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Abstract

The US and Europe have long experienced the expansion of low-cost carriers (LCCs) in the aftermath of extensive aviation liberalisation offering free access to the market for US and European airlines, respectively. More recently, following the opening of the progressive aviation market, China has also emerged as a country that welcomed LCCs to some extent, but has not subscribed to full liberalisation. In this context, our paper compares China's largest LCC, Spring Airlines, to the largest European (Ryanair and EasyJet) and US (Southwest and JetBlue) low-cost airlines. Comparisons in this context include volumes supplied, spatial coverage, network geography and financial results. This comparative study found that Spring Airlines is still a small/emerging LCC compared to the European and US giants and in terms of China's potential market. This is notably due to the lack of whole free access to the market and trunk routes that are still protected to some extent in favour of the Big Three in China. However, Spring uses its production means in an efficient way and generates good financial results, especially compared to those of China's Big Three airlines. Finally, Spring appears to be a composite case rather than a duplicate of a reference LCC.

Keywords:

Low-cost carrier, airline networks, aviation liberalisation, China

1. Introduction

China has experienced major policy, economic and demographic changes over the past decades. These changes have resulted in the growth of the population, infrastructure, industry and urbanisation; major internal migrations; transition to a market economy; and reintegration into the world economy. Along with new spatial patterns, these changes have induced a dramatic growth in long-distance travel demand within, from and to China (Gu et al., 2015). For instance, the number of annual domestic air passengers has increased from a paltry 3.4 million in 1980 to nearly 551.6 million in 2017[1].

However, in contrast with other large, developed economies (including the US and the European Union (EU)), China's air market has remained more protected. Authorities have engaged reforms towards a kind of state-managed domestic free market whose core goal is to strengthen the so-called Big Three (namely, Air China, China Southern and China Eastern) so they can later achieve critical size on the international scene (Wang et al., 2016; Zhang et al., 2014). As a result, setting new airlines and entering existing or new routes has remained subject to approval by the Civil Aviation Authority of China (CAAC). Even though CAAC policy has turned to the free market to some extent, setting up new airlines is still much easier in the US and the EU, where airlines are also free to operate nearly any route.

[1] Source: China traffic statistics yearbook, 2018

As a result, the impacts of aviation regulatory regimes in China have been quite different than those in fully liberalised air markets. In both the US and the EU, extensive aviation liberalisation has induced two opposite trends (see Goetz and Volwes, 2009; Dobruszkes, 2013 and 2014; Burghouwt and de Wit, 2015). On the one hand, incumbent traditional airlines (also referred to as 'flag airlines') engaged in hub-and-spoke networks in order to concentrate production means on a restricted number of routes to achieve economies of density, to lower costs and, in certain cases, to build "fortress hubs" that tend to restrict competition and to increase fares (Lijesen et al., 2001). Bankruptcies (e.g., Pan American, Sabena and Swissair) and mergers have also contributed to market consolidation. On the other hand, low-fare/low-cost carriers have been set up as a major consequence of free access to the market. LCCs have dramatically challenged traditional airlines by entering many trunk routes (head-on competition) and starting a myriad of new, thinner routes that incumbent airlines had previously abandoned or had never even served. LCCs have captured significant market shares worldwide, although with significant differences across regions. Bowen (2016) estimates that LCCs account for 23.4% of the world's capacity offered in 2013, with large gaps across regions. In this context, the US and Europe are certainly the two more mature markets, considering that LCC operations started in the 1970s and in the 1990s, respectively. The largest US (Southwest) and European (Ryanair) LCCs have become the largest US and European airlines, respectively, although they have not become global, being mostly restricted to intra-continental flights. The former is the world's fifth top airline according to various traffic metrics.

Being more regulated, China's air market has not followed the same pathway. Competition has recently increased, along with the increase in the Big Three's market share, which dominates trunk routes and core airports (Wang et al., 2016). However, a few airlines owned by private investors and local authorities have been allowed. This has included some LCCs that could thus expand, but in a more controlled environment than most other LCCs worldwide.

In this context, this paper's goal is to investigate the development of China's earliest founded and largest LCC Spring Airlines and to compare it to the largest European and US equivalents. Three dimensions are considered: technical (aircraft used and volumes supplied), geographical (spatial coverage and network geography) and financial (economic results compared to technical means and to traffic). More precisely, our goal is to assess which pathway Spring Airlines has followed considering the specific and special context of China.

The remaining parts are as follows. The next section briefly summarises the context in which LCCs have been operating in China, and their output. Section 3 introduces China's largest LCC, Spring airlines. Section 4 introduces the data and methods used. Section 5 supplies the comparative results. The paper then concludes.

2. Aviation regulation and low-cost carriers in China: a brief state of the art

In China, some existing literature has been used to illustrate how deregulation of the sector evolved (Zhang and Round, 2008; Shaw et al., 2009; Zhang et al., 2014; Wang et al., 2016). Although China's air deregulation started as early as 1978, this process was quite limited in the early stages. The way towards air deregulation in China could be divided into four stages (Wang et al., 2016): pre-reform tight regulation (before 1978), transitional stage (1979-1987), state-led consolidation and privatization (1988-2004), and new entrants, market-driven consolidation and deregulated competition (2005-2012). Before 2004, air deregulation was only partial because the government

wanted to protect its growing domestic market and cultivate the Big Three to compete internationally. Therefore, private and foreign airlines were strictly regulated from entering into the market. In 2005, in line with the central government's "non-public economy 36" policy, the CAAC started to open the commercial airlines sector to private, collective and foreign capitals. Consequently, between 2005 and 2007, 14 airlines were given approval to operate domestic passenger flights (Wu et al., 2016). After 2007, the CAAC slowed down its rate of approval of applications for new airlines in response to the rapid growth of airlines and a particular concern over aviation safety. In 2010, China launched safety checks, and then market-driven consolidation continued due to some private airlines facing bankruptcy, and the market expansion of the Big Three. Although private airlines were founded one after another, they lack the freedom of route choice of their US and European cousins. For example, the CAAC still has to approve airlines' entry into busy air routes such as Beijing-Shanghai or Beijing-Guangzhou. Therefore, the Chinese approach to deregulation differs from that of the Western markets (the US and European Union[2]), where airlines are allowed to serve any route, provided capacity is available at airports. As a result, most private airlines in China try to seek approval to operate in regional or peripheral air markets. Besides, the prices of air tickets were strictly regulated before 2004 and the government currently controls ticket prices. Between 2004 and 2013, air ticket prices could vary between 55% and 125% of standard air ticket prices. In 2013, the CAAC started to open up the price limits for some air routes, and by the end of 2017, airlines were free to set their own prices on almost one third (1,030 of 3,615) of domestic air routes, including that between Beijing and Shanghai.

