Network development of low-cost carriers in China's domestic market

Abstract:

This paper examines China's LCC market and assesses the network development patterns from a geographical perspective. Overall, a nationwide LCC network has been formed with each individual LCC focusing on their own markets with limited overlap to avoid cut-throat competition. Spring Airlines has developed an advanced network supported by its core bases including Shanghai in East China, Shijiazhuang in North China, Shenyang in Northeast China and Shenzhen in South China. China United has developed a network radiating from Beijing. West Air and Lucky Air seem to be developing a hub-and-spoke network that contributes to the tourism industry in West China. The LCC network is affected by seasonal variations, especially for the routes to tourism destinations such as Haikou, Sanya and Xiamen. Hub cities, however, experience less seasonal impact. This research also finds that routes between 600-1800 km account for a large proportion of the LCC markets. Aviation policy, local government's subsidization and the expansion of the high-speed rail network have helped shape the landscape of China's LCC sector.

Keywords: network, tourism destination, seasonality, connectivity, Chinese LCC

1. Introduction

China's private airlines emerged in 2005 after the government opened the air transport sector to private investors in 2004. Three private carriers (Okay Airways based in Tianjin, United Eagle Airlines in Chengdu, and Spring Airlines in Shanghai) launched their maiden flights in 2005. In 2006 two more private carriers (Junyao in Shanghai, and East Star Airlines in Wuhan) commenced their services. By the end of 2007 the number of private airlines in China reached 20. One of these private carriers, Spring Airlines, adopted the low-cost carrier (LCC) business model, and is now the largest LCC in China. The quick increase in the number of new private airlines put huge competitive pressure on the state-owned carriers, which was deemed as undesirable by the Civil Aviation Administration of China (CAAC), the nation's civil aviation regulator (Zhang and Zhang, 2016). As a result, the CAAC stopped granting new licenses for establishing new carriers during the period 2007-2013. This policy was not repealed until 2013, and a revised version of the Provisions on the Business Licensing for Public Air Transportation Enterprises was issued in 2014. The revised Provisions emphasized the safety requirements, but acknowledged the role of market mechanism in the air transport sector and thus simplified the operating permit approval procedure, aiming to promote the development of the low cost aviation sector. As a result, from 2013 to 2015, there was another wave of the entry of private airlines and LCCs.

By the end of 2017, there were five airlines in China adopting the low-cost business model, which were Spring Airlines, West Airlines, China United Airlines, Jiuyuan Airlines and Lucky Air. Spring and Jiuyuan are private airlines. West Airlines and Lucky Air are owned by Hainan Airlines (HNA) Group and used to be full service airlines (FSAs). Believing that West China has great potential for LCC operation, HNA transformed West Airlines and Lucky Air into LCCs in 2013 and in 2016, respectively. China United belonged to Air Force before 2004 and was taken over by Shanghai Airlines. Both Shanghai Airlines and China United are now subsidiaries of the China Eastern Group. China United adopted the LCC business model in 2014. Table 1 shows the general information of the

LCCs including their fleet size, home airport and ownership. As the earliest Chinese LCC, Spring owns the largest number of aircraft. It accounts for about 40% of the LCC market measured by the fleet size. By the end of 2017, the market share of LCCs in China's domestic market was about 9.3%, which was much lower than the world's average of 31.4% (Spring, 2018), but still represented a huge progress considering that the LCC sector is relatively young in China.

It should be mentioned that sometimes there is no clear boundary between LCCs and FSAs. The airlines listed in Table 1 were considered as LCCs because they fulfill three criteria. First, they are recognized as LCCs by the CAAC and treated as LCCs in the media reports. Second, they have implemented a strict cost control strategy, including no compensation for flight delay, no free or limited meals onboard, lower (less than 20 kg) or no free baggage allowance and lower carry-on allowance than what FSAs usually offer. Third, scholarly literature has treated them as LCCs. For example, Spring Airlines has been extensively examined by many studies (e.g. Zhang and Lu, 2013; Fu et al., 2015; Jiang et al., 2017; Dobruszkes and Wang, 2019). Other Chinese LCCs receive less attention in scholarly literature but have been mentioned in recent studies such as Liu and Oum (2018). Wang et al. (2017) examined the expansion of China's high-speed rail (HSR) and its impact on China's LCCs including all the LCCs listed in Table 1. Therefore, treating these airlines as LCCs is consistent with industry practices and academic literature.

Table 1. Profile of LCCs in China as of December 2017

Carrier name	Year declaring as LCC	Fleet size	Base	Ownership
Spring Airlines	2005	81（Airbus 320, Boeing 737）	Shanghai Hongqiao and Pudong, Shijiazhuang, Shenyang, Shenzhen	Private
West Air	2013	30（Airbus 319, Airbus 320）	Chongqing, Zhengzhou	Private

China United Airlines	2014	31（Boeing 737）	Beijing	State-owned
Jiuyuan Airlines	2014	14（Boeing 737）	Guangzhou	Private
Lucky Air	2016	45（Boeing 737）	Kunming, Lijiang, Chengdu	Private

Source: Websites of relevant airlines

Over the last decade, researchers have studied China's LCC market with a general conclusion that LCCs had limited impact on China's air transport industry (e.g. Fu et. al., 2015; Wu et. al., 2017; Jiang et al., 2017). However, existing studies on China's LCC mainly focus on Spring Airlines as it was the only LCC in China before 2013. This paper aims to examine China's LCC market and assess their development pattern, and network structure by considering all Chinese LCCs from a geographical perspective. Based on China's domestic air passenger timetables issued by CAAC, this study uses descriptive statistics, mapping and topological structure analysis methods to fulfil the study objectives. Also, topological indexes and complex network indicators are used to evaluate the network connectivity of each carrier. This study provides a comprehensive analysis on the attributes and characteristics of LCCs network, which will contribute to the literature on the development of LCCs in emerging markets.

2. Literature review

It is generally believed that LCCs are good at controlling operation costs by using single model fleet and operating short-haul flights with attractive fares and limited cabin services (Bitzan and Peoples, 2016; Buaphiban and Truong, 2017). In particular, LCCs have traditionally adopted point-to-point route strategies (Graham and Shaw, 2008; Graham,2009). During the initial developing period, LCCs preferred to open new routes rather than to compete directly with FSAs or charter airlines (Dobruszkes, 2013). The entry of LCCs is commonly regarded as a new method to connect airports with more destinations and extend airports' route networks (Wit and Zuidberg, 2016). However, on

the other side, the development of LCCs is also restricted by a country's aviation policy and local conditions, such as airport facilities or subsidies policies (Gillen and Lall, 2004; Yu et al., 2019).

Many researchers have assessed the impact of LCCs on the tourism industry. Most researchers found that LCC promotions could stimulate new demand, change travel patterns, and develop new tourism destinations (e.g. Bel, 2009, Graham, 2013). However, some studies argue that LCCs may not necessarily create new demand by bringing in new tourists (Clavé et al., 2015) and that the effect of LCCs on tourism remains uncertain, at least from the characteristics and behavior of the tourists (Dobruszkes et al., 2016). In some cases, LCCs could have some negative impacts on the tourism industry, such as short tourists' average stay period (Pulina and Cortés-Jiménez, 2010), and decrease tourists' expenditures (Alivernini et al., 2012; Marrocu et al., 2015). In the US and Europe, LCC operations have made tourists preferences more flexible and reduced the seasonality of tourist arrivals (Donzelli,2010; Graham and Dennis, 2010; Dobruszkes and Mondou, 2013). However, Chung and Whang (2011) found that LCC operations have limited impact in reducing tourism seasonality in Asia.

Studies on the effect of LCCs on the tourism industry in Asia are small in number. Wu and Hayashi (2014) found that LCCs had little impact on the charter traffic due to the differences in target markets and routes in Japan. Chung and Whang (2011) claimed that LCCs did not smooth out the seasonality of tourist arrivals to Korea's Jeju Island. China is the largest aviation and tourism market in Asia, which has attracted the attention of many researchers in recent years. Some researchers investigated the performance of Chinese major airlines in term of their pricing, market power, network configuration and so on (e.g. Zhang and Round, 2008; Wang et al., 2011; Fu et al., 2015). A number of studies assessed the performance of the largest LCC, Spring Airlines (e.g., Zhang and Lu, 2013; Fu et al., 2015, Jiang et al., 2017). Dobruszkes and Wang (2019) claim that China's Spring

Airlines is still a small, emerging LCC compared to well-established Ryanair, EasyJet, Southwest, and JetBlue. Wang et al. (2018) compared the development of LCCs in China and India and found that private and LCCs have become dominant players in the Indian airline market while the state-owned airlines still enjoy a dominant status in the Chinese market. The heavy presence of LCCs in India's aviation market has resulted in a more elastic travel demand. However, a comprehensive study covering all the Chinese LCCs and their network development is still lacking. With the rapid expansion of China's HSR, as a good substitute for air, and particularly for LCC services, it is worth taking a close look at China's LCCs and examine their development trend in the world's second-largest aviation market.

3. Data and methodology

The data used in this paper are obtained from China's domestic air passenger timetable from 2008 to 2017. Every year, the CAAC publishes two timetables: the summer & autumn timetable (effective from late March to late October) and the winter & spring timetable (effective from late October to late March of the next year). The OAG data were used in previous studies when studying Chinese LCCs. However, given that many Chinese airlines, especially new airlines and LCCs, do not report or only report part of their flight data to OAG, we prefer to use the timetable data.

This study uses descriptive analysis, mapping and network structure analyses to fulfil the study purposes. Specifically, the route and network data for each LCC are collected to examine the development patterns and make comparisons. In addition, topological indicators are used to evaluate the performance of the LCC networks.

