSR from 2007 to 2015. Based on these recent findings, we divide the market into short- (<800 km), medium- (800–1500 km) and long-haul (>1500 km) markets.

Table 2 shows that the number of routes operated by Spring continuously increased during the period of 2011–2019. The most significant fluctuations in route entries occurred in 2013 and 2014, with the former showing a sudden decrease and the opposite in the latter. A closer examination of the data shows that several routes served by Spring in 2012 seem to 'disappear' in 2013 but 'reappear' in 2014. It may show a temporary attempt for network reconstruction by Spring in order to prepare for its planned IPO on the Shanghai stock exchange in January 2015. A validity check can be conducted when additional data are available.

Table 2. The number of routes operated and entered by Spring during 2011 and 2019.

Year	Number of Routes Operated				Number of Routes Entered			
	Short-Haul	Medium-Haul	Long-Haul	Total	Short-Haul	Medium-Haul	Long-Haul	Total
2011	11	32	20	63				
2012	10	38	25	73	3	10	7	20
2013	11	36	21	68	1	1	1	3
2014	18	54	43	115	9	17	18	44
2015	20	55	36	111	4	13	3	20
2016	24	69	47	140	8	23	13	44
2017	28	83	62	173	8	14	19	41
2018	43	96	64	203	15	25	14	54
2019	42	100	62	204	2	8	6	16
Total					50	111	81	242

4. Econometric Model

To investigate the determinants of Spring's route entry decision in China's domestic market, this study adopts a Probit model corresponding to the previous research [11,43]. The Probit model is derived from the assumption that Spring will serve a route only if its expected profit is positive. In particular, dividing the air transport market into three distance categories, we apply a panel data Probit model to examine how market structure, HSR and demand and supply variables influence Spring's route entry in these three markets, and combine the model with the market environment in China, which is not completely

deregulated. The model assumes that Spring's entry into route i in time t is related to the expected profit and the influence of several explanatory variables:

$$R_{it} - C_{it} = X_{it}\beta + u_{it} \tag{1}$$

where R_{it} is the expected revenue, C_{it} is the cost of route entry, X_{it} represents the explanatory variable vector, and β is the vector of the explanatory variable coefficient. u_{it} serves as the error term which obeys the standard normal distribution. It is difficult to obtain actual profit data for Spring's entries. As a result, the observed entry decision itself serves as the dependent variable. As shown in Equation (2), Y_{it} represents the decision of Spring's entry. If the expected profit of a route is positive, then Spring decided to enter the route; otherwise, it would not enter the route.

$$Y_{it} = \begin{cases} 1, R_{it} - C_{it} > 0 \ (entry) \\ 0, R_{it} - C_{it} < 0 \ (no\ entry) \end{cases} \tag{2}$$

The maximum likelihood method is applied to estimate the parameters. For explanatory variables, we focus on four main aspects: (1) demand and supply characteristics of cities and airports (including GDP, population, tourism, distance, and seats), (2) market structure variables (including market competition and presence), (3) HSR effects and (4) route structure variables. We detail the specific Probit model in Equation (3).

$$\begin{aligned} D_{i,t} = \alpha_0 \quad & +\alpha_1 \mathrm{In}GDP_{i,t-1} + \alpha_2 \mathrm{In}Pop_{i,t-1} + \alpha_3 Tour_{i,t-1} + \alpha_4 \mathrm{In}Dist_i + \alpha_5 \mathrm{In}AirportSeats_{i,t-1} \\ & +\alpha_6 RouteHHI_{i,t-1} + \alpha_7 MaxAirportHHI_{i,t-1} + \alpha_8 MinAirportHHI_{i,t-1} \\ & +\alpha_9 RivalNumbersBothEnds_{i,t-1} + \alpha_{10} ServeOneEnd_{i,t-1} + \alpha_{11} ServeBothEnds_{i,t-1} \\ & +\alpha_{12} HSR_OneEnd_{i,t-1} + \alpha_{13} HSR_BothEnds_{i,t-1} + \alpha_{14} Hub_1_i + \alpha_{15} Hub_2_i + \alpha_{16} Y_{2013} \\ & +\alpha_{17} Y_{2014} + u_{i,t} \end{aligned} \tag{3}$$

where α_0 is the intercept, and α_m $(m = 1, 2, \cdots, 15)$ are the estimated coefficients for the independent variables; $u_{i,t}$ is the error term.

