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Relevance of airport accessibility and airport competition

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ABSTRACT

Airport accessibility is an important criterion for airport competition. The relevance of airport accessibility and airport competition was studied in this paper based on the panel data collected from nine large airports in Jiangsu province, China from 2005 to 2014. The results showed that the cost of expense, time and fatigue for the arrival at the airport are proposed to quantify levels of fastness, economy and amenity for the passengers to arrive at airport. The airport accessibility is significantly affected by airport passenger traffic and airline frequency. The passenger traffic can be increased by 2% with 1% increase of airport accessibility based on the analysis results of the nine large airports in Jiangsu province.

1. Introduction

In recent years, there seems to be a growing tendency of airport constructions and reconstructions in China. It is estimated that by the end of the 13th five-year plan, there will be 244 airports including 23 newly constructed airports, and 37 reconstructed airports. Within these 244 airports, there will be 30 large-scale airports with 10 million passenger traffic annually. Accessibility is an important indicator which reflects the degree of difficulty that travelers have in accessing to the destination. The higher level of airport accessibility indicates that the airport landside transportation facilities are more perfect and passengers can access to the airport more conveniently. Studies have shown that airport accessibility is one of the important factors that affect whether travelers choose air travel or not. In the same area, airports of high level of accessibility are more competitive. Therefore, accurately measuring the level of the airport accessibility and quantifying relationship between the level of accessibility and airport competitiveness can help the planning department reasonably position airport nature, scientifically plan the airport development scale and can also effectively promote the management department to improve the level of airport external transport service so as to enhance the overall competitiveness of the airport.

Airport accessibility has been studied for quite a long time over the world. The evaluation methodology based on disaggregate theory has been found in various types of applications in recent years. However, there still lacks in depth researches on airport accessibility. It is usually caused by choice of too many competitive models of airports. Series of studies on selective competition of airports in San Francisco was conducted by Skinner, Harvey and Pels E (e.g., Skinner, 1976; Harvey, 1987; Pels et al., 2001). It showed that the cost of time and expense of arrival at airports affected passengers' choices. Some other studies measured airports' accessibility in perspective of spacial scale (e.g., Pels et al., 2003; Hess and Polak, 2005; Zhang and Xie, 2005). For instance, Humphreys studied airport accessibility and regional layout in Britain (e.g., Humphreys and Franccis, 2002). Feighan compared airport accessibility with different spacial scales in Europe (e.g., Fengjun et al., 2010). Few scholars have studied airport accessibility in perspective of transportation cost (e.g., Kim and Kwan, 2003; Bielli et al., 2006). For example, Ying Xiwen and Xu Tao studied the accessibility of hub airport and civil airport respectively (e.g., Xiwen and Jing, 2006; Xu et al., 2008). Although some results had been gained from studies listed above, some deficiencies were still present: (1). Studies on airport accessibility in Europe and North America were mostly focused on the traffic model using automobile, and measurement of time or distance, rather than on integration of different means and tourists' needs of being comfortable. (2). There were quite a number of researches focusing on how to improve the level of airport accessibility, but very few studies have been focused on the relevance between accessibility and competitiveness of airport, especially the airport development scale. Thus,

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it leads to the lack of persuasive data for later studies to refer to.

Proceeding from perspective of convenience, economy and comfort level for passengers, and series of data were obtained by investigating the transportation infrastructure and passenger travel behaviors of the nine large airports in Jiangsu province. In this paper, an airport accessibility model based on cost is proposed to intuitively reflect every airport's level of accessibility by generating a figure which shows the relationship between airport accessibility and range of services. It provides scientific support for airport managers to objectively grasp and evaluate the level of airport external transport services. A panel data model is also applied to study the relation among passenger scale, accessibility, scope of air routes, and economic level. It also analyzes the effect of different indexes on airports of different scales and scientifically quantifies the relationship between the level of airport transportation service and airport competitiveness, thus helping managers have a deep understanding of the importance of airport external transportation system construction and prompting managers to speed up improving the convenience for passengers to access to the airport, so as to enhance the overall competitiveness of the airport.

2. Accessibility model

2.1. Airport accessibility

Airport accessibility refers to the degree of convenience for passengers to arrive at the airport, which can be indicated by the usage of various transportation tools. Given that there exists differences among the airports in technical performance and operational features. The economy of arrival at the airport was measured based on fastness and customer service's amenity (e.g., Matisziw and Grubesic, 2010). In order to define and quantify the accessibility, the cost form was adopted in this paper, as shown in Table 1.