Following Jiang et al. (2017), topological indexes are used to assess the network structure of LCCs. That is, four topological indexes μ, α, γ and β are used to evaluate the network connectivity of each LCC in winter and summer, respectively (Garrison and marble, 1965). μ represents the number of

circuits in a network, which reflects the degree of the redundancy and development of the network; α is the ratio of the number of circuits in a network relative to the maximal number possible, reflecting the complexity of network; γ is the ratio of actual links to the maximal number of air routes, representing the cohesiveness of network; and β is the average air routes of each navigable city. The formulation of these indexes is as follows:

(1) $\mu=m-n+g$

(2) $\alpha=2(m-n+g)/[(n-1)(n-2)]$

(3) $\gamma= 2m/[n(n-1)]$

(4) $\beta = m/n$

where, *m* is the number of routes; *n* is the number of navigable cities; and *g* is the number of disconnected subgraphs, which is usually set to 1; and a larger value of α, γ, *or* β indicates a better connectivity.

A number of complex network indicators are also considered. Following Wang et al., (2011), each airline network is regarded as an undirected connectivity graph $G = (V, E)$, where *V* is a set of nodes (airports) and *E* is a set of edges (routes). To compare the different characteristics of network structure of the five LCCs, this study adopts the following indicators.

- Degree distribution

  Degree k_i is defined as the number of edges that a node connects, that is, the degree of a node $v_i = k_i$. Assuming that there are *N* nodes, the average degree of all nodes $\langle k \rangle$ represents the degree of the whole network, written as:

  $$\langle k \rangle = \frac{1}{N}\sum_{i=1}^{N} k_i$$

  We use probability distribution function $p(k)$ to describe the degree distribution of a network. It reflects the macroscopic statistical characteristics of the network system.

- Average path length

The node distance d_{ij} is defined as the number of edges that connects the shortest path between node *i* and *j*. The average path length (L) represent the mean distance of any two nodes of a network, written as:

$$L = \frac{1}{\frac{1}{2}N(N-1)}\sum d_{ij}$$

It can measure the transmission performance and efficiency of the entire network.

- Clustering coefficient

The clustering coefficient (C_i) of node *i* is the ratio of the connected edges (E_i) with all its neighbors to the maximum number of possible links. The clustering coefficient of a network (C) is the mean value of all the single nodes, written as:

$$C = \frac{1}{n}\sum_{v_i \in V}\frac{E_i}{k_i(k_i-1)/2}$$

This indicator reports to what extent all nodes in the network is clustering, and the larger the value is, the easier for the nodes to connect each other by short distance.

4. Routes expansion and network construction of Chinese LCCs

The first batch of LCCs were established around 2005-2006, but only Spring Airlines survived and succeeded. It is argued that 2014 is the banner year for the Chinese LCC industry because of the release of the Guiding Opinions on Promoting Low Cost Aviation Industry Development in 2014 by the CAAC. For the first time, the aviation authorities acknowledged the significant role played by LCCs in the nation's economy. This led to some existing FSAs transforming and rebranding themselves as LCCs including China United Airlines.

4.1 The development of individual LCCs

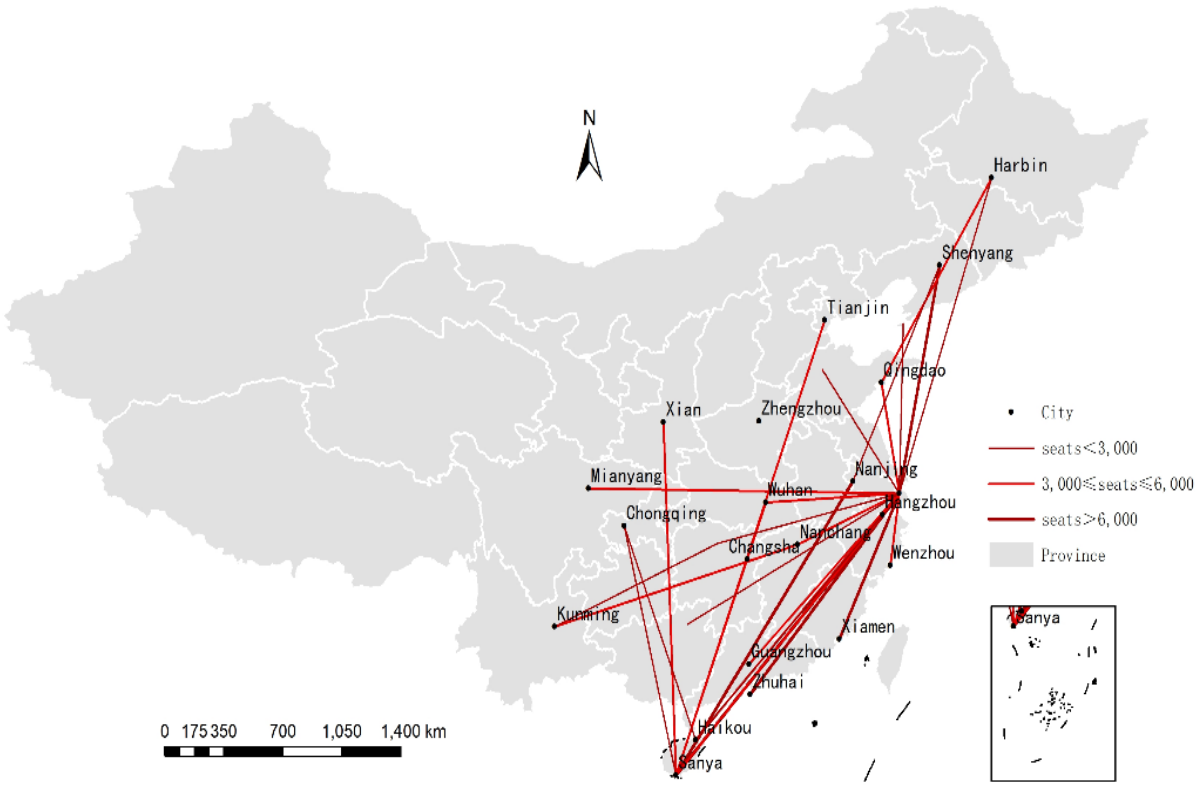
4.1.1 Spring Airlines and Jiuyuan Airlines[1]

[1] As Jiuyuan is still small in scale, we only briefly describe its network in words without presenting its network map.

From 2008 to 2013, the number of passengers carried by Spring Airlines increased from 2.9 million to 9.1 million, the number of cities served increased from 20 cities to 41, and the number of routes increased from 23 to 64. By the end of 2017, Spring served 62 domestic cities and carried 1.3 million passengers in the domestic market. Figure 1 illustrates Spring's fast domestic route expansion from 2008 to 2017. A closer examination of its network data reveals the following key developments over this period. First, it entered key trunk and profitable routes such as Shanghai-Beijing and Shanghai-Guangzhou. This is not easy as market access to the routes associated with Beijing, Shanghai and Guangzhou are still regulated to protect the interests of the state-owned carriers. Although based in Shanghai, Spring did not obtain the right to fly the Shanghai-Beijing route until 2011 and it was only allowed to fly one flight with the departure time close to mid-night. Second, it constructed three new hubs, Shenyang, Shijiazhuang and Shenzhen. This is due in part to the heavy subsidies provided by the local governments and the geographic importance of these cities. For example, the choice of Shijiazhuang is largely because of its closeness to Beijing. As it was difficult to gain access to the Beijing market, operating a base near Beijing could be a second best solution. In addition, the CAAC announced in 2017 that some flights from second- and third-tier cities to over-congested Beijing Airport would be shifted to Tianjin and Shijiazhuang and it is only half an hour's ride from these cities to Beijing via HSR (Zhang et al., 2017). Third, Spring launched and increased flights to long-haul route destinations in Southeast and Northwest China such as Kunming, Chengdu, Chongqing, Urumqi, most of which have an intermediate point at small airports. Spring has constantly changed the intermediate airports. For example, in recent year, it shifted some of its intermediate points from Central China to less developed Southwest China, including Guiyang, and Zunyi.

The distribution of China's aviation market is mainly driven by routes associated with a few major cities including Beijing, Shanghai and Guangzhou (O'Connor et al., 2018; Zhu et al., 2019). The vast majority of China's flights are operated in the area to the east of Beijing-Guangzhou route, more than 60% of which are within the triangle area formed by Shanghai, Beijing and Guangzhou (Zhu et al.,

2018). Increasing competition from HSR in this triangle has forced China's airlines to keep an eye on a broader market including underdeveloped West China and international markets. Therefore, apart from looking to the less developed region, Spring has put a substantial part of its capacity in the international markets in the last few years. At the same time, it suspended routes overlapped with HSR and Juneyao Airlines, another Shanghai based private carrier (Wu et al., 2017).