4.1. Dependent Variable

$D_{i,\,t}$ represents the entry event of Spring on a route i in year t. If Spring provided more than 1% of the total nonstop seats on this route in the present year and did not serve the route in the previous year, then $D_{i,\,t} = 1$. Otherwise, $D_{i,\,t} = 0$. The dependent variable shows which specific routes are (not) entered by Spring in the China domestic market between 2011 and 2019.

4.2. Demand and Supply Variables

$GDP_{i,t-1}$ calculates the geometric average value of Gross Domestic Product (GDP) of the two endpoint cities linking route i in the previous year $t-1$. $Pop_{i,t-1}$ measures the geometric average population of the two endpoint cities connecting route i in the previous year $t-1$. The coefficients of these two variables are expected to be positive. $Tourism_{i,t-1}$ is a dummy variable representing whether one of the endpoint cities of route i is a tourism destination in the previous year $t-1$. If so, then the value of this variable is equal to 1, 0 otherwise. A city is defined as a tourism destination if the tourism share is larger than 0.5. We calculate this by dividing the total revenue of the tourism industry by the city's GDP. Considering Spring was founded on the base of tourism companies, we expected this variable to have a positive impact.

$Dist_i$ measures the great circle distance in kilometers (km) of route i. As mentioned in Section 2.1, this variable is expected to be positive. $AirportSeats_{i,t-1}$ measures the arithmetic average of the available seats of the two endpoint airports linking route i in the previous year $t-1$. This variable is expected to negative to test the strategy mentioned in Section 2.4.

4.3. Market Structure Variables at Route and Airport Levels

$RouteHHI_{i,t-1}$ measures the HHI as calculated based on the market share of available seats across all the airlines serving route i in the previous year $t-1$. Fu et al. [11] found that the route concentration index did not significantly influence Spring's entry decision during 2005–2013. Instead, the potential profit derived from relatively high prices on denser routes and market presence driven by low-cost on thinner routes often led to Spring's entry. In this way, the route concentration driven by the number and market share of carriers is not a barrier for small carriers such as Spring. The expected impact of this variable is indeterminate.

$AirportHHI_{i,t-1}$ measures the arithmetic average of HHI as calculated based on the share of available seats across all the airlines at two endpoints linking route i in the previous year $t-1$. We also design two variables, $MaxAirportHHI_{i,t-1}$ and $MinAirportHHI_{i,t-1}$, to measure the maximum and minimum of the HHI of the two endpoints linking route i in the previous year $t-1$, respectively. As shown by other scholars' research on this variable in Table 1, we expect these variables are negative.

$RivalNumbersBothEnds_{i,t-1}$ calculates the total number of Spring's competitors simultaneously present at both endpoints of route i in the previous year $t-1$. This variable is expected to be negative. We designed two market presence variables, i.e., $ServeBothEnds_{i,t-1}$ and $ServeOneEnd_{i,t-1}$, to show whether Spring has a presence at one or both endpoints of a route i in the previous year $t-1$, respectively. If so, then the value of the two variables is equal to 1, 0 otherwise. We expect that Spring has a higher probability to create new route with established endpoints.

4.4. HSR Effects

In order to investigate whether HSR operation has an impact on the entry decision of Spring, we designed two variables, i.e., $HSR_OneEnd_{i,t-1}$ and $HSR_BothEnds_{i,t-1}$. If either endpoint city of a route entered by Spring also has the HSR, then the value of $HSR_OneEnd_{i,t-1}$ is 1, and 0 otherwise. If HSR serves both endpoint cities of a route entered by Spring, then the value of $HSR_BothEnds_{i,t-1}$ is 1, and 0 otherwise. As discussed in Section 2.2, several researchers have found the substitutability and complementarity between HSR and air transport, but the effect varies from the distance. Therefore, it is difficult to predict the sign of these variables.