The total cost of airport accessibility can be written as a linear combination including all compositions of accessibilities as the formula listed below:

$$S = F + T + C \tag{1}$$

wherein:

S is the total cost of the passenger's trip to the airport, F and T are the expense cost and the time cost of the passenger on the trip to the airport and C is the fatigue cost of the passenger on the trip to the airport.

2.2. Cost calculation

(1) Cost of expense

Cost of expense refers to the money spent by a passenger on the trip to the airport by a certain transportation tool, which is directly shown in the form of currency.

(2) Cost of time

Cost of time refers to the time spent by a passenger on the trip to the airport, which can be transformed in the form of currency. The cost of time is related with time value of passengers (i.e. labor value of unit time). The higher income the passenger has, the higher time value will be. In this paper, the time value of passengers is indicated as wages unit per hour.

(3) Cost of fatigue

Cost of fatigue refers to the cost yielded by fatigue during the trip to the airport, mainly measured by level of shaking and noise, temperature, and traffic condition. Since the calculation of fatigue cost is too abstract and complicated, it is easier to be indicated in a grading form. In this paper, the indexes of vibration, noise, temperature and congestion are divided into five grades, where the value ranges from 1 to 5. The number 1 means lowest level of discomfort and highest level of amenity, and 5 is the opposite. The cost of time was obtained by multiplying each index by conversion factors. For instance, it takes a passenger 1 h to reach to the airport. During the trip, the indexes of vibration, noise, temperature and congestion are all very high (grade 5). Thus he needs 1 h to refresh. We take 1/20 as the conversion factor. The result of conversion can be understood as the time a passenger need to recover from fatigue after going through a specific environment within unit time.

Cost of airport accessibility through traffic mode m can be expressed as Formula (2):

$$S_m^n = \alpha^n t_m + f_m + \alpha^n t_m \beta^n \sum_{i=1}^{4} c_i^m \tag{2}$$

wherein:

S_m^n is the total cost generated when the passenger n selects the travel mode m to reach to the airport. α^n is the time cost of the passenger n, t_m and f_m are the time and cost generated when the passenger selects the travel mode m to reach to the airport. β^n is the conversion factor of the passenger n's amenity, which needs to be calibrated. c_1^m ,c_2^m ,c_3^m ,c_4^m represent the level of vibration, noise, temperature and congestion accordingly. The recovery time of unit travel time can be obtained after the rank sum multiplies β^n. Then, the corresponding cost is obtained by multiplying the time by the time cost.

2.3. Partaking according to different group of people

The cost of arrival is different if people come to the airport from different areas. Thus, It needs to be classified according to the time cost (a). *logit* model. For people (n) in a certain district, the probability of choosing the travel mode m can be shown as Formula (3):

$$P_m^n = \frac{\theta^n \cdot V_m(\alpha^n)}{\sum_i \theta^n \cdot V_{mi}(\alpha^n)} \tag{3}$$

wherein:

P_m^n is the probability that people (n) select the travel mode m to access to the airport, V_m is the utility function of travel mode m, *which in* here is the reciprocal of travel cost S_m^n and θ^n is the Sensitivity coefficient, needs to be calibrated.

Table 1
Part of the airport accessibility.

Composition of accessibility	Corresponding cost composition	Instruction
Economy	Cost of money (F)	The travel expenses during a passenger on the trip to the airport
Fastness	Cost of time (T)	The time during a passenger on the trip to the airport
Amenity	Cost of fatigue (C)	The degree of comfort and good feelings during a passenger on the trip to the airport

In the Formula (3), the utility function adopts the reciprocal of travel cost. Thus the sensitivity coefficient θ needs to be calibrated. Based on the survey of the airport passenger travel, the travel rate data from various types of people can be obtained, which then allows the crowd n to be individually calibrated. Knowing k equation, there still need to calibrate an unknown. Typically, the k is greater than 1 and can be calibrated with least square method, which is the marked coefficient satisfied with the solution of k equations to get the minimum of error sums of squares.