The literature on LCCs in China is scarce (at least in international journals). One reasonable explanation is the still limited expansion of low-cost carriers. However, Jiang et al. (2017) point out that other LCCs have existed at some point, but have either disappeared or moved away from the low-cost business model, notably because of restricted access to profitable routes serving China's largest cities (Zhang and Lu, 2013). Spring Airlines was the single active LCC in China for a while (Zhang and Lu, 2013; Jiang et al., 2017), before merging with some other airlines. These include West Airlines (founded by Hainan Airlines in 2006 and turned into an LCC in 2013), China United Airlines (owned by Eastern Airlines and turned into an LCC in 2014; first state-owned LCC), 9 Air (founded by JuneYao Airlines and operated in 2015) and Chengdu Airlines, which claimed to turn its business model into an LCC in 2015. All the other LCCs transported relatively smaller numbers of passengers compared to Spring, which remains the earliest established and largest LCC in China.

Scholars agree that the development of low-cost air services in China has increased the degree of competition among airlines to some extent and has induced some to decrease charged airfares (Fu et al., 2015). Zhang and Lu (2013) studied the impact of Spring Airlines on traffic volumes (at the city-pair level) within a sample of 35 routes serving Shanghai over the 2004-2010 period. Having controlled for distance and for cities' GDP and fuel prices, they found that the presence of Spring on a given route induced a 23% increase in air passengers.

Among Chinese LCCs, only Spring Airlines' network has been investigated. Jiang et al. (2017) found that the network has evolved from a single, star-shaped network (centred on Shanghai Hongqiao Airport) to a more complex one with some extra nodes. However, the initial plan to get five nodes

[2] Plus some third countries, including Iceland, Norway and Switzerland.

has been counteracted partially by disagreement expressed by China's fourth-largest airline, Hainan Airlines. The network is expanding, but this does not prevent some degree of volatility at both airport and route levels. This is notably due to the fast development of HSR in eastern and central China, where it has a stronger negative impact on LCC fares than on network airlines (Wang et al., 2017). Jiang et al. (2017) also found that Spring mostly serves cities with high tourist potential due to the fact that Spring started out as a travel agency (namely Shanghai Spring International Travel service, Ltd), often together with second- or third-ranked airports[3]. Routes are typically short- and medium-haul, and attempts to operate long-haul routes have been cancelled. Fu et al. (2015) have specifically investigated route entry choices made by Spring and concluded Spring favours opening dense routes linking its Shanghai base and second-tier cities. It does not escape competition from other airlines and HSR, even though the airline has launched some niche routes (that is, routes with non-competing airlines). Fu et al. (2015) and Zhang and Lu (2013) also recall that Spring is constrained by CAAC's protective attitude, which prevents it from penetrating some lucrative routes and from scheduling flights at optimal time slots. For instance, the airline had to wait until 2011 to be allowed to launch the Shanghai-Beijing route, and it had to exit the route in 2014 because of the low load factor and money loss on this route[4]. However, the exact magnitude of these restrictions and related impacts cannot be comprehensively assessed.

Unfortunately, published research works cover Spring's network only up to 2013, which is already far away in time considering its rapid development. In addition, Spring's network pattern has been studied *per se*. In contrast, this paper intends to compare it with leading European and US LCCs to detect whether the airline follows a well-known pathway or a specific one.

3. Introducing Spring Airlines, China's largest low-cost carrier

Although China lags behind other liberalized aviation markets in LCC development, its largest LCC Spring Airlines, has achieved rapid growth in traffic volume and revenue since its inauguration in 2005. Shanghai Spring International Travel Services (Spring Travel) was established in 1981, and its business operations have expanded to include not only travel services but also hotel reservations, airline ticket reservations, conventions, exhibitions, business travel, immigration, sports game planning and more. Spring Travel is the highest grossing travel agency in China, with more than 30 branch offices in cities across the country as well as six in the US, Thailand, South Korea and Hong Kong. Every year since 1994, Spring Travel has won the China National Tourism Administration Award as the number one domestic travel agency in China and was the first domestic travel agency in China to have its own airline.

Spring Airlines was founded by Spring Travel in 2004, with its operational base in Shanghai (Hongqiao Airport). It operated its first flight from Hongqiao to Yantai on July 18, 2005. Spring Airlines begun as a private airline. In the early stages of its establishment, it was a chartered carrier for tourists, and transported cargo with three rented A320 planes. In 2006, Spring Airlines carried 1.1 million air passengers and 8,137 tons of cargo, accounting for 0.71% and 0.23% of China's air market, respectively (CAAC, 2007). At the end of 2017, Spring Airlines owned 76 planes operating on 159 air

[3] Their analysis is restricted to Mainland China, excluding Hong Kong, Macau and Taiwan. Other routes (such as toward Japan, South Korea and Thailand are thus not included, despite their importance in terms of tourist flows from China).

[4] The route was later cancelled.

routes and connecting 94 cities in China and abroad[5]. Compared to the other airlines in China, Spring is the third most internationalised supply – 35% of its seats-km (ASKs) went abroad in 2017 (mainly to Japan, Thailand and South Korea). In comparison, the average for Chinese airlines then was 30%, with internationalisation ranging from none to 42% (China Eastern Airlines) and even 49% (Air China).[6] However, considering passengers, Spring has the higher degree of internationalisation, with 21.6% in 2017 against 12-13% for the Big Three airlines (CAAC, 2018).

Similar to other LCCs, Spring Airlines only uses a standardized fleet comprising the Airbus 320 and offers deep discount fares that are substantially lower than those offered by traditional (full service/network) airlines. Spring Airlines also has the highest passenger load factor in China with 91.7% in 2016 and 90.6% in 2017. Since its establishment, Spring Airlines has expanded rapidly, as evidenced by Table 1. However, its passenger market share remains under 3% and just 1% of cargo in a context where China's Big Three accounted for 68.0% of air passengers and 73.7% of air cargoes in 2016, with the entry of other LCCs such as China West Air, 9 Air (Jiu Yuan Airlines) in 2013 and China United Airlines in 2014[7] (Table 2). To meet strong demand for aircraft, Spring Airlines listed on the Shanghai Stock Exchange in January 2015.

Table 1. Trends in Spring Airlines traffic, 2006-2017

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2017 /2006
Air passengers (1,000)	1,137	2,353	2,944	4,313	5,860	7,151	9,111	10,551	11,447	12,988	14,228	17,169	15.1
Revenue passenger-km (10,000)	135,168	308,869	375,294	587,943	810,864	1,026,072	1,398,430	1,649,410	1,826,999	2,217,554	2,475,905	3,024,805	22.4
Freight (tons)	8,137	1,3641	18,073	21,945	34,931	38,653.1	46,800.8	49,231.8	47,010.3	45,779.4	44,389.4	50,343.4	6.2
Revenue freight ton-km (10,000)	947.5	1,578.7	2,130.1	2,822.2	4,853.2	5,614.44	7,168.3	7,518.31	7,395.8	7324.6	7102.5	8,273.8	8.7

Table 2. Spring Airlines as a share of China's domestic market, 2006-2017

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Air passengers	0.71%	1.27%	1.53%	1.87%	2.19%	2.44%	2.85%	2.98%	2.92%	2.98%	2.92%	3.11%
RPK	0.57%	1.11%	1.30%	1.74%	2.01%	2.26%	2.78%	2.92%	2.88%	3.05%	2.96%	3.18%
Freight	0.23%	0.34%	0.44%	0.49%	0.62%	0.69%	0.86%	0.88%	0.79%	0.73%	0.66%	0.71%
RFTK	0.10%	0.14%	0.18%	0.22%	0.27%	0.32%	0.44%	0.44%	0.39%	0.35%	0.32%	0.34%

4. Comparing Spring Airlines with the European and US models: Methods and data

In this paper, we investigate the case of Spring Airlines, the largest LCC in China, and compare it with the two largest LCCs in Europe (Ryanair and EasyJet) and the US (Southwest Airlines and JetBlue Airways). Selecting four reference LCCs also guarantees that the diversity of LCC network models

[5] Data is sourced from the annual report of Spring 2017.

