



# Evolution trends of the network structure of Spring Airlines in China: A temporal and spatial analysis



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## ABSTRACT

Both the sustainable development of China's economy and the deregulation of the China air transport market have acted as a spur for the halting development of low-cost carriers (LCCs) in China. To analyze the development trends of LCCs' network in China, this paper took Spring Airlines, the only LCC in China as an example. First, the winter flight plans of Spring Airlines from 2005 to 2013 were collected. Secondly, the development trends of air transport network of Spring Airlines were explored with methods of mathematical statistics and social network analysis. Additionally, the development trends were analyzed from the levels of navigable cities, air routes and air transport networks. The results show that although Spring Airlines actively launched air routes between tourist cities with non-class I airports, its network has been transformed from a star structure into a complex one with multi-hubs. The development process of the Spring Airlines network can be separated into three stages. In addition, the problems and evolution trends of its network are discussed further.

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## 1. Introduction

During the past three decades, air transport together with the four other major transport modes has developed rapidly with China's great economic growth. The airports and airlines at the time could not meet the increasing demand for air transport in China. Thus, a market-oriented reform in the air transport industry was conducted by the Chinese government to deregulate the market. However, factors such as the protection of noncompetitive airlines, open-skies blocks, limited capacity of domestic airports (Zhang and Chen, 2003) and concentration of domestic airlines (Zhang and Round, 2008, 2009) have acted as obstacles for the deregulation in China. In addition, incomplete deregulation of China's air transport market has led to new trend in the Chinese civil aviation market. One of these trends is the market access of civil aviation having been eased, many new investors including private ones and

foreign ones have been attracted to the deregulated market of Chinese air transport since 2004. In 2005, the first low cost carriers (LCCs) of China, Spring Airlines, was established in Shanghai City. Since then, because of their distinct advantage of price, more people have begun to consider air transport for long distance journeys. At the same time, the price equilibrium of China's aviation market has been broken by the cheap air tickets of Spring Airlines, which have already gained considerable market shares on some airlines. To respond to the market changes, the Chinese full-service carriers (FSCs) have to cut their prices and offer other discounted services.

There has been fierce competition between LCCs and full-service carriers (FSCs) since the liberalization in the United States in 1978 (Dresner et al., 1996; Windle and Dresner, 1999). In addition, LCCs created a low-cost business model, in which some services offered by FSCs have been canceled to cut down operation costs and maximize profits (Gillen and Morrison, 2003). However, according to some empirical studies (Fu et al., 2011; Yu et al., 2013, 2015, 2016), the key determinant LCCs' success is product differentiation. LCCs, particularly Southwest Airlines, have obtained the lion's share of the air transport markets of North America, Europe

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and Australia with an average annual growth rate of 30%. However, in China the development of LCCs is not that fast. At present there is only one LCCs, Spring Airlines, in China. Other LCCs, such as Okay Airways and Junyao Airlines, have either shut down or changed their operation modes. Compared with the 33% market share in Europe and North America, the Spring Airlines accounts for only 3% of China's air transport market by the end of 2013. Considering the huge potential of air transport, a series of measures aimed at promoting and deregulating the air transport industry was issued by the government, according to the <State Council Issues Opinions on Promoting Civil Aviation Development > published in 2012. Thus, it is believed that LCCs are facing tremendous development opportunities in China. However, the development of LCCs in China suffered many a setback over the past decade, while only Spring Airlines survived. What are the characteristics of the strategic position, operational mode and expansion mode of airline network behind the success of Spring Airlines? Systematical analysis of the development of Spring Airlines can shed lights on the sustainable development of LCCs in China.

It should be noticed that the network structure of LCCs is one of the key factors that would determine whether LCCs could survive and even win more market shares in China air transport market. The air transport network (ATN) of concentrated FSCs in China has been established and operated for decades, and is generally considered to be stable and effective. Thus, the construction of the ATN of LCCs should be based on the ATNs of FSCs. To be more specific, the navigable cities and airlines of the ATN of LCCs should be selected from the existing navigable cities and airlines on the ATN of FSCs. This paper explores the evolution characteristics of the ATNs of Spring Airlines from the elements of ATN: navigable city, air route and air transport network based on the data of annual flight schedules of Spring Airlines, and tries to offer insight into the successful experiences of the survival and expansion of Spring Airlines while the deregulation of the air transport market is still incomplete and the state-owned FSCs dominate the air transport market.