2.4. Calculation of comprehensive assessment

With the cost of different groups of people choosing different transportation modes, the average cost of arrival can be obtained by weighing average of means and groups:

$$S = \sum_n a^n \sum_m p_m^n S_m^n \tag{4}$$

wherein:

S is the average access cost for all passengers in one area, a^n is the percentage of people (n) in the regional general population.

To compare the accessibility of airports in different types, the cost of accessibility needs to be normalized and divided by GDP per day in one district to eliminate economic and currency unit disparity from different regions, then, inverse it. The formula is as below:

$$A = \frac{GDP}{S} \tag{5}$$

wherein:

A is the average accessibility of the passengers access to the airport in one region.

3. Correlation analysis method and model setting up

In this paper, panel data model was adopted to analyze the relationship between the scale of airport and airport accessibility in Jiangsu province. The panel data is a two dimensional data combining with time series data and cross-section data (e.g., Haiyan, 2014; Haiyan, 2006).

3.1. Selection of variables

In this paper, the panel data of airports in prefecture-level cites of Jiangsu province, china over a nine-year period (from 2005 to 2014) were selected for this study. Previous studies had shown that airport accessibility standards and regional economic level may have effects on the scale of passengers(C). Therefore, indexes such as airport accessibility (A), number of airlines (L), GDP(G), gross industrial production(I), disposable income of residents(S) are selected as variables in this study.

3.2. Statistical tests and theoretical model

(1) Unit root test and cointegration test

Unit root test: Panel data might be unstable since time series usually contains unit root. Therefore, it is necessary to test the unit root of the selected variables. Eviews7 proposed 6 methods of unit root test of which Levin-Lin-Chu test (LLC), IPS and Fisher-ADF (Augmented Dickey-Fuller) are frequently used (e.g., Hanbin, 2014). The null hypothesis and alternative hypothesis are as follows:

Cointegration test: The long and stable relationship among variables is called the co-integration relationship, for explanation. If it exists the cointegration relationship between variables Y and X ($Y_1 = a_0 + a_1X_1 + \mu_t$), the stochastic interference $\mu_t = Y_1 - a_0 - a_1X_t$ should be stable series. If u contains no unit root, then, Y and X are cointegrated.

(2) Theoretical model

The panel data model mainly consists of three kinds of models: mixed effect model, entity fixed effect model, and entity random effect model (e.g., Longfei, 2012).

Mixed effect model:

$$y_n = \alpha + X_n\beta + \varepsilon_n, i = 1, 2, \ldots, N; t = 1, 2, \ldots T \tag{6}$$

wherein:

y_n refers to explanatory variable, α refers to cross-section; X_n refers to k explanatory variable that is $k \times 1$ column vector; β refers to regression coefficient of explanatory variable, that is $k \times 1$ order column vector, ε_n refers to error. In this model, α and β are the same.

Entity fixed effect model:

$$y_n = \alpha_i + X_n\beta + \varepsilon_n, i = 1, 2, \ldots, N; t = 1, 2, \ldots T \tag{7}$$

wherein:

Regression coefficient β remains the same for different entities while α varies. For the i different entities, it means here have i different cross-section; α_I includes the influence of variables which changes with entities rather than with time; The distribution of α_i is related with X_n.

Entity random effect model:

$$y_n = \alpha_i + X_n\beta + \varepsilon_n, i = 1, 2, \ldots, N; t = 1, 2, \ldots T \tag{8}$$

wherein:

Regression coefficient β remains the same to different entities; α_i is a random variable, whose distribution has nothing to do with X_n,ε_n and αi are presumed to be independently and identically distributed.

3.3. Model selection

Step 1: Establish the entity fixed effect model and test its feasibility. F tests null hypothesis H_0: the true model is a mixed effect model and alternative hypothesis H_1: the true model is an entity fixed effect model or random effect model. If null hypothesis could not be rejected, the mixed effect model is used. Otherwise, it should be continued to choose the model between entity fixed model and entity random effect model (Step 2).

Step 2: Establish the entity random effect model and perform the Hausman test. Hausman test null hypothesis H_0: the true model is the entity random effect model and alternative hypothesis H_1 the true model is the entity fixed effect model. If null hypothesis is rejected, the entity fixed effect model is used. Otherwise, the entity random effect model should be established.