[6] Authors' computations based on OAG.

[7] In 2013, the CAAC speeded up its approval for the foundation of new airlines from scratch under China's policy reform in 2007 (Wang et al., 2015). In June 2013, China West Air, a subsidiary of the Hainan Airline Group based in Chongqing and Zhengzhou, announced its intention to transform into a LCC, the second one in China. In late 2013, the CAAC approved the establishment of one private LCC called 9 Air (Jiu Yuan Airlines) by the JunYao Group. In 2014, China Eastern Airlines also announced its plan to convert its subsidiary, China United Airlines, into an LCC.

(Dobruszkes, 2013; Bitzan and Peoples, 2016) is taken into account to some extent. Indeed, the dramatic development within (and spatial coverage of) their respective regions makes them relevant references for LCC developments in large, mature markets.

Using data from airlines' annual reports, civil aviation authorities, the OAG dataset and AeroTransport Data Bank, we drew a comparison of airline supplies by various metrics. Subscription to the OAG Schedules Analyser offers extensive information about scheduled air services that is disaggregated at the flight level and is spatially very extensive[8]. This has made such information widely used in aviation research and market business analysis. OAG data make it relatively easy to compute the volume of air services provided by given airlines, to build indicators characterising airline routes and networks and to prepare spatial data for mapping networks. We extracted June 2017 data, considering that June is usually an "average" month between traffic peaks such as the Chinese New Year (in January or February) or summer holidays (July and August in the northern hemisphere). In addition, the AeroTransport Data Bank gives details on airlines' fleets, including tracking changes over time.

More specifically, for each airline we gathered or computed the following series of indicators:

- Traffic (number of passengers and of passenger-km) and volumes supplied (number of flights, of seats, of seat-km, etc.).
- Spatial coverage (number of airports and of airport-routes served, median distance, etc.).
- Network characteristics, considering traditional geo-economical indicators (share of international services, monopoly routes, routes not servicing airlines' home country, distance split, etc.), complex network indices (average degree, clustering coefficient, average path length, etc.) and small-world properties.
- Technical efficiency (fleet use and load factor).
- Financial results and efficiency (operating result, operating margin and net result).

Of course, China differs from Europe[9] and the US in terms of area, demographic and economic weight and air market size (Table 3). In particular, air traffic per inhabitant remains significantly below Europe (and thus the US, where distances are longer than in Europe and passenger railways are notoriously poorly developed compared to China and Europe). However, Europe and the US are the only two large spaces with extensive and mature LCC markets. In that sense, they offer a relevant reference for comparisons involving China.

	China	Europe*	USA
Area (sq. km, millions)	9.634	4.913	9.832
Population (inhabitants, millions)	1,383	525	323
GDP (US$, billions)	11,199	17,547	18,624
GNI per capita, PPP (US$)	15,500	40,166	58,700
Air supply (departing seat-km, billions, 2016)	909	1,826	1,961
Air supply (departing seat-km per capita, 2016)	657	3,474	6,070
Aviation liberalisation (internal market)	Partial	Extensive	Extensive

* EU28, Iceland, Norway and Switzerland.

[8] The whole 2017 dataset covers 742 airlines, 3,834 airports and 142,763 flight codes.

[9] Hereafter, Europe means the 28 European Union's Member States (EU28), Iceland, Norway and Switzerland, that is, the European liberalised airspace, since the three latter countries have joined the aviation liberalisation scheme.

Table 3. Comparing China to Europe and the US (2016 values).
Sources: World Bank's World DataBank and OAG.

5. Comparing China's low-cost carriers with European and US models

5.1. Airline sizes and ranks

Table 4 shows the passengers carried out and supply provided by Spring compared to the four reference LCCs. Though Spring has clearly reached a significant position as one of the global top-100 airlines, it remains a middle-sized LCC by all metrics compared to the European and US giants. Indeed, Ryanair, EasyJet, Southwest and JetBlue are roughly 6, 4, 11 and 4 times larger than Spring, respectively. However, let us recall that Spring Airlines is growing rapidly (see the previous section). Subject to freedoms offered to the airline and considering potential market saturation in Europe and the US (Budd et al., 2014), the gap between Spring and the reference LCCs may progressively narrow. It is also worth noting that for each airline, ranks do not significantly change across indicators, except for the volume of seat-km supplied. In this regard, airlines compared loose ranks, except for Southwest. This is explained largely by the operation of rather short flights (compared to airlines not considered in this paper) and by the fact that Southwest operates higher-frequency routes (see below).

Table 4. Comparing Spring Airlines to the largest European and US LCCs (I): Volumes carried and supplied

Airline name	**Spring**		**Ryanair**		**Easyjet**		**Southwest**		**JetBlue**	
Airline code	9C		FR		U2		WN		B6	
Registration	China		Ireland		UK		USA		USA	
Start	2005		1985		1995		1967		1999	
Start as/turn into an LCC	2005		1995		1995		1971		1999	
Fleet										
Typical fleet	A320		B737-800		A319/A320		B737-700		A320,A321,E190	
Active fleet (planes, 2017 year-end)[4]	76		413		276		698		243	
Passengers (2017)*	Volume	Rank	Volume	Rank	Volume	Rank	Volume	Rank	Volume	Rank
Passengers (millions)[1]	17.2	65	130.3	4	80.2	8	157.7	1	40.0	18
Passenger-km (billions)[2]	30.2	71	160.0	7	89.7	21	207.8	5	76.0	25
Services (2017)	Volume	Rank	Volume	Rank	Volume	Rank	Volume	Rank	Volume	Rank
Flights (thousands)[3]	102.9	83	715.6	6	523.9	9	1364.1	4	362.6	15
Seats (millions)[3]	18.5	73	135.2	5	88.2	8	203.2	3	49.9	21
ASKs (billions)[3]	27.1	84	168.6	13	97.1	24	249.8	5	92.0	26
Distance flown (plane-km, millions)[3]	150.5	79	892.2	7	570.9	18	1651.6	4	623.4	16
Time flown (hours, thousands)[3]	282.2	70	1613.7	7	1078.4	14	2911.7	4	1055.3	15

Sources: (1) Airlines' annual reports, (2) Flight Airline Business, (3) OAG, (4) AeroTransport Data Bank
Ranks are considered worldwide
* Ryanair: Financial year ending on March 31, 2018. Easyjet: Sept 30, 2017

5.2. Spatial coverage and network characteristics

Figures 1 to 5 compare the Spring Airlines network to the other four reference LCCs, while Table 5 shows key indicators of both spatial coverage and network characteristics. Altogether, they deliver several key findings.