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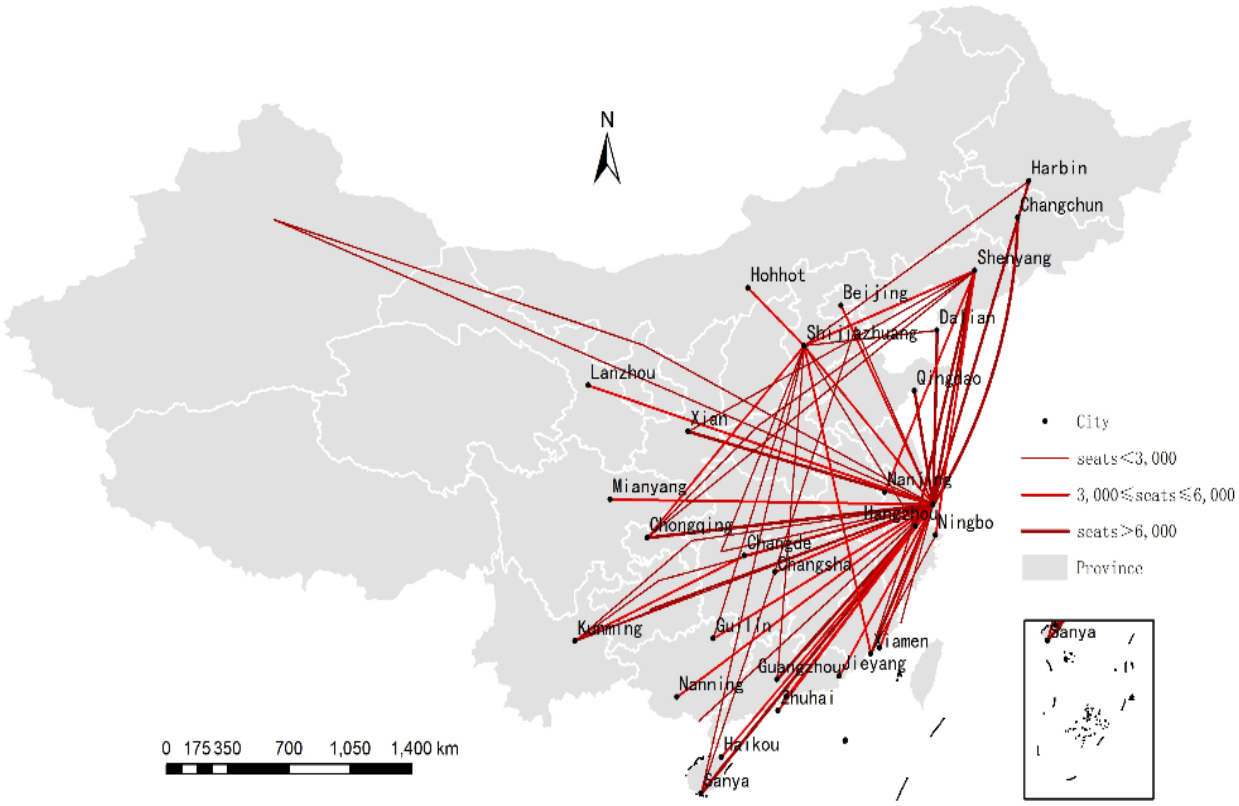
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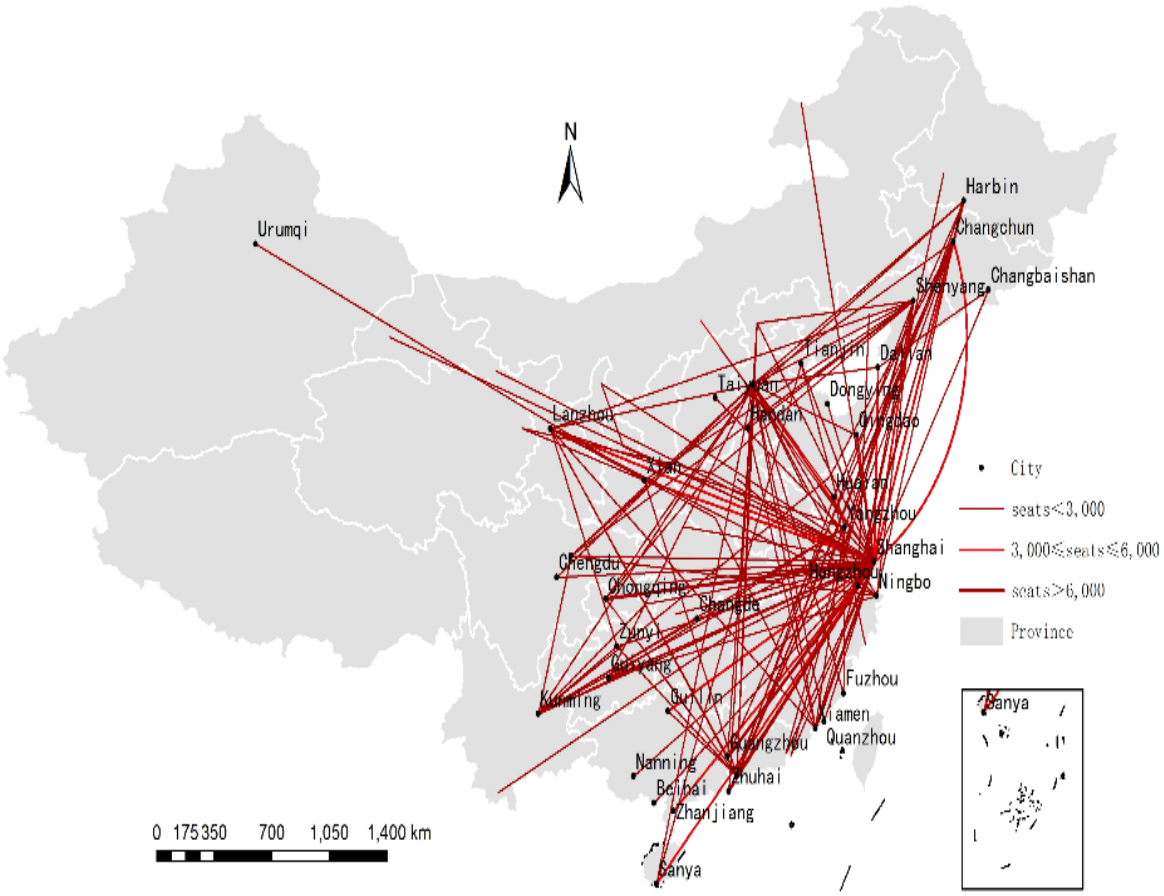

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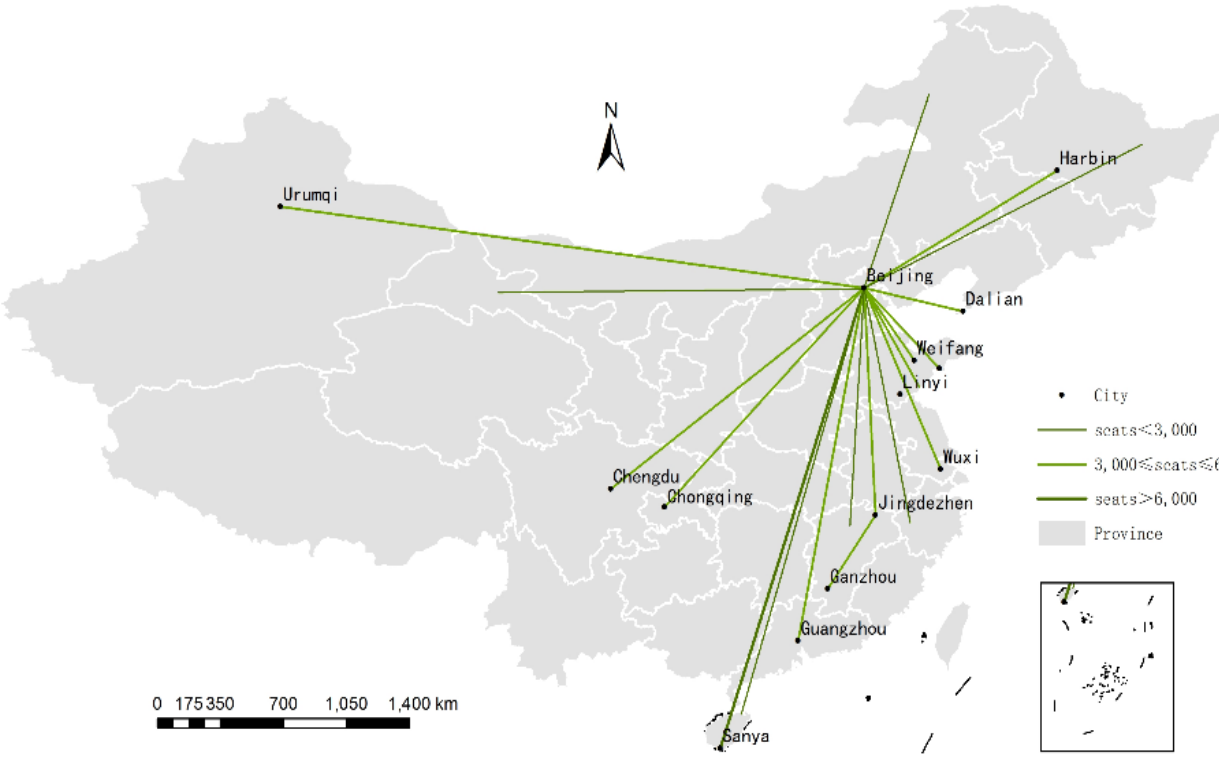
Figure 1. Route expansion of Spring Airlines 2008-2017

Juneyao Airlines started operations from September 2006 and bears several striking similarities to Spring Airlines: both are privately owned and headquartered in Shanghai; both account for a market share of about 9% at Pudong and Hongqiao airports in terms of the number of flights. In addition, both have a similar fleet-size and scale. Nevertheless, Juneyao is positioned as an FSA, targeting medium to high income-level passengers and focusing on bigger cities. Thus, by the end of 2013, 80% of the cities served by Juneyao were provincial, autonomous regional, and municipal capitals or important commercial cities, and the rest 20% were regional centers such as Xilinhot, Baotou,

Qinhuangdao, Changzhi, and Tongliao. Seeing the great potential of the LCC market, Juneyao Airlines invested a new LCC - Jiuyuan Airlines in 2014. Probably influenced by its parent company, Jiuyuan takes Guangzhou as its only hub and operates flights mainly on trunk routes connecting provincial capital cities.