4. Case analyses

4.1. Data acquisition and traffic survey

The data of passenger traffic and scope of airlines etc. in nine large civil airports of Jiangsu province were obtained from the website of Civil Aviation Administration of China (www.caac.gov.cn/). The data of basic geographic information such as administration boundary, body of water, residential area etc. were derived from 1:4 million vector database of National Geometric Center of China. The social economic statistical data were from the City Statistical Yearbook 2013 of Jiangsu Province.

The survey questionnaire was designed to obtain information of travel characteristics of the air passengers. The two types of questions were asked in survey: 1) social-economic attributions and 2) travel characteristics including: travel mode, time, expense, class, and amount of registered luggage etc.. A 2-day survey of each airport was conducted from February 2015 to March 2015 in the nine large airports in Jiangsu province, China, with a total of 900 questionnaires distributed in the nine airports (~100 for each airport). A total of 855 usable surveys (95%) from 882 collections were used for further analysis.

All the collected data were analyzed by using Excel and SPSS.

4.2. Calculating result of accessibility

(1) Identification of airport service area

Both theoretical service area and valid service area are identified (e.g., Jinghu and Yibo, 2015) in order to use disaggregate theory to calculate the total accessibility of all passengers within a region.

a) Theoretical service area. If the amount of time spent from one point within a region to airport A is less than that spent from this point to any other airport, this point belongs to the service area of airport A. A region formed by such consecutive point around the airport is the theoretical service area of airport A. The theoretical service area plays an important role for the residents in choosing the airport for their travel plan.
b) Valid service area. According to prescription of CAAC, the area within which takes less than 1.5 h to airport is the valid service area of airport A, The valid service area is the core service area of airport.

In this study, ArcGIS was applied with its Spatial Analyst function to generate the distribution map of the valid service area for each airport in Jiangsu province by analyzing the arrival times and service areas of the airports based on the traffic network data (1:250,000 fundamental geographic information data of Jiangsu province) (Table 2).

Jiangsu province was divided into grids with side length of 1000 m. The grids scattered outside of the province were set as invalid areas. The grids located in the blocked areas (impassable areas such as rivers, reservoirs and high mountains) were set as blocked grids. Jiangsu province was divided into 120,301 units, which includes 94,930 valid grids, and 7371 blocked grids. According to Technical Standard of Highway Engineering (JTGB-2003) of China, the speed on different grades of highways was identified (Table 3). The designate speed was set as 15 km/h for the areas without the graded highway. The speed of highest grade was used if there are different grades of highways within one grid.

From the arrival time distribution of civil airports in Jiangsu province (Fig. 1), it was found that the arrival time of civil airports in Jiangsu province presented a circle-layer structure with airport being the center. The arrival time of 87% of the region was within 1.5 h while 96% of which was within 2 h. The arrival time in southern area of Jiangsu province was the shortest. Due to the sophisticated traffic network, the average arrival at the three airports of Nanjing, Wuxi and Changzhou was within 1 h. The arrival time at the airports of central Jiangsu province was the longest, being above 2 h, because there are only two airports in Yangzhou and Nantong. The average arrival time at airports in Lianyungang, Xuzhou, and Huai'an in the northern Jiangsu province was about 1–1.5 h, which was in the medium level.

From the frequency statistics of the arrival time (Fig. 2), the distribution frequency of arrival time at civil airports of Jiangsu province presented a rise-fall trend as time increases. The percentage of region of arrival time within 1 h–2 h was from 65% to 99%. The arriving time at the airport was within 0.6 h in 40% of the area. The region that needs 2 h to arrive at the airport only accounts for 1%. The amount of the arrival time in Jiangsu province was in line with the national standard, being less than 1.5 h, except for few regions.

As shown the theoretical range of service (Fig. 3(a)), the service areas of airports in Southern Jiangsu province (Nanjing, Changzhou, and Wuxi) were much smaller than those in Northern Jiangsu province (Lianyungang, Xuzhou, and Huai'an). This was related to the distribution density of airports and their locations etc. As shown in the valid service area (as Fig. 3(b)), Nanjing Airport owns the largest valid service area covering the entire Nanjing city and some districts of Yangzhou, and Changzhou etc., which took less than 1.5 h for passengers to arrive at the airport. This was because Nanjing airport is a three-dimensional comprehensive transportation hub incorporating interurban railways, highways, and regional express rails which contributed to quick arrival at the airport for passengers in Nanjing and its peripheral cities. The valid service areas of airports in Xuzhou and Yancheng were the smallest, and some districts have not been covered. Therefore, the number of airports in the northern Jiangsu province and the scale of collecting and distributing network need to be enhanced.