First of all, Spring's spatial coverage is lower than that of the four reference LCCs. However, the gap is

smaller in relation to the volumes supplied (Table 5), except for the number of routes served by Ryanair, which is well known for operating a myriad of low-frequency niche routes[10], even though the airline has recently focused more on the main airports of large cities (Dobruszkes et al., 2017). Actually, Spring has developed a spatial coverage that is close to the second-largest US LCC, JetBlue. In addition, it is focused mainly on eastern China, the nation's densest inhabited area and economic core. This suggests Spring may serve a large part of China's population with a rather limited number of routes. The top ten airports by available seats-km served by Spring in June 2017 are listed as: Pudong airport in Shanghai, Hongqiao airport in Shanghai, Shijiazhuang, Shenzhen, Shenyang, Yangzhou, Guangzhou, Xiamen, Ningbo, and Harbin, all of which (with the exception of Harbin) are located in East China.

[10] Since Ryanair operates B737-800s only, it cannot balance low-demand routes by using low-capacity planes. As a result, frequency is its only means of adjusting the number of seats offered.

Table 5. Comparing Spring Airlines to the largest LCCs in Europe and the US (II): Spatial coverage and network characteristics (June 2017)

Airline name	**Spring**	**Ryanair**	**Easyjet**	**Southwest**	**JetBlue**
Airline code	9C	FR	U2	WN	B6
Registration	China	Ireland	UK	USA	USA
Spatial coverage					
Airports (N)	81	199	132	103	100
Routes (airport-pairs, one direction) (E)	175	1492	809	711	245
Network characteristics (geo-economical indicators)					
Monthly flights per route	24	22	30	83	63
Monthly seats per route	4314	4133	5055	12375	8653
Median route distance (km)	1415	1438	1201	1366	1773
Median route distance, weighted by seats (km)	1324	1202	964	1070	1703
Long-haul routes (4000+ km)	0%	0%	0%	0%	6%
Seats on long-haul routes (4000+ km)	0%	0%	0%	0%	6%
Centralisation index (1-star shaped network = 1)	0.48	0.61	0.70	0.55	0.66
Monopoly routes (airport-pairs)	40%	69%	43%	52%	32%
Seats on monopoly routes (airport-pairs)	26%	60%	37%	47%	20%
Monopoly routes (city-pairs)	37%	48%	29%	27%	27%
Seats on monopoly routes (city-pairs)	24%	30%	16%	20%	16%
International routes	32%	90%	90%	8%	35%
Seats on international routes	26%	82%	82%	4%	27%
Inter-regional routes(1)	0%	4%	5%	8%	33%
Seats on inter-regional routes(1)	0%	2%	2%	4%	25%
Routes not serving the airline's home country	0%	91%	51%	0%	2%
Seats on routes not serving the airline's home country	0%	87%	43%	0%	2%
Network characteristics (graph theory)(2)					
Average degree (<k>)	4.321	14.995	12.258	13.806	4.900
Average path lenght (L)	2.558	2.226	2.064	2.031	2.162
Clustering coefficient (C)	0.218	0.404	0.465	0.795	0.698
Random network (L')	3.003	1.955	1.948	1.766	2.898
Random network (C')	0.053	0.075	0.093	0.134	0.049

(1) Based on 11-region boundaries

(2) Degree is the number of edges that a node shares with others. The average degree of a network <k>, is the average number of neighbors (i.e., directly connected nodes) a node has in the network. Average path length (L) is defined as the average number of edges along the shortest paths for all possible node-pairs in the network. The clustering coefficient (C_i) of a node is the portion of actual edges between the nodes within its neighborhood divided by the maximal possible edges between them. The clustering coefficient of the whole network C is the average of all individual C_i's (Watts and Strogatz, 1998, Barabási and Albert, 1999). L' and C' represents the average path length and clustering of a random network with the same number of nodes and links.

Sources: authors' computations after OAG

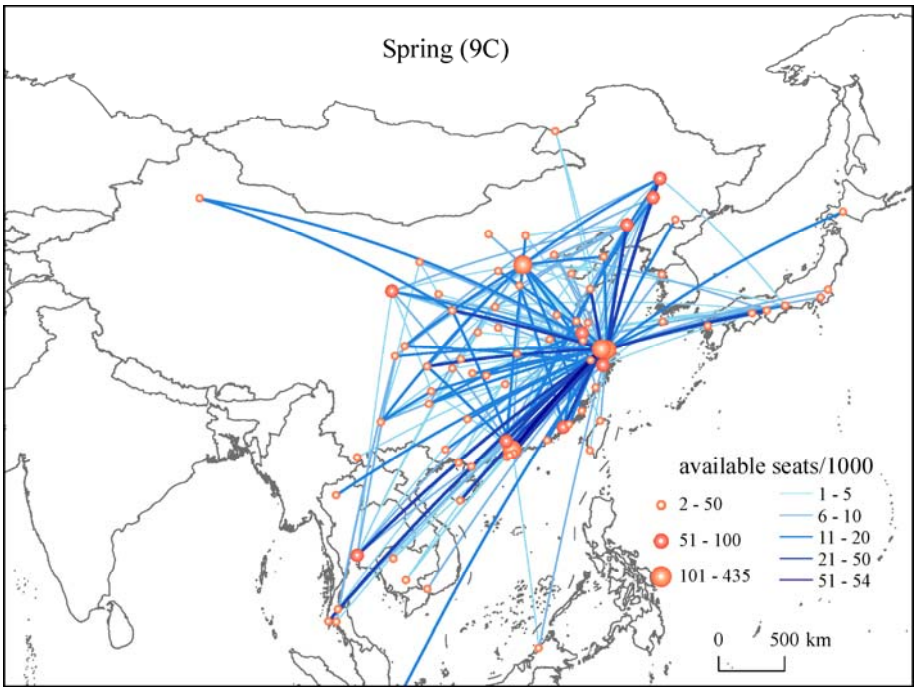


Figure 1. Spatial distribution of Spring Airlines network (June 2017)