4.5. Route Structure Variables

Jiang et al. [10] examined the evolution of Spring's hub cities and found that a multi-hub network structure has emerged. Shijiazhuang (SJW) and Shenyang (SHE) were established as second and third hubs in 2011, primarily due to the scarce slots and severe congestion at its primary base in Shanghai (i.e., Shanghai Hongqiao (SHA) and Shanghai Pudong (PVG)). Two variables, i.e., $Hub1$ and $Hub2$, are thus designed to characterize the network configuration of Spring. If either endpoint of a route is SHA or PVG, then the value of $Hub1$ is 1, and 0 otherwise. If either endpoint of a route is SJW or SHE, then the value of $Hub2$ is 1, and 0 otherwise. It is expected that Spring has a higher probability to entry into the market with their hubs.

4.6. Time Dummies

As mentioned in Section 3.2, the number of routes entered by Spring showed a special performance in 2013 and 2014. It may be related to Spring's planned IPO on the Shanghai stock exchange in January 2015. Therefore, we set two time dummy variables (Y_{2013} and Y_{2014}) to control the effect of this event.

5. Results and Discussion

Table 3 shows the descriptive statistics of variables, and we present the estimation results of the Probit model in Table 4. We report results for the entire market in the first column and then for the three distance-based market segments. Aside from the HSR

variables, the estimation results for the other variables are generally consistent across all four models.

Table 3. Descriptive statistics of variables.

Variables	Average	Standard Deviation	Minimum	Maximum
Entry	0.015	0.123	0	1
GDP(000)	4.76×10^8	3.34×10^8	2.37×10^7	3.06×10^9
Pop(000)	6885.080	3476.326	836.164	27,270.410
Tourism	0.057	0.232	0.000	1.000
Dist	1184.135	596.216	43.000	3512.000
AirportVol(000)	1.55×10^4	11,150	120.108	7.44×10^4
RouteHHI	0.426	0.409	0.000	1.000
MaxAirportHHI	0.249	0.147	0.074	1.000
MinAirportHHI	0.137	0.051	0.000	0.497
RivalNumbersBothEnds	2.973	2.871	0.000	18.000
ServeOneEnd	0.511	0.500	0.000	1.000
ServeBothEnds	0.936	0.244	0.000	1.000
HSR_BothEnds	0.522	0.500	0.000	1.000
HSR_OneEnd	0.933	0.251	0.000	1.000
Hub_1	0.080	0.271	0.000	1.000
Hub_2	0.070	0.255	0.000	1.000
Y_{2013}	0.143	0.350	0.000	1.000
Y_{2014}	0.143	0.350	0.000	1.000
Number of observations		13,472		

5.1. Demand and Supply Variables

Four out of five demand and supply variables show significant impacts on Spring's entry. Spring tends to enter routes with greater *GDP*, aiming to capture business customers who pursue cost efficiency and higher on-time performance. According to VariFlight—a data company providing global travel information—Spring is first among large and medium carriers in China based on arrival on-time performance in 2019 [50]. *Tourism* has no statistically significant impact on Spring's entry. Although Shanghai Spring International Travel Service Co., Ltd. (China's largest travel service provider) founded Spring, it does not solely rely on the tourism component of its related company. This result also confirms Spring's unique business model in exploring various types of markets to earn profits.

The estimation of the *Pop* variable is significant in medium- and long-haul markets but not in the short-haul market. The negative sign indicates that cities with relatively lower populations have gradually become the niche market for Spring during 2010–2019, likely for two reasons. First, airports located in less-populated cities may have more available slots that allow Spring to expand its network. Second, local governments in these cities also provide subsidies and favored policies to support Spring's entry.