4.1.2 China United Airlines

China United Airlines was re-launched by China Eastern Airlines and China Aviation Supplies Import and Export Group as an FSA in 2012, and quickly switched to the LCC model in 2014. It is the only state-owned LCC in China. It is also the only commercial airline approved by Air Force to use Beijing Nanyuan Airport (a military air base with civil aviation facilities) as its home airport. Figure 3 shows that compared with its network in 2008, China United launched more short-haul flights to regional cities located in Inner Mongolia and Shanxi Province in 2013, most of which are military airports. From 2014 to 2017, it extended its destinations to major cities in Northwest and Southeast China, or along the midstream and downstream of Yangtze River with little overlapping with its parent company, China Eastern's network. During this period, China United also suspended routes overlapped with HSR. It is apparent that the distribution of its parent company's network and its historical link with Air Force are two important factors leading to this expansion pattern. As market access to and from Beijing is still regulated and China United has enjoyed such protection, there is no sign for it to develop other hubs before it loses such protection.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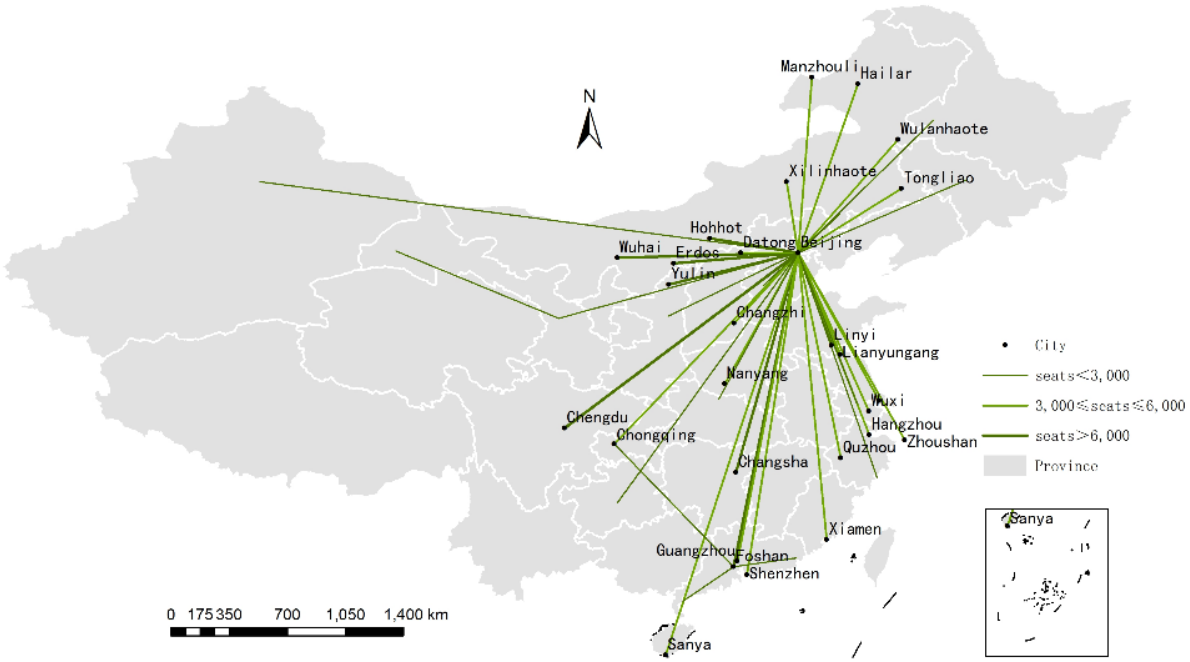
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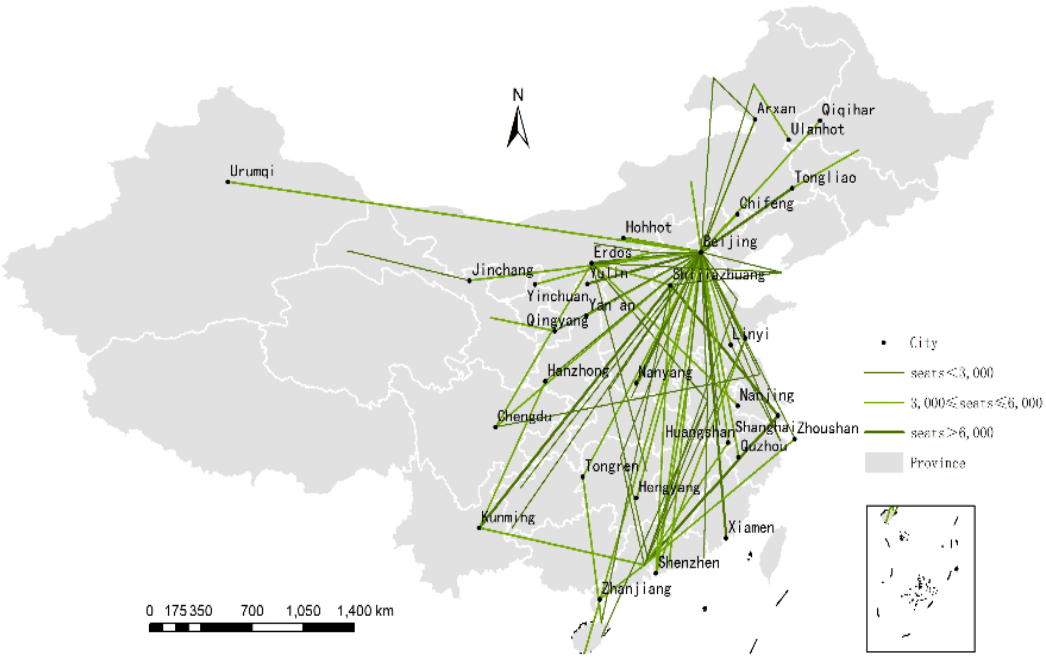


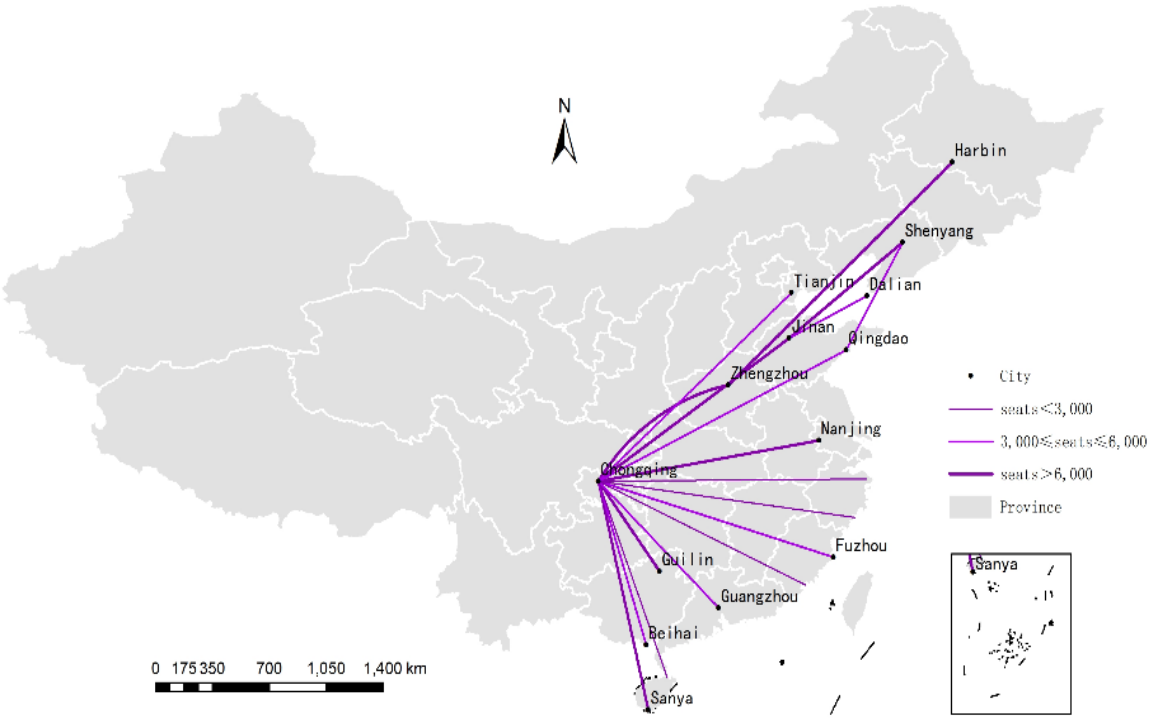
2017

Figure 2. Route expansion of China United Airlines 2008-2017

4.1.3 West Air and Lucky Air

West Air and Lucky Air are both subsidiaries of HNA Group. Taking Chongqing Jiangbei Airport as its major home hub, West Airlines was transformed into an LCC in 2012. Since then, West Air has attempted to build Chongqing as a tourism transfer hub to Yunnan and Sichuan by providing competitive fares. Figure 3 shows the routes of West Air in 2008, 2013 and 2017. Before 2013, West Air mainly developed routes to East and South China. Since becoming an LCC, it started to develop new routes to Southwest China, including tourist destinations located in Yunnan, Sichuan and Guizhou that are rich in tourism resources. It also launched services on long-haul routes to Northwest China such as Urumqi that is rich in mineral and energy resources. Since 2013, West Air

has built a new hub at Zhengzhou Airport that is currently developing a reputation of aviation city in Central China supported by the Central Government.



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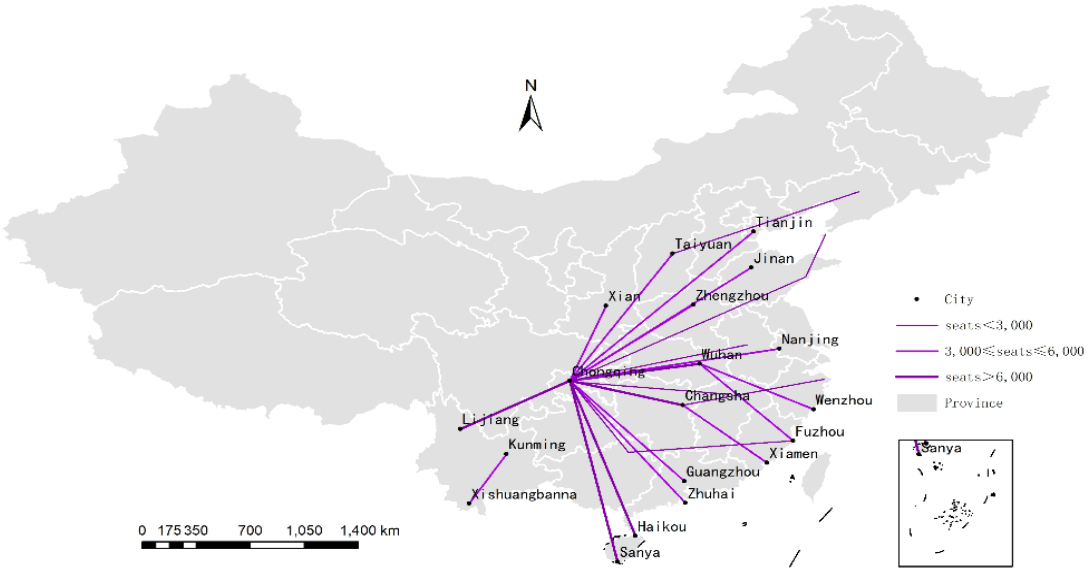