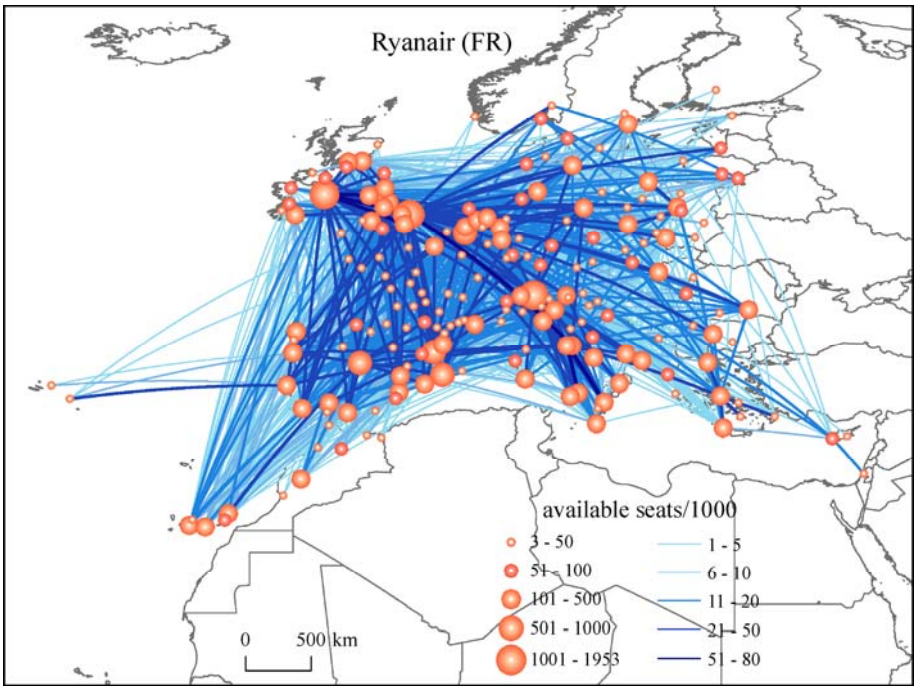


Figure 2. Spatial distribution of Ryanair network (June 2017)

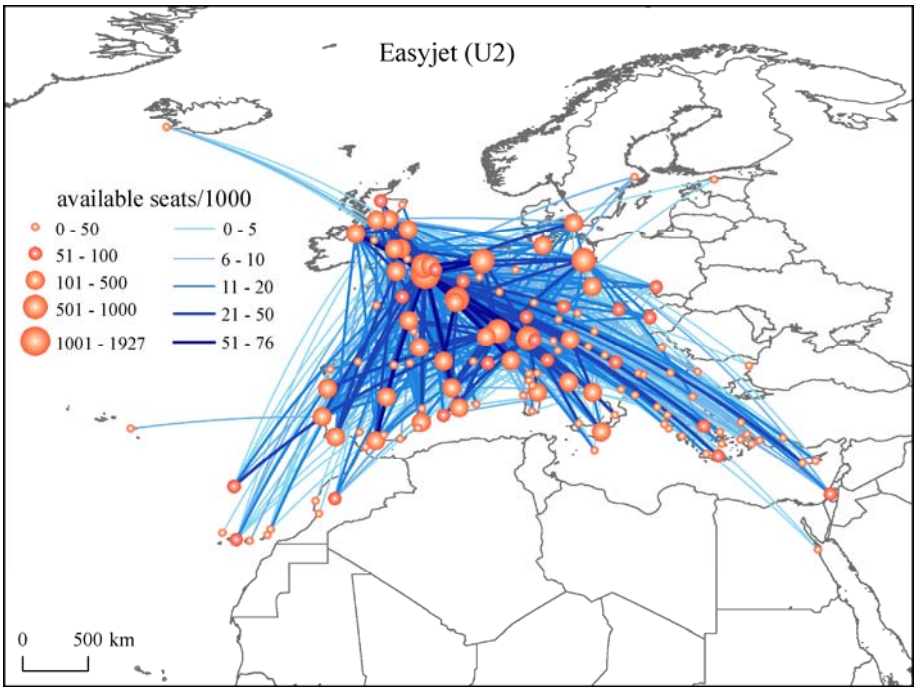


Figure 3. Spatial distribution of EasyJet network (June 2017)

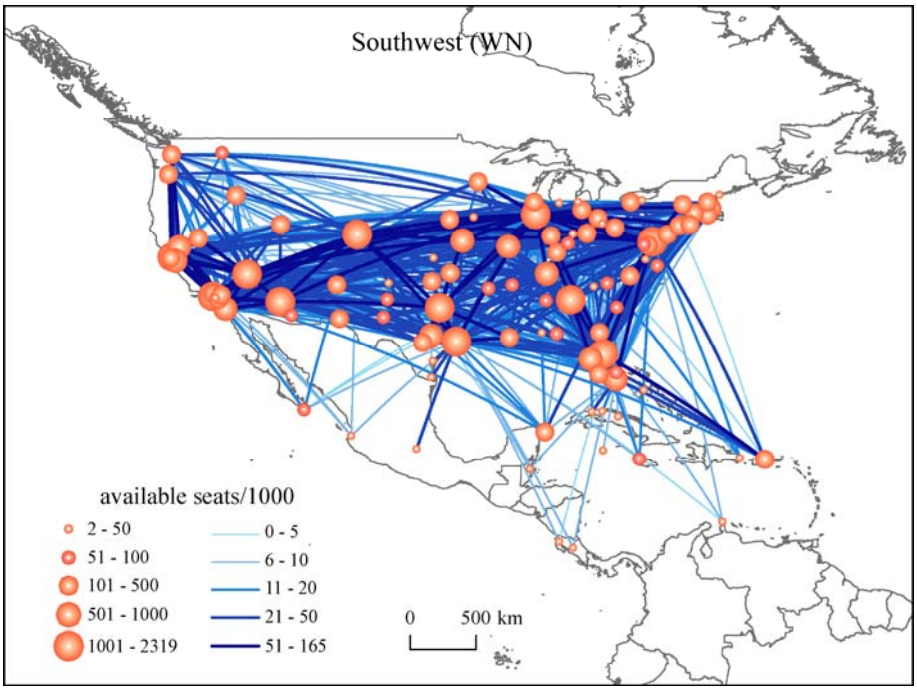


Figure 4. Spatial distribution of Southwest network (June 2017)

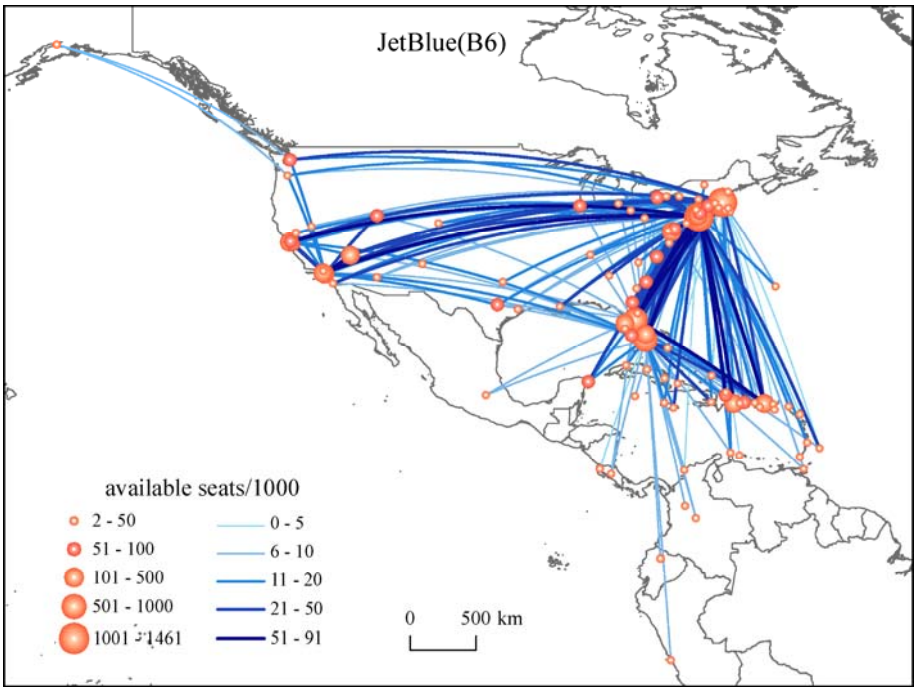


Figure 5. Spatial distribution of JetBlue network (June 2017)