(2) Accessibility contrastive analysis.

In this study, the valid service area of airport was set as the calculated scope of accessibility. The details were explained by taking Nanjing airport in 2014 as an example.

Step 1: Categorization of people and traffic means.

According to the 12th five-year plan (a roadmap for the nation's development from 2011 to 2015), people are divided into two income groups: 1) the high-income group (annual income above 100,000 Yuan, i.e. 40 Yuan per hour) and 2) middle and low-income group (50,000 Yuan according to average GDP, i.e. 20 Yuan per hour). The means of transportation include railways, airport shuttle buses, taxis, and private cars. Their basic features and ratios are shown in Table 4.

Step 2: Data process.

The utility value of different means of transportation by two income groups of people was calculated.

The cost of accessibility can be identified as follows:

$$S_1^1 = 40 \times 0.8 + 10 + 40 \times 0.8 \times \beta^1 \times 13$$

Table 2
Unit root test method.

Test method	Original hypothesis	Alternative hypothesis
LLC test	H_0: ρi = ρ = 1 (Each section has the same unit root)	H_1: No unit root
IPS test	H_0: ρi = 1 (Each section has different unit root)	H_1: No unit root
Fisher-ADF test	H_0: ρi = 1 (Each section has different unit root)	H_1: No unit root

Table 3
Grades of highway and its designated speed in Jiangsu Province.

Grades of highway	Freeway	National highway	Provincial road	County road	Urban road	Other roads
Designated speed (km/h)	120	75	60	30	40	15

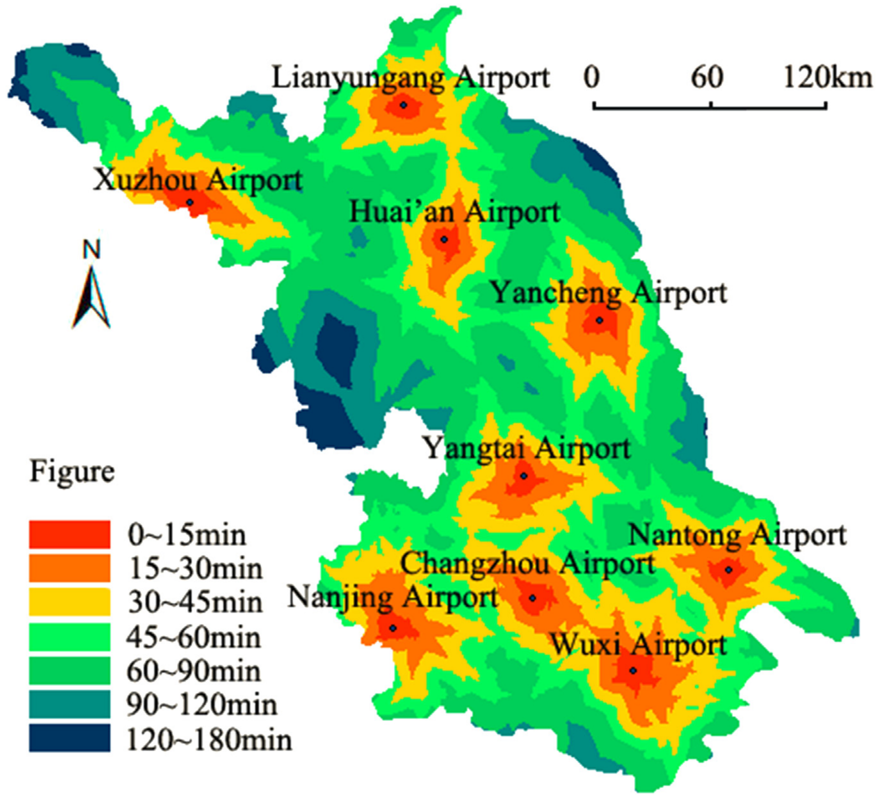

Fig. 1. Arrival time distribution of the airports in Jiangsu Province.