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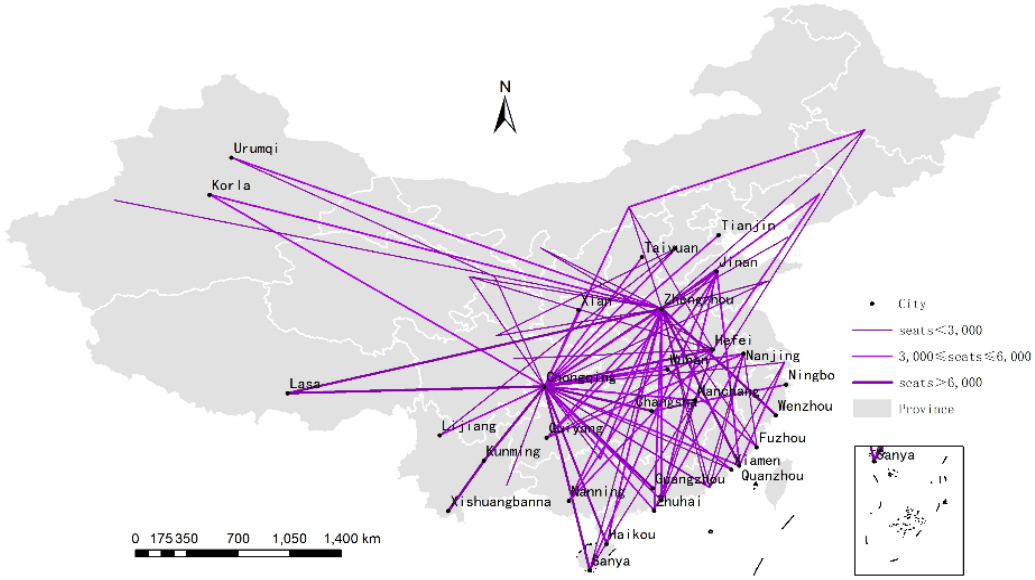

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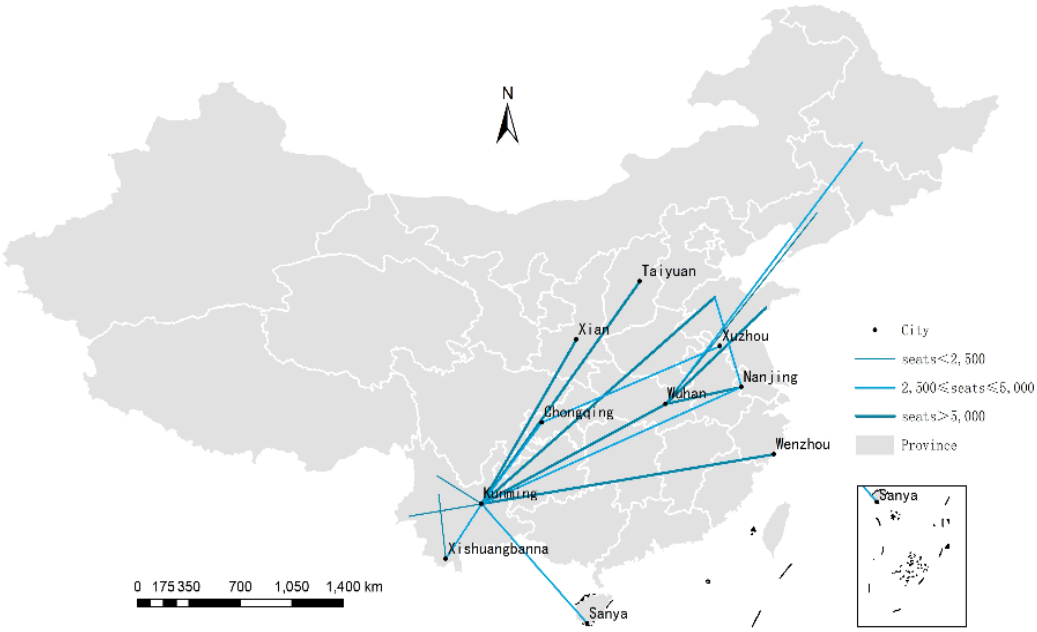
Figure 3. Route expansion of West Air 2008-2017

Lucky Air had investment from HNA (68%), Shanxi Airlines (31%), and a travel company in 2004, and started operations in Yunnan Province. It initially operated services from Kunming to Dali and Xishuangbanna, and then expanded its network to North and Central China. After the state-owned Assets Supervision and Administration Commission of Yunnan Province became one of the main stakeholders, Lucky Air shifted part of its capacity back to Yunnan and increased services to the provincial regional airports such as Simao, Dehong, and Tengchong. Thus, Lucky Air has gradually developed Kunming into a transfer hub, transporting tourists from other provinces to Kunming and then from Kunming to the provincial tourist destinations. Figure 4 shows that Lucky Air's network development from 2008 to 2017 is quite impressive. It has connected Kunming with many other provincial capitals, including Xi'an, Shijiazhuang, Zhengzhou, Lanzhou, Taiyuan, Wuhan, Chengdu, Changsha, Guiyang, and Zhengzhou. Many of the long-haul routes have intermediate points to allow the carrier to achieve a higher load factor.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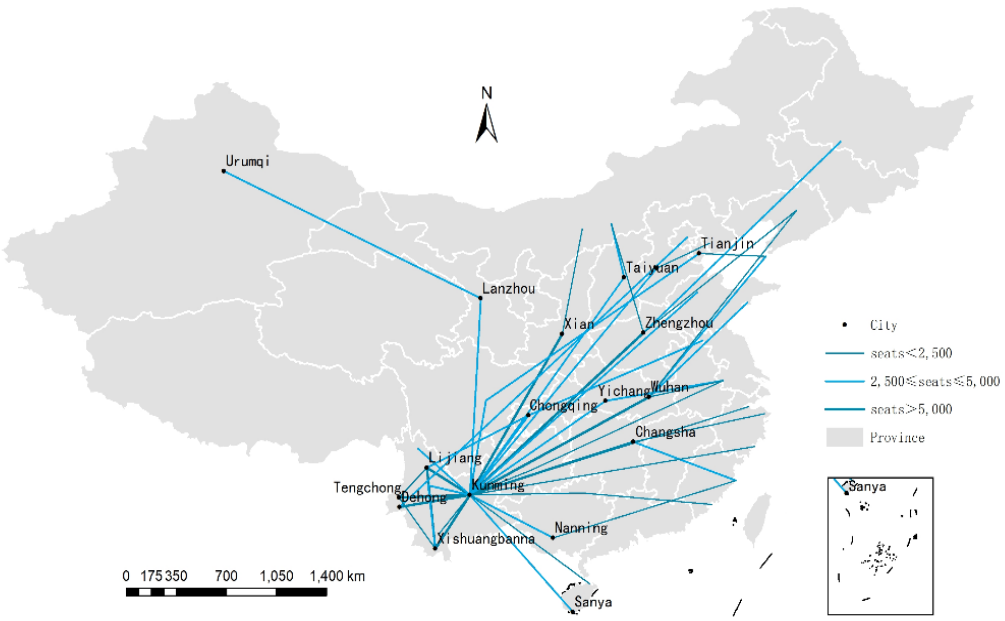
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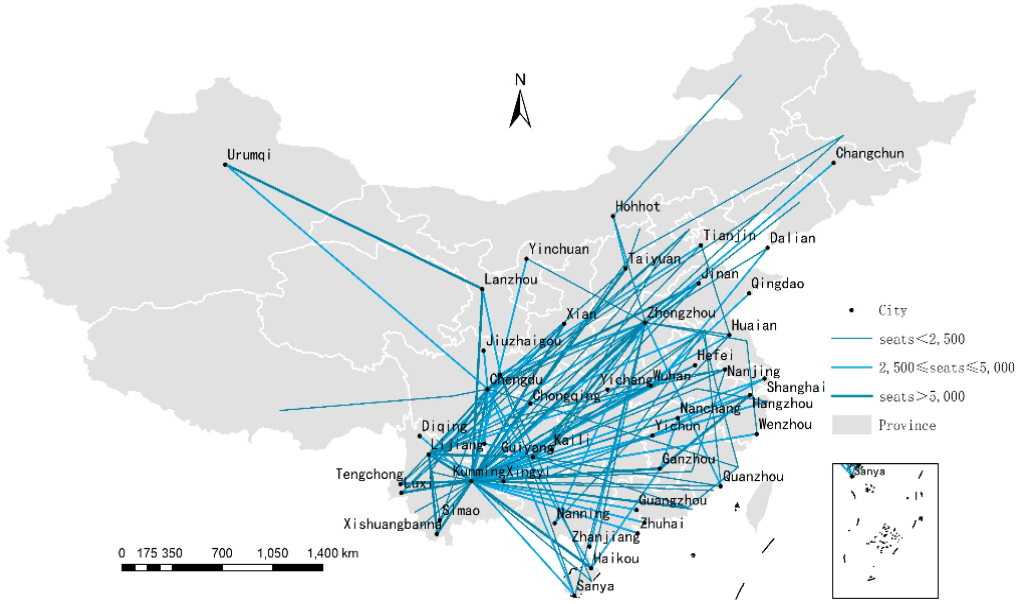


