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# Spatial distribution characteristic of Chinese airports: A spatial cost function approach

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ABSTRACT

This paper uses spatial econometric models to analyze the spatial distribution of Chinese airports from 2002 to 2012, taking into consideration the factors that explain the distribution of airports around the country. A cost function allowing for latitude and longitude is estimated based on spatial location, which leads us to advise the implementation of policies that take into account the spatial distribution of the airports. Results show that the development of airports in China needs to consider the spatial relationship among the many different regions of China. To improve the cost efficiency, airports should be located in more economically developed areas. Meanwhile, it also helps to reduce the cost when listing on the stock market.



## 1. Introduction

Airports located in specific locations serve China's transportation network as feeders of a hub-and-spoke system and as origins or destinations of point-to-point services (Button, 2002). The airport network service contributes to China's economic growth and regional development (Wells and Young, 2004). Research conducted on China's airports has generally focused on efficiency and productivity, while neglecting the role of space in the study of airport activity (Fung, 2008; Fung et al., 2008a, 2008b; Fan et al., 2014). Therefore, the locations of airports and its spatial effects are needed to be included into consideration to study airport benchmarking and policy review (Lian and Rønnevik, 2010; Fröhlich and Niemeier, 2011; Fan et al., 2014; Pavlyuk, 2016). The present research aims at filling this gap and analyze Chinese airports using spatial models; a cost function is estimated for the period from 2002 to 2012 that takes into account the spatial effects measured by latitude and longitude of the airports analyzed.

The motivations behind the present research are the following. First, China is an extensive country, and airports are a core asset for connecting the country and regions; therefore, an understanding of the spatial distribution of airports around the country is important. As the connectivity of China's airports is complementary rather than competitive in nature, establishing a balance of competition and cooperation (Derudder et al., 2010), it is important to understand the spatial correlations that may exist on airports (Miller, 1999). Second, China's airports have recently undergone several reforms since Deng Xiaoping's policy changes. In this context, an analysis of the cost of China's airports, as well as of their observed spatial characteristics, is justified, as it may help clarify the role that transportation networks play in cost, and thus allow for analysis that proposes optimal cost controls. Third, built on the deregulation of China's air transportation, the hub airports also faced increasing competition for hub passengers because of the adoption of hub-and-spoke models for organizing route structures (Button, 2002). This factor justifies the focus on cost efficiency and the adoption of spatial analysis to identify spatial correlations. Finally, while research has noted the significant effects of location on an airport's performance or productivity, no study has used spatial models in its methodology. Rather, the existing literature mainly focuses on the technical efficiency or productivity of Chinese civil airports with traditional SFA (Stochastic Frontier Analysis), which ignore independence between observations. This paper is innovative and make use of the spatial models found in the SFA to examine the cost efficiency of Chinese airports.

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The present research analyzes the cost functions of Chinese airports during the period from 2002 to 2012 using five alternative spatial models, which (to reiterate) no study on Chinese airports had done before. It also provides certain policy implications for improving cost efficiency that should be considered before a new round of construction of civil airports begins (Hyard, 2013). This research is of particular interest at this time (Chang et al., 2013; Fan et al., 2014; Jiang and Zhang, 2014; Wang et al., 2015).

The remainder of paper is organized as follows: Section 2 describes the background of Chinese civil airports; Section 3 surveys the literature on the topic; Section 4 presents the methodology framework and the data; Section 5 presents the results, and finally Section 6 presents the discussion and conclusion.

## 2. Background of Chinese civil airports

With the rapid development of China's economy in the last three decades, more people and cargo than ever now moves from one place to another (see Fig. 1), causing China's civil airports to become increasingly important in the national infrastructure. The number of civil airports has been doubled, increasing from 83 in 1987 to 180 in 2012 (See Fig. 1). However, the overall progress of civil airports in China may create some problems. According to the government reports, the majority of Chinese airports still lost money, the demand for airport services still outweighs supply, and many civil airports are overloaded at present (Wang et al., 2014)[1]. Therefore, more research is needed in order to study how to enhance the management and the planning of airports investment in China. Therefore, according to "the National Civil Airports Scheme" that was approved by the State Council of China, there will be 244 civil airports established in total by the year 2020.