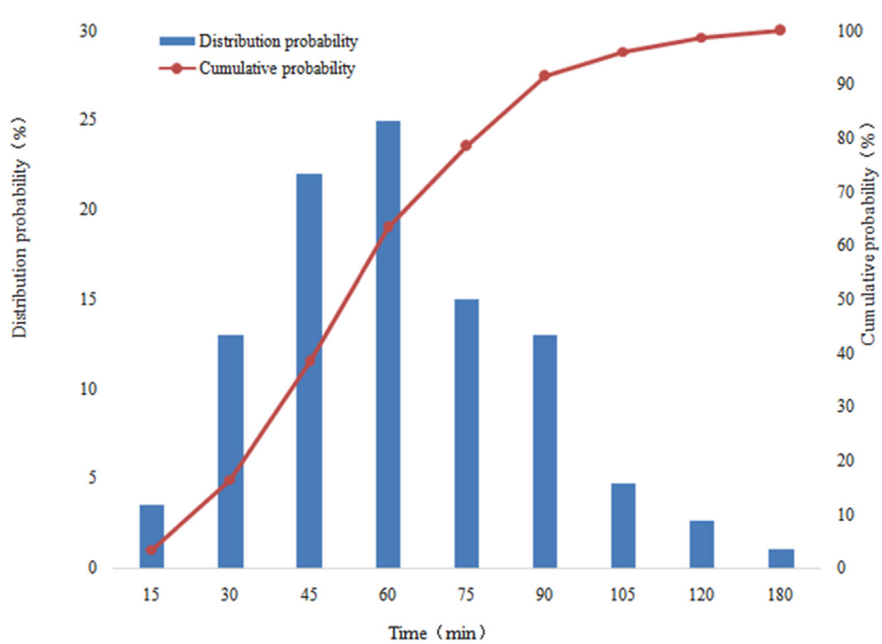

Fig. 2. Frequency of the arrival time of airports in Jiangsu Province.

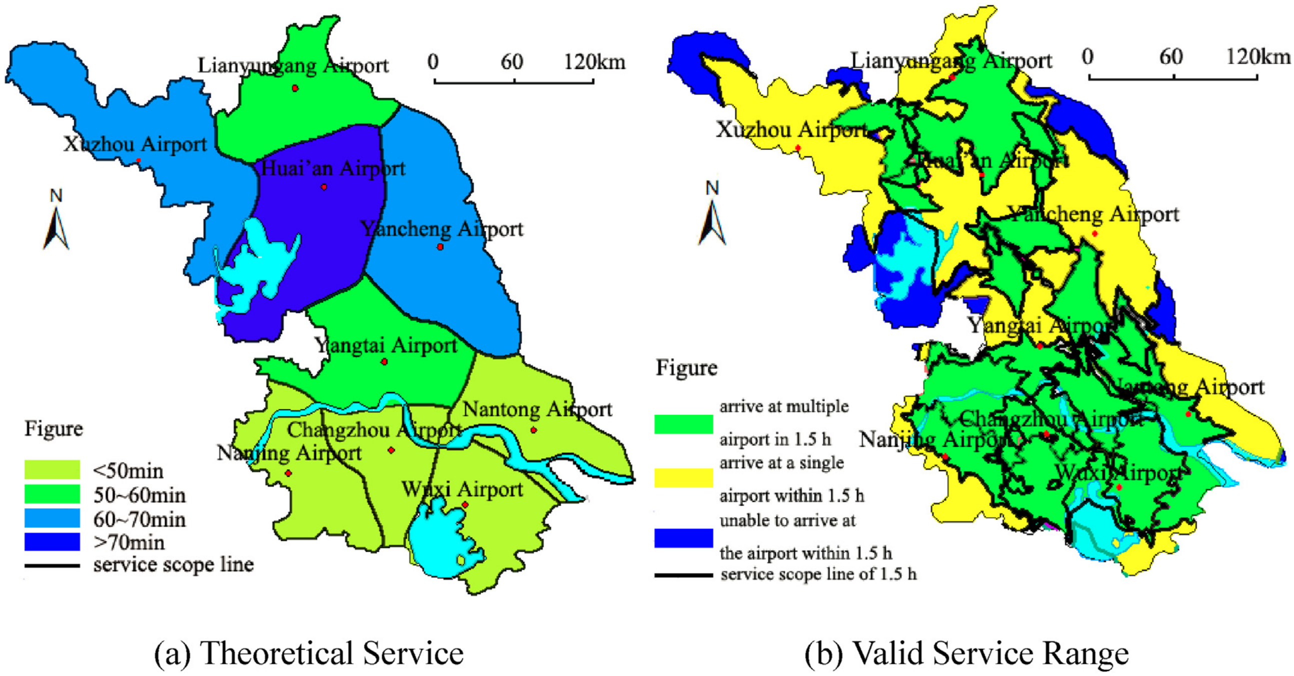

Fig. 3. Service range of airport in Jiangsu Province.