Similar to the finding of Fu et al. [11], who studied Spring's entry pattern during 2005–2012, we also find that distance has a positive and significant impact on the entry probability of Spring during the more recent 2011–2019 period. The effect is present in the overall model and the short/medium-haul markets. This result confirms the differentiated strategy of Spring, which is inclined to enter longer routes, deviating from the traditional LCC model, in which carriers typically show a preference for shorter distance segments. The effect, however, is not significant in the longest-haul market segment market. This divergence may be due to the economics of its single fleet configuration or a desire for faster aircraft turnaround, both of which may limit its capacity to explore the longest domestic markets. The *AirportSeats* variable, as expected, is significant and negative in all of the models, confirming the strategic decision of positioning to the secondary cities.

5.2. Market Structure Variables at Route and Airport Level

The *RouteHHI* variable has negative impacts on Spring's entry in the entire model at 10% significance level but not in the three segment models, signifying the mixed entry

decisions of Spring to enter denser routes with high competition and less-dense routes with low (or no) competition.

Table 4. Estimation results of the panel data Probit model.

Variables	Entire Market	Short-Haul	Medium-Haul	Long-Haul
Constant	−7.489 ***	−9.880 ***	−6.507 **	−0.756
	(−1.440)	(−3.025)	(−2.653)	(−2.629)
ln GDP	0.370 ***	0.391 *	0.309 *	0.583 **
	(−0.110)	(−0.219)	(−0.160)	(−0.240)
Tourism	−0.148	- [1]	0.092	−0.261
	(−0.178)		(−0.239)	(−0.319)
ln Pop	−0.324 **	−0.338	−0.286	−0.474 *
	(−0.131)	(−0.282)	(−0.189)	(−0.271)
ln Dist	0.272 ***	0.762 ***	0.575 **	0.271
	(−0.063)	(−0.239)	(−0.243)	(−0.281)
ln AirportSeats	−0.253 ***	−0.215 **	−0.253 ***	−0.387 ***
	(−0.055)	(−0.099)	(−0.088)	(−0.121)
RouteHHI	−0.143 *	−0.205	−0.0998	−0.168
	(−0.077)	(−0.166)	(−0.114)	(−0.146)
MaxAirportHHI	0.762 ***	0.950 **	1.017 ***	−0.124
	(−0.220)	(−0.405)	(−0.323)	(−0.590)
MinAirportHHI	0.128	0.942	−0.932	2.033
	(−0.677)	(−1.243)	(−1.019)	(−1.606)
RivalNumbersBothEnds	0.053 ***	0.065 **	0.060 ***	0.056 **
	(−0.012)	(−0.026)	(−0.019)	(−0.022)
ServeOneEnd	0.014	−0.136	0.012	0.144
	(−0.064)	(−0.135)	(−0.095)	(−0.131)
ServeBothEnds	0.994 ***	- [2]	- [2]	0.482
	(−0.333)			(−0.421)
HSR_OneEnd	−0.075	−0.344	0.642 *	−0.203
	(−0.07)	(−0.262)	(−0.364)	(−0.272)
HSR_BothEnds	0.025	−0.109	−0.241**	0.229*
	(−0.151)	(−0.156)	(−0.105)	(−0.136)
Hub_1	0.575 ***	0.237	0.723 ***	0.628 ***
	(−0.095)	(−0.264)	(−0.137)	(−0.172)
Hub_2	0.613 ***	0.730 ***	0.558 ***	0.563 ***
	(−0.085)	(−0.178)	(−0.136)	(−0.149)
Y_{2013}	−0.970 ***	−0.899 **	−1.208 ***	−0.860 **
	−0.192	−0.359	−0.35	−0.339
Y_{2014}	0.0907	0.0537	−0.0443	0.320 **
	−0.0784	−0.17	−0.123	−0.139
Observations	13,472	3273	5968	3448
Number of routes	1684	460	787	431

Notes: (1) * $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$; (2) The robust standard deviation is shown in the parenthesis. [1] Spring did not enter the routes connected with tourism cities in the sample of short-haul market. [2] In the short- and medium-haul markets, the endpoints of routes which Spring entered were all served by Spring in the previous year.