## 2. Literature review

### 2.1. Structural patterns of air transport networks

The numbers of airports and flights have increased rapidly since the 20th century with the development of the air transport industry, and many complicated ATNs of different scales have been formed. Thus, some research studies have tried to analyze the structural patterns of ATNs to evaluate their service level. Due to the popularity and wide application of the Complex Network Approach (CNA), analysis of the characteristics of ATNs under different spatial-temporal dimensions has drawn much attention since 2004. Research on the structures of ATNs could be generally divided into four groups according to geographical characteristics, as shown in Fig. 1.

- (1) World-Wide Air Transport Networks (Guimer'a & Amaral, 2004; Guimerà et al., 2005; Hsu and Shih, 2008; Dang et al., 2009);
- (2) Air Transport Networks of Europe and North America (Xu and Harriss, 2008; Barrat et al., 2005; Palcari et al., 2010; Jia et al., 2014),
- (3) China Air Transport Networks (Li and Cai, 2004; Liu and Zhou, 2007; Peng and Zhou, 2009; Liu et al., 2009; Wang et al., 2009; Zhang and Round, 2009; Zeng et al., 2011; Wang et al., 2011; Lin, 2012; Wang and Mo, 2014);
- (4) Other regions (Bagler, 2008) and airlines (Jiao and Wang, 2014).

Additionally, their research results can be summarized as follows. First, all types of ATNs are small-world networks, and gradually show the characteristics of scale-free and disassortative mixing over time. Second, there is a spatial hierarchical structure, which is rare in other ATNs, in the air transport network of China (ATNC). Furthermore, it is particularly easy to identify the structure among the backbone airports. Finally, constrained by the data availability, there are few studies that have focused on the evolutions of ATNs.

Although some researchers endeavored to introduce environmental factors such as urban economics and traffic into ATNs, CNA can only be employed to analyze the topological properties. With CNA, the evolution rules and social-economic attributes of real-world ATNs cannot be further explored.

### 2.2. Socio-economic properties of ATNs

Some other study has concentrated on the socio-economic properties of ATNs within different geographical scopes with statistics, social network analysis and so on. Wang et al. (2003) analyzed the geographic patterns of ANTC from 1980 to 1998 by the Spatial Economics, transport economics and GIS technology. They found that the ANTC was in the stage of development; the rule of distance decay in air traffic was significant; the generation and growth of air traffic lacked regional inequality. Matsumoto (2007) employed a gravity model to analyze the distributions of passengers and freight in the ANTW as well as the passenger densities of the main cities. The results show that many cities, particularly Seoul, Hong Kong and Amsterdam, has the fastest growth rates of passenger density, acting as international air transport hubs. A time-dependent minimum path approach was proposed by Malighettia et al. (2008) to analyze the connectivity of ATNE (Air transport network in Europe), and the result shows that roughly two thirds of the fastest indirect connections are not operated by the airlines alliance system. Pan et al. (2009) divided the airports of China into 5 types based on Factor Analysis, and then, the evolution properties of ATNC were analyzed from the viewpoint of airports and air routes by statistical analysis. The results showed that a hub-and-spoke structure has already formed within ATNC. Bowen Jr. (2012) assessed the evolutions of FedEx's and UPS's ATNs based on graph theory measures. The results showed both of the two firms operate their networks with a high concentration of activity at their principal hubs. With the Core-Peripheral Model, Cui and Pan (2014) found that there is a typical core-periphery model in ATNC with three central nodes: Beijing, Shanghai and Guangzhou. In addition, the radius of the positive influence of these central nodes is in the range of 500–550 km.

Furthermore, there are some other studies related to ATN. Both Wu and Pan (2010) and Wu et al. (2012) compared the structure of ATNs and inbound tourism flow networks. Lordan et al. (2014a, 2014b, 2015) concentrated on the robustness of ATN. Xu et al. (2014) and Santos and Antunes (2015) employed planning models to optimize the structures of ATNs.

### 2.3. Development characteristics of LCCs

As a novel business model, the fast increase of LCCs' market share and the rapid expansion of their networks have drawn the attention of some researchers. Dobruszkes (2006, 2013) observed the fast development of LCCs in Europe, and analyzed the structure of European LCCs by statistical analysis and social network analysis. He found that LCCs prefer to provide air service in large cities, tourist destinations and cities with secondary airports, and LCCs also prefer to launch new air routes to supplement the services of FSCs. Furthermore, the competition on pre-existing routes between

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