Turning to network characteristics in light of geo-economic indicators, it initially seems as if Spring is like Ryanair and EasyJet in terms of traffic density at the route level, with clearly fewer average flights and seats per route than Southwest and JetBlue. Considering this is not explained by network structure (see the range of centralisation index values) or aircraft sizes, it is likely the gap between the two US LCCs and the two European LCCs is due to the almost complete absence of medium- and long-distance rail services in the USA. In contrast, both China and Europe high-speed rail (HSR) services have become significant carriers that compete with air services (Chen, 2017; Dobruszkes et al., 2014). In addition, traditional (slower) rail services still exist on many routes, and sometimes compete with air travel by employing acceptable travel times and/or lower fares. Differences in terms of seats per route also relate to the potential of traffic to some extent, and thus fill in the gap between trunk routes (where the market is large enough to accommodate several airlines and many seats per route for each of them) and thin routes, where there is no room for competition. In other words, there is some correlation between lighter traffic density and de facto monopolies.

In addition, median distances flown (both raw and weighted by the number of seats) recall how much LCCs run a mostly short- and medium-haul business. Figure 6 supplies detailed distance profiles. Beyond median distance (which puts Spring close to Ryanair), Figure 6 suggests a more complex distance pattern. Spring supplies only 21% of its capacity under 1,000 km, which is close to JetBlue (26%) but significantly less than Ryanair (39%), Southwest (47%) and EasyJet (53%). This may be the consequence of a higher use of railways in China, even for distances that are travelled rather by plane in Europe and the US. In 2016, traffic volume by HSR in China reached 1,443 million passengers, which is almost three times the number of passengers who travel by air (488 million). Then, Spring's distance profile converges with the other LCCs considered (with less than 5% of capacity above 3,000 km), except JetBlue influenced by its significant focus on transcontinental flights between the two US coasts (Figure 5). Actually, JetBlue is the only LCC considered here with a significant share of long-haul

(i.e., more than 4,000 km) services[11].

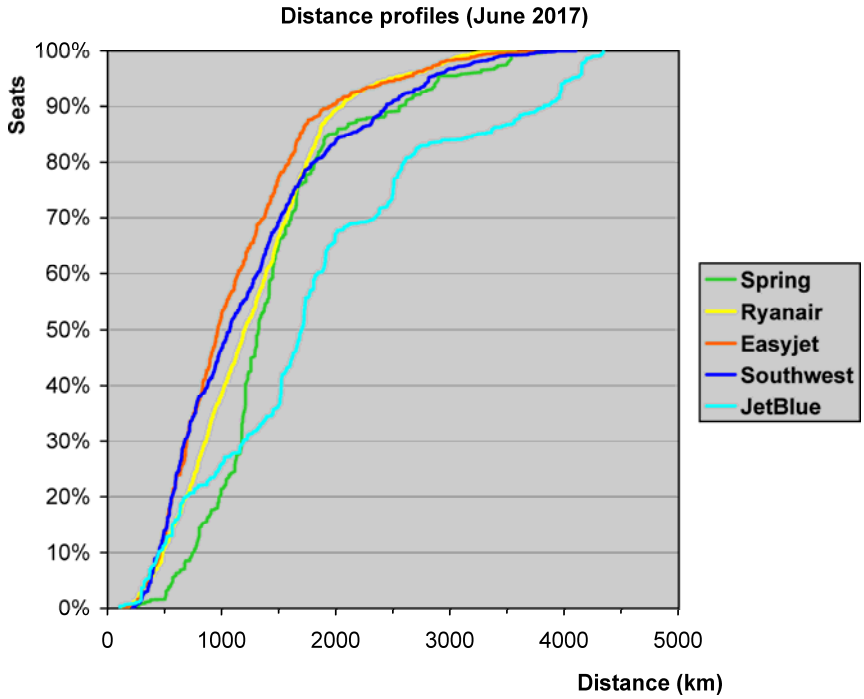


Figure 6. Distance profiles of Spring and the four reference LCCs.

Source: Computed by the authors from OAG.

Considering intra-modal competition issues, it appears that most LCCs considered operate a large share of monopoly routes, but Ryanair clearly surpasses the four other airlines. The share of monopolistic routes remains significant, even if one looks at city-pairs instead of airport-pairs (thus implicitly considering that airports belonging to the same city are substitutable[12]). The reasons for operating niche routes likely differ among airlines. In China, Spring cannot freely select the routes it serves. As mentioned earlier, the CAAC intends to encourage the growth of the three big state-owned airlines, so the newly founded airlines do not threaten their major market, and, in any case, would experience difficulty gaining approved entry into China's busy air routes and their golden time slots. This would tend to push Spring into niche markets to some extent. In contrast, European and US airlines can freely design their networks within their respective liberalised air markets. In this context, serving niche routes is a common strategy for developing one's business (exactly like a soda manufacturer can opt for radically new products or imitate incumbent products). Having said that, the LCCs considered here still operate a significant share of their network with at least one direct competitor, so they do contribute to more competition. Furthermore, one should also keep in mind that routes are substitutable to some extent (at least for the purpose of holiday travel). For instance, Spring's Shanghai-Jeju route competes with Shanghai Airlines' Shanghai-Phuket route as far as the leisure market is considered. In this perspective, the contribution of LCCs to competition is arguably higher than suggested by route-based figures.

[11] Ryanair and Southwest operate some flights beyond 4,000 km but they account for less than 1%. Spring and Easyjet operate virtually no long-haul flights.

[12] Which is debatable, at least in very large urban areas, because distance to an alternative airport can be discouraging.

A closer analysis of the route structure shows that operating a significant share of niche routes does not prevent airlines from also being present on top routes, as evidenced by Table 6, which shows the split of each airline's supply according to internal markets divided into seat quartiles. Here Spring shows mixed patterns: about one third of its seats are in the top 25% densest markets (such as EasyJet and JetBlue, and in contrast with Ryanair and Southwest, which were well known for avoiding leading airports and trunk routes until recently) but another third is in the thinnest routes (close to Ryanair's record). This suggests the CAAC is actually not totally against a certain degree of penetration of top markets by Spring.