Three of the four market structure variables at the airport level show significant and positive impacts concerning Spring's market entry. Compared to the non-significance of market concentration at the route level, the results emphasize the importance of airport concentration. Since higher airport concentration reflects less carrier competition, the entry of Spring helps to obtain high operating margins and larger potential gains. Combined with the negative impact of *AirportSeats*, Spring is inclined to enter routes where the endpoints display higher airport concentration or those connected by endpoints with less capacity, after controlling for hub effects.

The *RivalNumbersBothEnds* variable is significant and positive. As the number of potential entrants increases, Spring has a higher probability of actually operating the route, revealing a 'first-mover' effect. As the majority of entry threats imposed by potential

entrants will not be responded by incumbents [33,34], Spring can take advantage of saving costs to cultivate new routes with no/less competition from incumbents or potential entrants, as also shown by the insignificant impact of the route concentration (i.e., RouteHHI variable). The result differs from the negative impacts on LCC's entry in other regions such as JetBlue in the U.S., also verifying Zhang et al.'s [13] finding that the market structure of Chinese airline industry still does not have significant competition due to the existence of a certain degree of market power. The presence at only one endpoint of a route does not stimulate Spring's entry. The presence at both endpoints encourages its entry of the route, although the impact is significant only for the model of the entire market.

5.3. HSR Effects

In the short-haul market, the two HSR variables show no significant impact on Spring's route entry choice. This result reflects that Spring tends to intuitively avoid the potential influence of HSR by diverting its capacity away from the overlapping routes. In other words, the diversion effect from HSR never has the opportunity to function on Spring's short-haul markets. However, Spring does carefully consider the adaption modes on the HSR in the medium and long-haul markets. If one of the endpoint cities connecting a route has an HSR station in the medium-haul market, the probability of Spring entering the route is high. The presence of the HSR station in an airport city can help enhance the attractiveness of airports per se by improving accessibility to travelers outside the city [13]. This finding reveals the complementary effect between air and HSR, a strategy that seems to fit well in Spring's medium-haul market. However, it is worth noting that the entry probability is less if both endpoint cities have HSR stations, reflecting the competition effect between Spring and the HSR due to the overlapping of distance advantages. In the long-haul market, the *HSR_BothEnd* variable is positive and significant, whereas the *HSR_OneEnd* is not significant. The long-haul market favors air service, while HSR becomes less attractive [36]. Spring considers the complementary strategy as an effective way to utilize the linkage and schedule of HSR on routes with the presence of HSR at the two endpoints.

5.4. Route Structure Variables

The two route structure variables are significant and positive in all the models except the $Hub1$ variable in the short-haul market. In contrast with large full-service carriers that apply a hub-and-spoke network configuration [51], Spring tends to explore a point-to-point network with four core focus cities: two long-established nodes in Shanghai and two relatively newer ones in Shijiazhuang and Shenyang.

5.5. Time Dummies

Corresponding to the exploratory analysis in Table 2, the Y_{2013} variable was significant and negative in all models, indicating that Spring adjusted and contracted the network in that year. The Y_{2014} variable was only significant and positive in the long-haul market.

5.6. Discussion

It is worth performing a systematic comparison of our study with that of Fu et al. [11] from the perspective of sampling, the design of independent variables and the estimation results. The extension of sampling beyond the top 500 routes helps identify more route entries of Spring and reveals a transition in the market position of Spring to serve more routes with lower density during 2011–2019.

As shown by the estimation results of the two studies, a redesign of market structure and HSR variables can not only reflect the significant changes in market environment comparing to the period of 2005–2012, but also capture their delicate impacts on Spring's route entry decisions. The distance segmentation of markets significantly contributes to these findings. The reveal of both positive and negative impacts of the new designed variables shows its flexibility in network reconstruction. For instance, both Route HHI and

HSR variables in Fu et al.'s [11] paper was not significant, while most of our designs of market structure and HSR variables show significant signs.

In addition, an update in demand and supply as well as hub locations is also necessary to capture the changes in selection of niche markets for Spring.