2017

Figure 4. Route expansion of Lucky Air 2008-2017

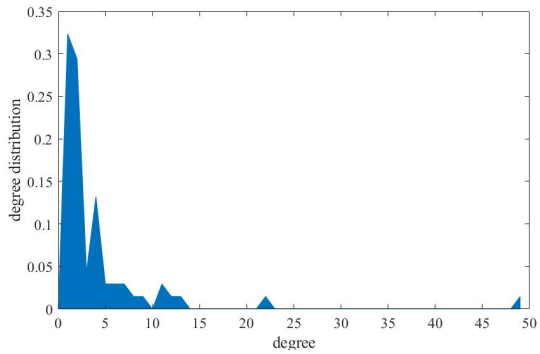
4.2 LCC network structure indicator comparison

Table 2 shows the results of the complex network indicators of each LCC. The characteristics of China's air transport network reported in Wang et al. (2011) are also included as a comparison. Compared with China's overall air transport network, Chinese LCCs are small in scale as can be seen from the numbers of nodes and edges. This is also evidenced by the relatively small average degrees. In contrast, Dobruszkes and Wang (2019) report that major LCCs in the US and Europe have an average degree around 12-15. Interestingly, the average path lengths do not differ much across LCCs and the values are larger than those reported in Xu and Harriss (2008) for the US aviation market. Except Jiuyuan, the magnitudes of Chinese LCCs' clustering coefficients are similar to those of Ryanair and Easyjet reported in Dobruszkes and Wang (2019). In addition, all the degree distributions in Figure 5 clearly follow a power law. These indicators may suggest that the Chinese

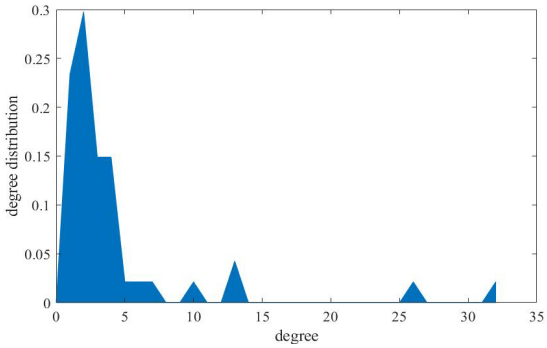
LCCs' networks have the properties of small-world and scale-free. They are still in a rapid development stage and far from mature.

Table 2 Characteristics of the networks of Chinese LCCs

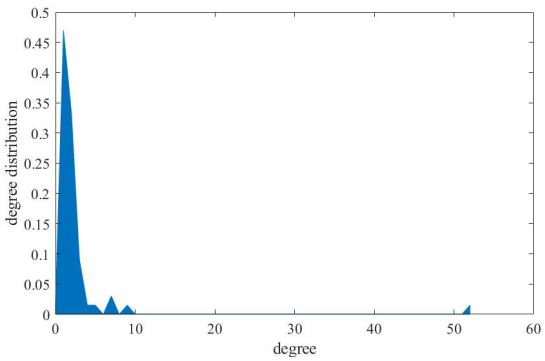
Airline name	No. nodes(n)	No. edges(m)	Average degree($\langle k \rangle$)	Average path length (L)	Clustering coefficient (C)
Spring Airlines	72	146	4.06	2.33	0.49
West Air	47	90	3.83	2.22	0.40
China United	66	91	2.76	2.28	0.56
Jiuyuan Airlines	22	34	3.09	2.51	0.23
Lucky Air	79	145	3.67	2.46	0.45
China's airline network (Wang et al., 2011)	144	1018	14.14	2.23	0.69



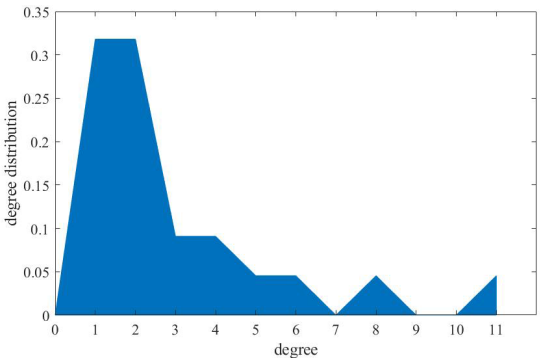
Spring Airlines



West Air



China United



Jiuyuan Airlines

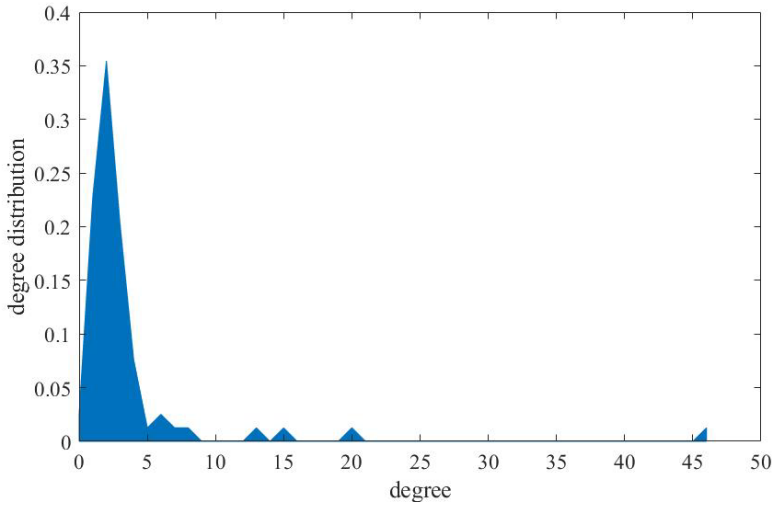


Figure 5. Degree distributions of Chinese LCC's network

4.3 Market structure of LCC routes

In 2017, LCCs operated scheduled flights on more than 400 domestic routes, accounting for a share of 13% in the domestic market. Table 3 reports the market structure of the routes where LCC was present based on the the summer season schedule data in 2017. The LCC routes are grouped into five categories based on the LCC market share measured by the number of flights. The proportion of the routes of each category is shown in the table. The monopoly group contains the routes only served by an LCC. For the group with the LLC share less than 25%, the LCC can be seen as a fringe carrier. As can be seen, Spring and Lucky were the only service provider on 42% of the routes that they each served. It is worth noting that 68% of the China United's routes were monopoly routes. This clearly shows that Spring, Lucky and China United deliberately devoted a significant amount of their capacity on the routes that are not served by other airlines. This pattern is similar to that of the major US and European LCCs reported in Dobruszkes and Wang (2019). In contrast, Jiuyuan and West Air's monopoly routes only accounted for 12% and 15% of their total routes, respectively. These two LCCs each commanded a share of less than 25% on a large proportion of their routes. Such

significantly different penetration patterns imply that Chinese LCCs are actively pursuing a niche market in their own market area. Interestingly, the percentage is almost zero for the 75%-100% category, implying that LCCs are unlikely to dominate a market where there is a presence of an FSA. This may suggest that Chinese LCCs are operating in an unfavorable environment and that market access restrictions are imposed on the LCC sector (Zhang and Zhang, 2017). With the opening of the new Beijing Daxing Airport and the introduction of the third terminal in Shanghai, congestion may be of a less concern in these cities, and it is possible that state-owned and LCCs could be treated equally.

The average route distance of each LCC is quite similar and almost all of them have engaged long-haul routes of more than 3000km. it should be noted that LCCs seldom compete directly with each other on the same route, as the number of routes served by two or more LCCs was only about 10% of the total LCC routes.

Table 3 Market structure of LCC routes in 2017

	Percentage of routes based on LCC market share					Distance (km)	
Airline	Monopoly (100%)	75%-100%	50%-75%	25%-50%	Less than 25%	Average	Longest
Spring	42%	0%	6%	19%	33%	1421	3277
Lucky	42%	0%	10%	18%	30%	1178	3087
Jiuyuan	12%	0%	10%	14%	64%	1499	3278
China	68%	1%	11%	7%	13%	1086	2431
United West Air	15%	0%	18%	26%	41%	1250	3024

4.4 LCC route distance comparison

Table 4 reports the percentages of the routes in different distance categories. As can be seen, the distances of most of the routes served by LCCs are between 600-1800km, particularly concentrating on the range of 1200-1800km, which in contrast with the median distance flown by the LCCs in

Europe which was around 900km (Dobruszkes, 2013). It is likely that for the markets less than 600km, HSR and other transport modes are good substitutes in China and air travel is less preferred (Zhu et al., 2019; Ma et al., 2019). Interestingly, Chinese LCCs have a higher percentage of long-haul routes (greater than 1800km) than their FSA counterparts. Compared with other LCCs, China United seems to be more interested in shorter routes (less than 1200km). This distribution pattern is quite similar to those of China Southern and China Eastern.

Table 4. Proportions of LCC routes in different distance categories in 2017

	Less than 600km	600-1200km	1200-1800km	1800-2400km	Over 2400km
Spring	18.2%	29.8%	38.0%	12.4%	1.7%
Lucky Air	2.7%	34.8%	40.2%	18.8%	3.6%
Jiuyuan	6.9%	31.0%	48.3%	10.3%	3.4%
China United	16.9%	42.8%	24.7%	13.0%	2.6%
West Air	2.9%	30.9%	47.1%	10.3%	8.8%
Air China	9.7%	42.9%	36.9%	7.0%	2.4%
China Eastern	12.1%	48.9%	30.8%	5.9%	2.2%
China Southern	12.0%	48.4%	27.2%	8.4%	3.8%

4.5 Seasonality and connectivity of the LCC network

In 2017, Chinese LCCs operated flights on 403 domestic routes in summer and 396 routes in winter. Figure 6 illustrates the distribution of these routes. It can be observed that LCCs mainly served the routes connecting cities located in South and East China with dense population and high level of economic development. The network extended to the south in winter but moved to north in summer. This pattern is similar to the direction of Chinese domestic tourism flows: southbound in winter, but northbound in summer. In particular, the number of routes connecting the famous tourist cities in Southern China such as Haikou, Sanya and Xiamen was lower in summer but higher in winter. For LCC operation hubs such as Beijing, Shijiazhuang, Shanghai, Kunming and Chongqing, the LCC

traffic flows were less affected by the seasonality and the number of LCC routes remained relatively stable throughout the year.