Reform of Chinese airports is kept in pace with development and transition of Chinese Economy. The regulator of civil aviation, the Civil Aviation Administration of China (CAAC), was founded in 1949 and was simultaneously in charge of airline companies, airports and traffic control, which are the three main businesses in the civil aviation industry. Between 1980 and 1986, the industry still operated under a planned economy, and the CAAC was the single institute that ran all of the business. Beginning in early 1987, the government divided business within the airline companies from business within the airports, in order to decrease the monopoly power of the CAAC. None of the civil airports was managed by the provincial government[2] until 2002, when the State Council ordered the CAAC to transfer administrative authority of airports over to the relevant provincial governments,[3] accompanied by their assets, liability and personnel. The main reason for this was that the CAAC, with its limited funds, could not afford the tremendous investments required to improve the airports. The principal airport hubs in China are Beijing Capital International Airport, Baiyun International Airport and Shanghai Pudong International Airport, each of which has started IPO (Initial Public Offering) proceedings and been listed on the stock market since 1998. This should help to attract private funds to increase investment in airports and also improve corporate governance.

Fig. 2 shows the location of all airports in China.

## 3. Literature survey

The present paper contributes to airport research by analyzing the cost function of airports with a spatial regression model. Some research has analyzed airports' regional characteristics (Barros and Sampaio, 2004; Barros, 2008a, 2008b; Barros and Dieke, 2007, 2008; Derudder et al., 2010; Papatheodorou and Arvanitis, 2009), but it has not analyzed the cost functions according to spatial distribution. Derudder et al. (2010) present a detailed empirical description of airport connectivity in four multiple airport cities (London, New York, Los Angeles, and San Francisco), taking into account the transnational routes that are flown; this study allows for a thorough assessment of the chief connectivity characteristics of specific airports. Using information derived from a number of sources, the study points to functional divisions among airports, both in terms of their geographical scale (e.g., national, regional and international airports) and their specific role in the airline network (e.g., origin/destination versus hub airports). Papatheodorou and Arvanitis (2009) explore the evolution of airport passenger traffic in Greece during the period from 1978 to 2006 and find that despite air transport liberalization, spatial concentration of traffic and asymmetry remains high and has not decreased significantly over time. Moreover, Greece is still short of traffic generated by low-cost carriers especially outside the main metropolitan airports, restricting the regional development. Martin and Voltes-Dorta (2008) analyze airline hubs in relation to spatial concentration indexes and conclude that the spatial concentration does not explain by itself the main features of the network hubs; in other words, this study distinguishes between connection and concentration. More related to the present research, Novak et al. (2008) apply a spatial linear regression to predict outbound freight generation in the United States. Fu and Kim (2016) also complete similar work. Meanwhile, Pavlyuk (2016) pays attentions to the implication of spatial heterogeneity in European airports. In a word, from the existing research on airport efficiency or performance, the spatial factors are widely recognized in the airport industry and should be not ignored in studies.

Until recent years, more research began to focus on the civil airports of China and their performance or productivity (Fung et al., 2008a, 2008b; Chi-Lok and Zhang, 2009; Chang et al., 2013; Fan et al., 2014; Jiang and Zhang, 2014; Wanke et al., 2015; Wang et al., 2015). Several studies have noticed the importance of locational or spatial effects on the performance or efficiency of airports (Chi-Lok and Zhang, 2009; Chang et al., 2013). They just introduced dummy variables or polytomous variables as spatial proxy, which can be considered as observed spatial heterogeneity (Pavlyuk, 2016). However, Barros (2008b) and Pavlyuk (2016) argue that the unobserved spatial heterogeneity is also essential for affecting airport performance. As we know, even the careful selection of these observed factors will still leave unobserved spatial heterogeneity out of a model. The spatial econometrics explicitly deals with spatial dependence and is able to fully take account of unobserved spatial heterogeneity (Pavlyuk, 2016). However, it is rarely applied to analyze the airports performance or efficiency.

Moreover, while much research has concentrated on the management of airport efficiency, no literature has analyzed the cost efficiency of Chinese airports with SFA (Stochastic Frontier Analysis) model. Fan et al. (2014) employs a directional distance function to evaluate the technical efficiency of twenty major Chinese airports during the period from 2006 to 2009 within a joint production framework of desirable and undesirable outputs (i.e., flight delays). Fung (2008), Chow and Fung (2009), Chi-Lok and Zhang (2009) and Zhang et al. (2012) also use the traditional DEA (Data Envelopment Analysis) method to estimate the technical efficiency of Chinese airports in different periods. They compare the difference in efficiency relative to the different characteristics of Chinese airports. However, comparing to the cost efficiency, the technical just takes account of the productivity ignoring the information of

[1] http://www.chinanews.com/cj/2015/05-17/7281640.shtml.

[2] It also can be a municipal government that is equal to a provincial government in China.

[3] It was also called the airport localization program (Chi-Lok and Zhang, 2009).