	Spring	Ryanair	Easyjet	Southwest	JetBlue
Q1 - Densest routes	34.5%	13.7%	32.4%	20.7%	36.5%
Q2	9.2%	18.3%	24.2%	29.8%	13.1%
Q3	19.5%	27.4%	23.3%	31.4%	29.9%
Q4 - Thinnest routes	36.8%	40.6%	20.1%	18.2%	20.5%

Table 6. Split of airline seats by reference markets' route density.

The reference market for Spring is China; for Ryanair and EasyJet it is the EU, Iceland, Norway and Switzerland; and for Southwest and JetBlue it is the US. Routes going out of these spaces have been excluded.

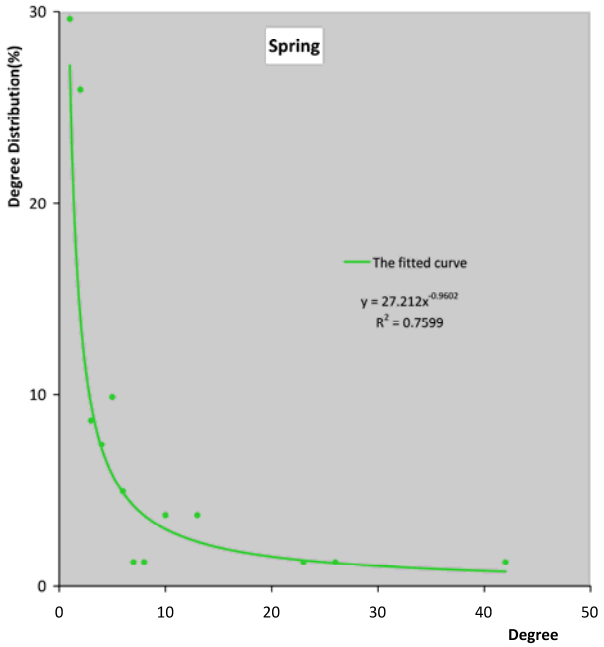
The next sub-group of indicators in Table 5 relates to the international dimension of airline networks. Here Spring's network matches JetBlue's, with roughly one out of four seats on international routes. While Spring was first restricted to domestic routes, it then progressively launched routes to several destinations across East and South-east Asia, including Japan, Thailand and South Korea. These countries have become the most popular international tourism destinations for Chinese people in recent years. Again, the airline is potentially constrained by both the bilateral agreements linking China and its neighbouring countries, and the CAAC's policy favouring the Big Three. In contrast, the two European LCCs operate at nearly full capacity on international routes. However, most of the so-called "international routes" operated by Ryanair and EasyJet remain within the European liberalised space. They could actually be considered domestic routes in terms of regulatory regime. Symptomatically, the share of inter-regional seats (based on 11-region boundaries[13]) falls to less than 5% for Ryanair, EasyJet and Southwest, against 25% for JetBlue, given its significant focus on Latin America. In contrast, Spring operates virtually no inter-regional services. The numerous factors that prevent the penetration of interregional air services include more protected markets, less demand on long-haul routes and difficulties in dramatically cutting costs compared to incumbent airlines that are already efficient on long-distance routes (Francis et al., 2007). However, the advent of single-aisle aircraft with extended ranges (such as the B737 Max and Airbus A321neoLR) may change these patterns, all other things being equal (Gudmundsson, 2015).

The following measures in Table 5 highlight whether airlines operate flights that do not serve their home country (that is, flights operated under the so-called 7th or 9th air freedoms). Unsurprisingly, only European LCCs can consider taking advantage of such an uncommon privilege in the context of multinational, extended aviation liberalisation. In contrast, virtually all Spring's services touch China at least at one end, which makes it close to the US LCCs.

[13] The 11 regions are East and South-East Asia, India and surroundings, Oceania–Pacific, Middle East, CIS, Europe, Maghreb, Sub-Saharan Africa, North America, Central America and the Caribbean, and South America.

The last part of Table 5 contains indices related to the concept of complex networks, abstracting all the five LCCs as connected networks with a set of nodes (*N* airports) and edges (*E* routes). To measure the network structure, a connectivity matrix has been created such that an element equals one when a flight link exists between airport-pair, and zero otherwise. Several indices, such as degree, average path length, and clustering coefficient have been employed to further analyze the configuration of the five LCCs' network. Overall, the average degree measures the average number of direct links between two airports, the average path length reveals the depth of the air transport system, and the clustering coefficient reflects the intensity of interconnectivity of the system (Wang et al., 2011). Table 5 shows that Ryanair has the largest average degree, followed by Southwest and Easyjet. Meanwhile, Southwest has the shortest average path length and the largest clustering coefficient. Undoubtedly, if compared by these indicators, Spring has the longest average path length and the lowest clustering coefficient. Although Spring has a comparative average degree and a random network similar to that of JetBlue, its clustering coefficient is much lower than JetBlue's, which reflects that Spring's network shape is not quite compact and intense.

Finally, Figure 7 demonstrates that all five LCCs are represented by small-world networks, since they have a relatively small or similar average path length but a much higher clustering coefficient compared to a random network with similar scale. Besides, all the degree distributions are best captured by a power function so that they are also scale-free networks. In a scale-free air transport network, most airports are not connected by direct flights, but most of them can be reached by a small number of transfers.