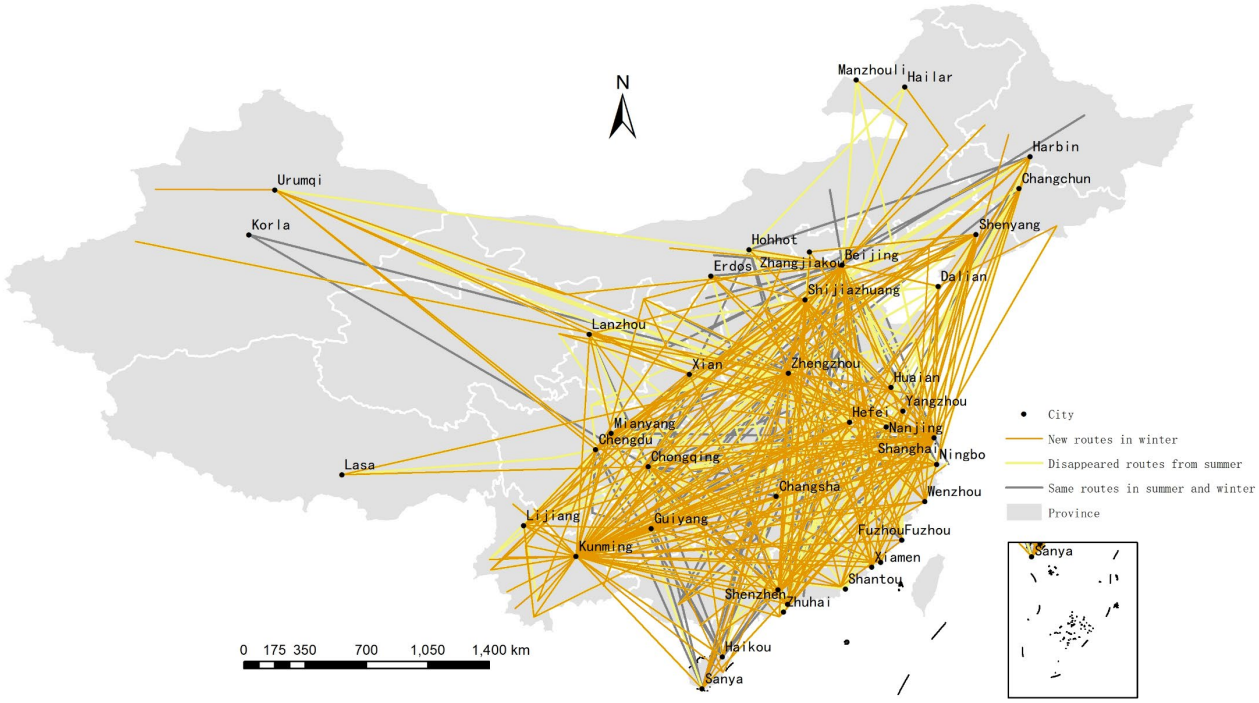


Figure 6. LCC routes and destinations in 2017: summer vs winter

Table 5 shows the calculation results of the network connectivity. It can been seen that the LCC network structure exhibits obvious seasonality, as the values of α and γ decrease from summer to winter. In other words, the network concentration degree of each LCC in summer is higher than in winter. From the level of the index μ, we can see that Lucky Air and Spring Airlines have developed a more advanced network. According to the values of β and γ, Spring Airlines' network structure is better than other airlines. The connectivity of Lucky Air in winter is better than in summer. It appears that West Air needs to improve it network connectivity in both summer and winter.

Table 5 The network structure index

		n	m	μ	α	γ	β
Lucky	summer	59	107	49	0.030	0.063	1.814
	winter	64	121	58	0.030	0.060	1.891
Spring	summer	56	122	67	0.020	0.079	2.179
	winter	55	112	58	0.019	0.075	2.036
Jiuyuan	summer	17	25	9	0.075	0.184	1.471
	winter	19	29	11	0.072	0.170	1.526
China United	summer	50	76	18	0.011	0.044	1.288
	winter	61	77	17	0.010	0.042	1.262
West Air	summer	46	75	30	0.030	0.072	1.609
	winter	41	68	28	0.036	0.083	1.659

4.6. The presence of Chinese LCCs in the international markets

The focus of this paper is mainly on the domestic market for the following reasons. First, China's aviation and competition policies still favor the state-owned FSAs and discriminate against the LCCs and private carriers (Yu et al., 2019). It is difficult for the LCCs to gain access to the domestic lucrative routes associated with Beijing, Shanghai and Guangzhou, let alone the international routes. Due to the market access restrictions, Chinese LCCs' international businesses are relatively small. Second, as Chinese LCCs mainly operate the routes for tourism purposes, their international services are subject to frequent changes, suspensions and cancellations. This is because international tourist flows are heavily affected by seasonality, bilateral relations, natural disasters, etc. For example, Spring served 17 international routes in 2014, and opened 64 new routes in 2015. However, the total number of its international routes was only 52 at the end of 2015. Therefore, it is difficult to paint a consistent picture of the LCC's international network. Table 6 compiles the international services provided by Chinese LCCs.

Table 6. International routes and destinations served by Chinese LCCs

Code	No. of routes	Description
Spring Airlines	52	- Started international services in 2010.

		- From 2013 to 2017, international routes increased from 7 to 52; The proportion of international ASK in total ASK increased from 8.78% to 30.4%. - Overseas destinations at the end of 2017: Cambodia (Phnom Penh, Siem Reap), Japan (Ibaraki, Nagoya, Osaka, Saga, Sapporo, Takamatsu, Tokyo), Malaysia (Sabah), Singapore, South Korea (Seoul, Jeju) and Thailand (Bangkok, Chiang Mai, Krabi, Phuket, Surat Thani).
Lucky Air	17	- Started international services in 2014. - The proportion of international ASK in total ASK reached 12.9% in 2017. - Overseas destinations at the end of 2017: Brunei (Bandar Seri Begawan), Indonesia (Bali, Jakarta), Malaysia (Kuala Lumpur, Penang, Sabah), Philippines (Manila, Cebu), Russia (Moscow, Irkutsk), Singapore, Korea (Jeju), Thailand (Bangkok, Krabi, Koh Samui) and Vietnam (Nha Trang).
West Air	4	- Started international services in 2016. - Overseas destinations at the end of 2017: Singapore, South Korea (Jeju), Philippines (Kalibo, Cebu)
China United	1	- Started international services in 2017 - One route at the end of 2017: Beijing-Yantai- Fukuoka
Jiuyuan Airlines	0	- No international services before 2018.

Source: Annual financial report of Spring Airlines (2014-2019) and relevant airlines' media releases.

As can be seen from Table 6, Chinese LCCs launched services to many tourism destinations. This is not surprising as Spring's parent company is Shanghai Spring International Travel Service (Group) Co., Ltd., and the purpose of establishing Spring was to sell packaged tourism products including air tickets. Most of the Spring's flights were chartered by Shanghai Spring International Travel Service before 2014, and also by other travel agents after 2015. Lucky has advertised its commitment of bringing passengers to 'exotic foreign capitals and islands'. Lucky's flights were chartered by travel agents before 2016. In 2016, the company opened the Kunming-Bangkok route, and began to handle the ticket sales by itself. Other LCCs had little presence in the international markets.

The low presence of Chinese LCCs on the international routes compared with Ryanair and Easyjet (over shorter distances in Europe) is largely due to China's protectionism policy towards the state-owned FSAs (Zhang and Zhang, 2017). In 2009, the CAAC introduced the 'one route one Chinese carrier policy' on the long-haul international routes (greater than 4500km) to the US and Europe to avoid cut-throat completion among Chinese carriers.[2] In 2018, the policy was revised, aiming to establish a sound, open, fair and just management system for international traffic rights resource allocation and use. It is hoped that this will open new opportunities for Chinese LCCs to access the long-haul international markets in the coming decade.

4.7 A summary

The above analysis shows that Chinese LCCs have experienced steady growth and successfully expanded their domestic networks. Spring Airlines has the most extensive network with hubs in Shanghai, Shijiazhuang, Shenyang, and Shenzhen. The development of Jiuyuan Airlines is at the preliminary stage, and its routes are relatively sparse. The routes of China United Airline mainly spread out from Beijing. In North and Northwest China, China United Airlines dominates the LCC market. It seems that West Air and Lucky Air are the only two LCCs that are deliberately developing a hub-and-spoke system, using their home base as a transfer hub. West Airlines takes Chongqing as its main transfer hub, linking cities in Central and West China. It has now expanded its network to the cities in Xinjiang and Tibet that have few direct flight links with Central and East China. Finally, Lucky Airlines mainly dominates the LCC markets in Southwest China, and contributes the connectivity of the tourist cities in Yunnan Province to the rest of the country via the capital city, Kunming. Apparently the historical background of each LCC has influenced the selection of their home base and that in developing new bases, local government subsidies, the geographic location and the presence of other airlines are significant considerations.

[2] These regulations have limited the growth and expansion of Chinese LCCs in the international markets. Even in the Northeast Asia market where there is a large Chinese tourist traffic, the number of passengers carried by Korean LCCs is five times higher than by Chinese LCCs (Ma et al., 2020).

It appears that these LCCs seldom share overlapping routes and hubs. They tend to target different markets as can be seen in the differences in airports they serve in Figure 7. The differences in distributions of the airports show the effect of the LCCs' strategy to consider the competition from peers, but also the network and impact of FSAs. As Chinese government has encouraged and guided mergers between state-owned carriers (Zhang, 2015), defending the market share is a challenge for private carriers. Therefore, it is not surprising to see that each LCC has sought their own niche market with different focuses. The way that LCCs manage these network structures will be a significant factor in determining whether LCCs could survive and succeed in China's air transport market.