6. Conclusions

This paper has investigated the impact of market structure and HSR on Spring's entry patterns considering the variation of route distance segments during the period of pre-pandemic. We contribute to three aspects of the literature. First, we address the impact of market structure on Spring's entry from the perspective of the entire market, rivals, and Spring's activity per se. Market concentration and market presence variables are systematically designed at both route and airport levels. Second, we reveal the complex interaction effect between HSR and LCC's route entry in China by re-defining the thresholds for different distance segments. Third, we verify the coexistence of substitutability and complementarity effects of HSR on Spring's entry patterns.

Drawing on the estimation results of the market structure variables for the entire market, including both competitors and Spring, we found that market concentration and market presence variables at the airport level have much more explanatory power than route-level variables. The finding that Spring tends to enter routes connected by airports with higher concentration or less capacity does not fully corroborate the previous studies [22,30,31]. Taken together, it seems that the dominance of the big three carriers (i.e., Air China, China Eastern and China Southern) and the capacity constraint in large airports in China leaves Spring no choice but to seek more niche markets.

In addition, airport presence at both endpoints is a significant factor that encourages Spring's entry. Our results suggest new evidence on how Spring saves costs to maintain low fares. An existing presence at airports can reduce costs in establishing new infrastructure, while recruiting new staff and serving both endpoints of a route can cut costs to an even greater extent. Spring tends to launch new links between airports where it and other carriers provide endpoint services (for other routes), but no direct en-route service is available. The newly entered routes thus help Spring construct a cohesive and tight network.

The interaction between HSR and LCCs in China continues to be important. We provide statistical evidence that both substitutability and complementarity effects of HSR coexist in Spring's entry decisions, as revealed by our redefinition of route distance splits. Our results differ from Fu et al.'s [11] finding that the presence of HSR had no significant impact on Spring during the period 2005–2012. Instead, we found that the presence of HSR at both endpoints of medium-haul routes deters Spring's entry (i.e., a substitution effect), while its presence at one endpoint of the same distance segment encourages Spring's entry (i.e., a complementary effect). In the long-haul market, the presence of HSR at both endpoints motivates Spring's entry, corroborating the result of Zhang et al. [13]. As expected, Spring exited or avoided parallel or semi-parallel routes with HSR in short-haul markets from 2011–2019, when HSR grew enormously in China.

The widespread construction of HSR in China will force transformations in the "traditional" business model for LCC(s). Although Wang et al. [12] stated that "Spring can be more adversely affected or even be forced out of the market after the HSR enters all of Spring's destinations," our analysis shows that Spring can still survive in long-haul and some medium-haul markets. The strategy is to explore more new destinations without HSR and connect them with current destinations coexisting with HSR and other air services.

According to the above conclusions, considering the sustainable development of low-cost carriers in China, the authors put forward the following suggestions for low-cost airlines and for authorities. First, referring to Spring's excellent layout in Shijiazhuang airport, LCCs should strengthen complementary cooperation with high-speed rail to achieve win–win results. The government should publish relevant policies to promote and standardize the cooperation between LCCs and HSR. Additionally, entering the routes between two airports with established services is an effective way to save costs for LCCs. Addi-

tionally, due to being based in Shanghai, Spring has more ability to obtain valuable slots in some congested airports than other LCCs carriers. The government should relax LCCs' access in the congested airport moderately to prompt the development.

Although we have revisited Spring's entry patterns from a much more comprehensive perspective, our analysis also has some limitations to address in future research. First, we confine the empirical analysis to China's domestic market. However, Spring was also anxious to explore international markets such as Japan and Korea before the COVID-19 pandemic. A follow-up study can investigate Spring's international network development strategy in the post-pandemic era. Second, the worldwide spread of COVID-19 has significantly transformed the entire air transport sector in every aspect. It would be worthwhile to trace how Spring adapts to this volatility and reforms its business model. In the follow-up study, from the perspective of financial sensitivity, we will compare the changes of Spring's business model in the period before and after the COVID-19 epidemic. Particularly, since the hybridization has been a widely applied strategy for both FSCs and LCCs, it is worth of investigating this phenomenon for Chinese carriers, such as connecting services for Spring.

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