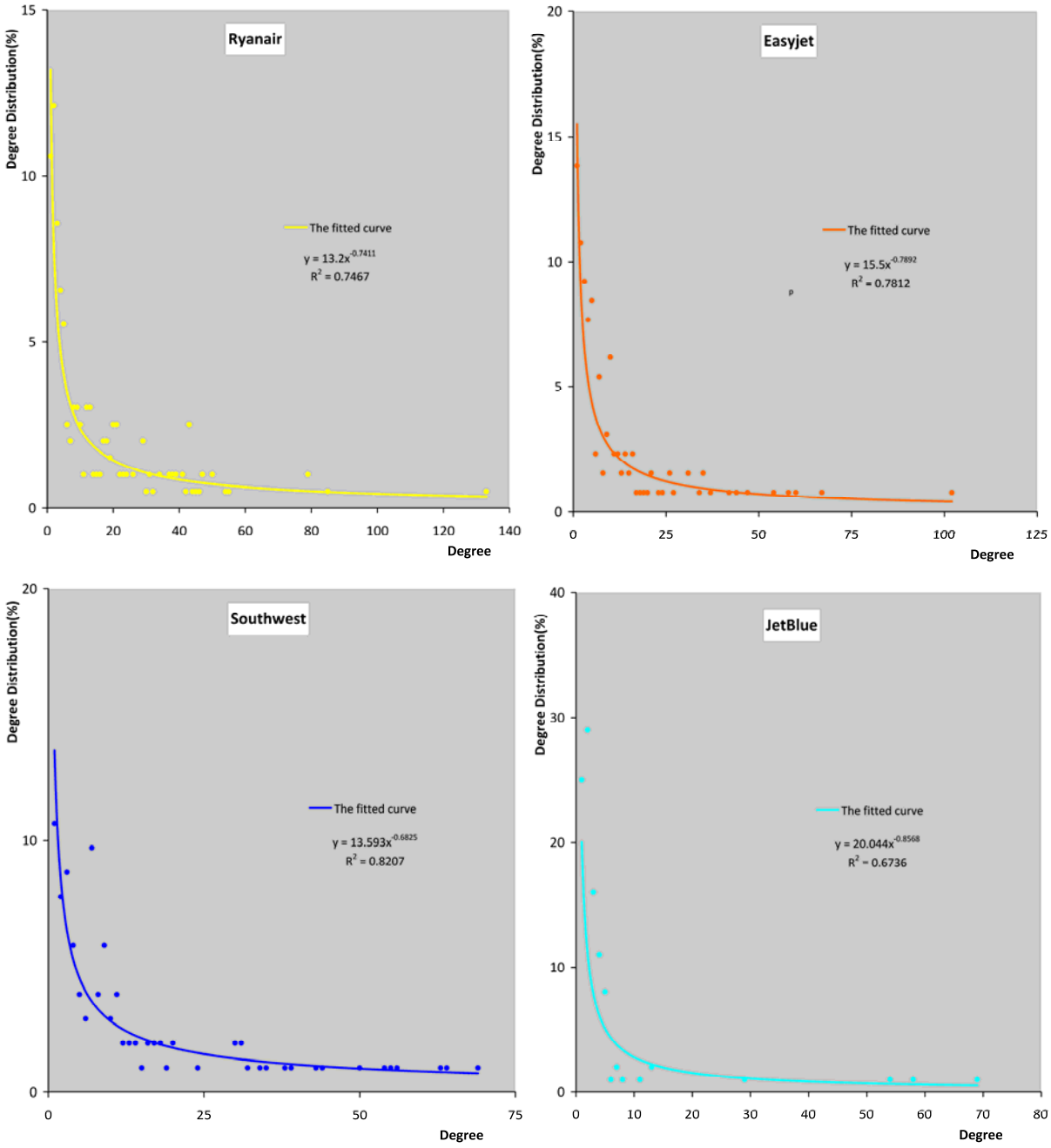


Figure 7. Degree distribution of the five airlines' networks

5.4. Technical and financial performance

Finally, Table 7 introduces some measures of both technical and economic performance for the LCCs considered here. Technical efficiency is acknowledged as a key factor for lowering operating costs, given the high fixed cost of the fleet. Table 7 shows that like other LCCs in our sample, Spring intensively uses its aircraft, with an average daily time flown of 11.1 hours. In addition, its load factor is high (90.6%), in between European and US LCCs.

Table 7 also reports financial results in terms of operation results and of net results. Because these figures are affected by airline size, they are also expressed in terms of operating margin and by both fleet size and traffic volumes. The operating margin shows that Spring is in the sample's average, close to the two largest US LCCs, so much better than EasyJet but not as high as Ryanair. Financial results by plane, seat-km or

passengers suggest that Spring works better than EasyJet only. The results are not easy to interpret because they may be affected by several factors, including each airline's distance profile. But maybe more importantly, it appears that in 2017, Spring had a higher operating result (14.5%) than China's Big Three Airlines, namely China Southern (7.2%), Air China (9.5%) and China Eastern (8.6%)[14].

Table 7. Comparing Spring Airlines to the largest European and US LCCs (II) – Technical and financial efficiency.

Airline name	**Spring**	**Ryanair**	**Easyjet**	**Southwest**	**JetBlue**
Airline code	9C	FR	U2	WN	B6
Registration	China	Ireland	UK	USA	USA
Technical efficiency (2017)					
Time flown per plane per day (hours)(1)	11.1	9.1	10.9	N.A.	11.7
Passenger load factor(1)	90.6%	95.0%	92.6%	83.9%	84.3%
Financial efficiency (2016)					
Operating result ($m)(2)	240	1 964	514	3 515	1 000
Operating margin(2)	14.5%	23.3%	8.0%	16.6%	14.3%
Operating result per seat-km (cents)	0.719	1.154	0.537	1.420	1.109
Operating result per plane ($m)	3.38	4.83	1.92	4.92	4.28
Operating result per passenger ($)	14.0	18.5	6.4	22.3	25.0
Net result ($m)(2)	190	1 708	388	3 488	1 147
Net result per seat-km (cents)	0.569	1.004	0.405	1.409	1.273
Net result per plane ($m)	2.68	4.20	1.45	4.88	4.91
Net result per passenger ($)	11.1	16.0	4.8	22.1	28.6

Sources: (1) Airlines' annual reports, (2) Flight Airline Business

6. Discussion and conclusions

This paper compares China's Spring Airlines with Ryanair, EasyJet, Southwest and JetBlue to detect whether it shows similarities to one of the leading LCC models. The key findings are as follows: In terms of volumes (supply offered, passengers carried, fleet and network size), Spring is still a smaller LCC compared to these four other airlines, although it is growing rapidly. In terms of network characteristics, Spring does not match with any of the reference LCCs for all the attributes investigated at the same time. 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 only common attribute shared by Spring with the four other LCCs is the fact that its network is considered a small-world, scale-free network. This suggests that Spring does not constitute a new network model in itself, but rather a composite of existing models. This also, incidentally, recalls that it would be futile to introduce LCC networks as a single model.

Having said that, the extent to which Spring's current network is shaped by China's spatial patterns and/or by the still partially protected air market remains open. In other words, the respective influence of the geography and of the regulatory context could not be investigated. To do so, one should be at the core of Spring's management to be aware of its ambitions for the network in a hypothetical fully liberalized environment, and to learn about any routes to which the airline has

[14] Source: Flight Airline Business.

been denied entry. Unfortunately, this is not feasible because of confidentiality issues. As discussed earlier, it is very likely Spring is restricted by actual regulations that still protect China's air market to some extent. In particular, the 2006 CAAC's "Provisions on the license for operating air routes in domestic air market" stipulates that entering the busiest route or routes from/to the busiest airports still requires the approval of civil aviation authorities. As a result, among China's top ten busiest air routes (Beijing-Shanghai, Taipei-Hongkong, Beijing-Chengdu, Shanghai-Shenzhen, Beijing-Guangzhou, Beijing-Shenzhen, Shanghai-Guangzhou, Shanghai-Chengdu, Guangzhou-Chengdu, and Kunming-Xishuangbanna), Spring airlines still operates flights only in two air routes, Shanghai-Guangzhou and Shanghai -Chengdu. Beyond the rights of entering the market, it is also more difficult to get a golden or daytime slot in the busiest air routes, even though Spring Airlines has been granted permission to provide flights; this is because the capacity of top airports has almost been filled. If Spring Airlines only flies so-called red-eye flights on the busiest air routes, the load factor will be another problem, even at a relatively lower price.

Of course, the story is not over and the dramatic expansion of both China's aviation market and Spring Airlines itself calls for further investigation of ongoing trends and the future context of China's aviation development.

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