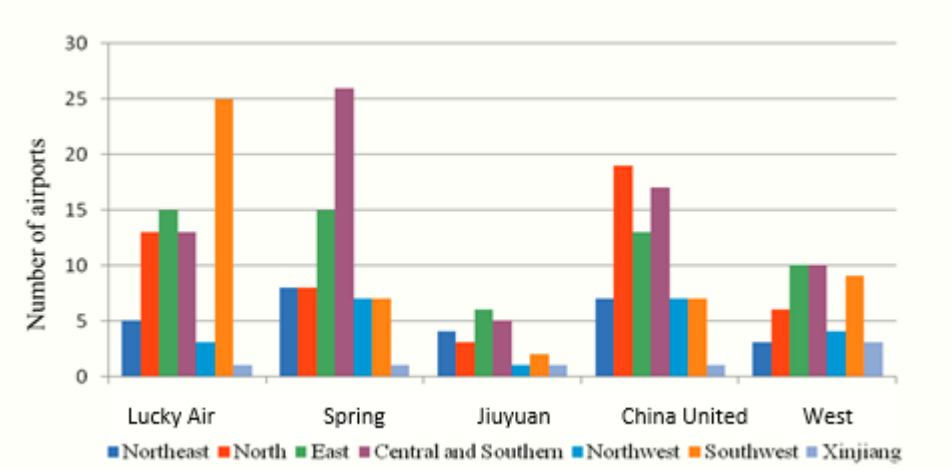


Figure 7. Number of airports served by each LCC in different regions in 2017

There were 203 new routes launched and 73 suspended in the period 2014-2017. Except Spring, all the LCCs have a parent airline. Therefore, these LCCs tend to choose a different home base and develop their networks with little overlapping with their parents. Figure 8 shows that air services to the tourism cities in Northwest and Southwest China have been strengthened as a result of the entry of LCCs, especially in Tibet, Xinjiang, Gansu and Yunnan Province. This phenomenon suggests that LCCs have looked to the underdeveloped area in West China, which has long been ignored by FSAs.

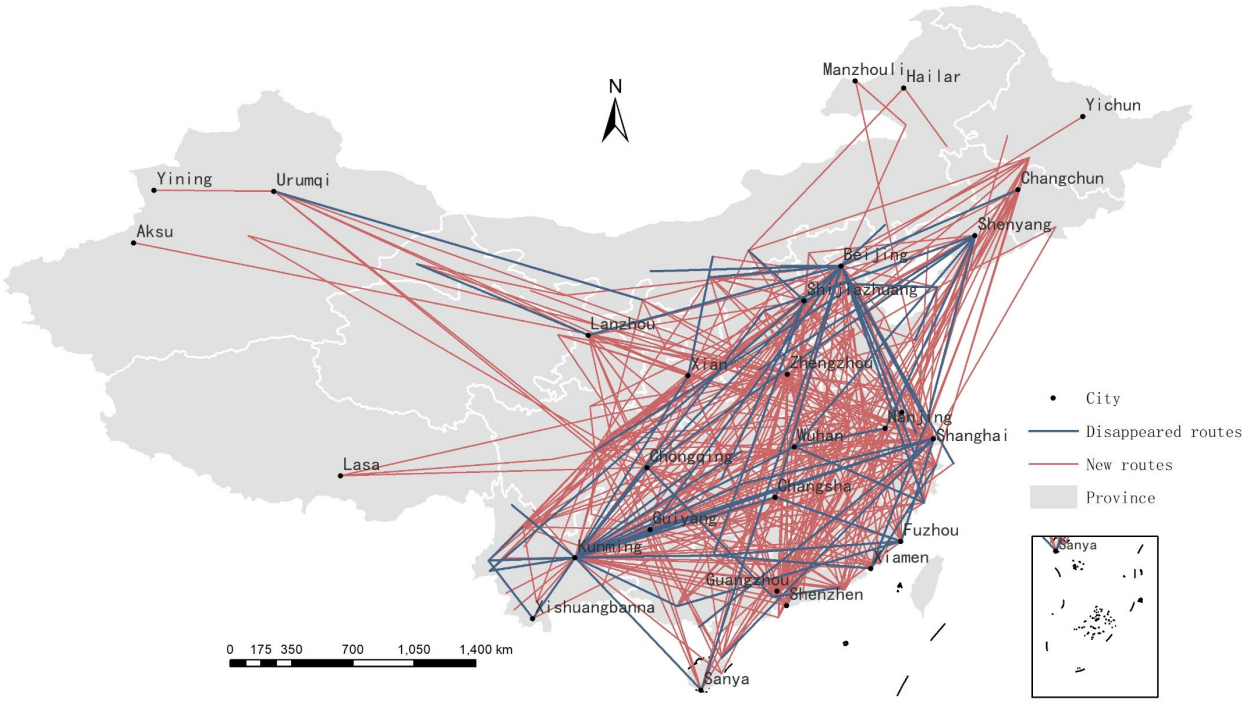


Figure 8. Changes of domestic LCC routes: 2013 vs 2017

5. Driving forces shaping behind the LCC network development in China

Aviation deregulation, local government subsidization, and the growth of leisure demand are believed to be the key factors driving the LCC network expansion. Aviation policy plays a significant role in influencing the development pattern of Chinese LCCs. Although regarded as a successful airline, Spring Airlines also faced the restrictions on the entry into some lucrative routes and ideal time slots (Zhang and Zhang, 2017). It had to wait for six years before allowed to fly the Shanghai-Beijing route in 2011 (Zhang and Lu, 2013). A few months later, Spring had to give up this important route as the low fare would not help attract many passengers due to the undesirable

departure and arrival times.[3] In 2015, The CAAC announced that it would reform flight time slot allocation at Guangzhou Baiyun Airport and Shanghai Pudong Airport with an aim to promote transparency, efficiency and equity as the previous allocation system favoured the state-owned airlines, which led to rampant corruption and bribery (Zhang and Zhang, 2017). The new allocation methods seemed to be fairer to the LCCs and private airlines. However, in the first round of slot auction at Baiyun Airport, all the good slots were claimed by the state-owned airlines and their subsidiaries, simply because they were too costly to the private carriers. An unfavourable operating environment would limit the growth of LCCs and force them to focus on the markets that are of less interest to state-owned carriers.

Subsidies from local governments constitute a significant part of LCCs' revenue and profits. Before Spring became a publicly listed company in 2015, its financial report revealed that government subsidies accounted for 55%, 53%, 60% and 75% of its profits in 2011, 2012, 2013 and the first half of 2014, respectively. The choice of Shijiazhuang as its second hub was not by chance. The generous subsidies from Shijiazhuang Government and Shijiazhuang Airport have incentivized Spring to deploy much of its capacity to Shijiazhuang and its market share has quickly exceeded other airlines including those that have had a base in Shijiazhuang. The contribution of Spring to the local economy was obvious: in 2010, Shijiazhuang Airport only handled about 2.7 million passengers and this number was 10 million in 2018. Spring alone contributed one third of the total passenger throughput. This is also the case for other LCCs that tend to develop their networks towards cities that provide generous subsidies.

Most LCCs have cancelled services in the markets with parallel HSR, suggesting that HSR is a close substitute of the LCC products, and has an impact on LCCs' route development. In the last decade, HSR has emerged as a significant transport mode in China. In 2017 the length of China's HSR track

[3] Spring Airlines re-entered the Shanghai-Beijing market a few years later.

amounted to 20,000 km, representing the largest HSR network in the world. According to the updated 'Medium-to-Long-Term Railway Network Plan' report covering the period 2016–25 with an outlook to 2030, China's HSR network will by 2025 reach a total of 38,000 km, including eight north–south and eight east–west trunk lines (Fu et al., 2015; Ma et al., 2020). By 2030 China's HSR network will reach 45,000 km in length, and most cities with a population of 500,000 or more will be connected by HSR. Chen (2017) finds that there was a significant drop in air traffic, flight frequency and seat capacity after the introduction of parallel HSR services and that the sizes of the effects differed across different HSR routes. Yang et al. (2018) find that the entry of a new HSR service led to a 27% reduction in air traffic. Zhang and Zhang (2016) confirm the negative effect of HSR on air passenger flows in China. The challenge from HSR will be greater after the rapidly expanding HSR network has connected most of the major cities, particularly after flexible HSR fares are offered. This will force Chinese airlines to consider redeploying part of their capacity to other markets, including international ones. This puts Chinese LCCs in a more difficult situation than their FSA counterparts. The emergence of HSR has given China's state-owned carriers and the aviation authorities the excuse to further restrict new entry to the profitable routes. Therefore, 'going west' and serving smaller cities are a natural choice for most of the new LCCs. In Southwest China, West Air and Lucky Air have enjoyed a relatively less competitive environment and expanded their routes largely because this region has not be well integrated into the nation's HSR system at the time of this research.

6. Conclusion

This study explores the development patterns of Chinese LCCs by analyzing their destinations, and network structures from a geographical perspective. As Chinese LCCs are still far from mature, research into their network development patterns is of great significance for the growth of the LCC market and China's tourism sector. The results show that a nationwide LCC network has been

constructed with each individual LCC focusing on their own markets to avoid overlapping and cut-throat competition. Spring Airlines has developed an advanced network supported by its core bases including Shanghai in East China, Shijiazhuang in North China, Shenyang in Northeast China and Shenzhen in South China. China United has developed a network radiating from Beijing. West Air and Lucky Air seem to be developing a hub-and-spoke network that contributes to the tourism industry in West China. The LCC networks are affected by seasonal variations, especially for the routes to tourism destinations such as Haikou, Sanya and Xiamen. Hub cities, however, receive less seasonal impacts. This research also finds that routes between 600-1800 km account for a large proportion of the LCC markets. During the period of 2014-2017, long-haul routes have significantly increased owing to the development of tourism market in West China. Aviation policy, local government's subsidization and the expansion of the HSR network are the driving forces behind the development of China's LCC network.

China's tourism destinations are no longer confined in the east and south. There has been increasing tourism demand for the northwest, southwest and northeast regions. LCCs can improve the accessibility to these tourism destinations. However, it should be noted that the network analysis of this study is based on standard geographic methods. Future studies should consider incorporating demand-side factors into the LCC network analysis to give a more comprehensive assessment of the development of LCCs in China and their impact on China's tourism.

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