Table 4
Parameters and percentage of passengers of all kinds of airport access mode.

Traffic modes	Time (h)	Cost (¥)	Vibration grade	Noise grade	Crowded grade	Temperature grade	Comfort grade sum	Percentage of passengers (%)	
								High income people	Middle and low income people
Subway1	0.8	10	3	3	4	3	13	18	41
Bus2	1.5	20	4	2	2	1	9	11	20
Taxi3	0.7	120	1	1	1	2	5	26	18
Private car4	0.7	90	1	1	1	2	5	45	21

$$S_2^1 = 80 + 540\beta^1 \; S_3^1 = 148 + 140\beta^1 \; S_4^1 = 118 + 140\beta^1$$

$$S_1^2 = 26 + 208\beta^2 \; S_2^2 = 50 + 270\beta^2 \; S_3^2 = 134 + 70\beta^2 \; S_4^2 = 104 + 70\beta^2 \quad (9)$$

wherein:

The superscript of S represents one kind of people: 1 for high-income group and 2 for medium and low-income group; the subscript of S represents one kind of means of transportation: 1 for subway, 2 for bus, 3 for taxi and 4 for provide car.

In the Formula (9), the two unknown parameters β^1 and β^2 are calculated by using the *Logit* sensitivity coefficients.

The four equations can be listed by using the classified logit model:

$$\frac{e^{\frac{\theta^1}{S_m^1}}}{\sum_{m=1}^{4} e^{\frac{\theta^1}{S_m^1}}} = \frac{P_m^1}{\sum_{m=1}^{4} P_m^1} \quad (10)$$

wherein:

P_m^1 refers to the percentage of No. *m* traffic means by No.*1* group of people. The least squares principle was adopted to make sure that the error sum of squares of the equations' solutions was the smallest. Then, the sensitivity coefficient and difficulty weighting coefficient are as follows: $\theta^1 = 360$, $\beta^1 = 0.5$. The same method was used to mark θ^2 and β^2, which are 270 and 0.4 respectively.

The results of the cost of accessibility are shown in Table 5.

Step 3: Average accessibility.

The average accessibility cost for passengers in valid service area of airport can be calculated by combing all the cost accessibility as follows:

$$\sum_{n=1,2,m=1,2,3,4} S_m^n \times P_m^n \times \gamma^n \quad [11]$$

wherein:

γ^n is the percentage of No. *n* group of people in the area.

The average accessibility for Nanjing airport is 160.3 calculated by Eq. (11). The average cost of arrival at Nanjing Airport is 160.3 Yuan including the cost of expense, time, and fatigue, divided by daily income of people in Nanjing. The normalized accessibility is 0.87.

The other eight airports in Jiangsu province were calculated by using the same method and the results were listed in Table 6.

The average accessibility of Nanjing and Wuxi airports is the highest and the average accessibility of Xuzhou and Lianyungang is the lowest (Table 6). One of the reasons is that the fundamental facilities of southern Jiangsu province are well-developed, and the airports can be reached by different means of transport such as railway, highway, subway and others. Therefore, the cost of time and expense were relatively low. Another reason is that the overall economic level of southern Jiangsu province is relatively high. The

Table 5
Parameter calibrations of different populations.

Traffic modes	S value (¥)		Exp (θ/S) value		Calculated percentage (%)		Actual percentage (%)	
	High income people	Middle and low income people	High income people	Middle and low income people	High income people	Middle and low income people	High income people	Middle and low income people
Subway	250	109	11.0	11.9	19.5	39.1	18	41
Bus	350	158	5.55	5.52	9.8	18.1	11	20
Taxi	218	162	15.6	5.29	27.7	17.4	26	18
Private car	188	132	24.3	7.73	43.0	25.4	45	21

Table 6
Average accessibility level of 9 airports in Jiangsu province.

Airport	Nanjing	Changzhou	Wuxi	Yangzhou	Nantong	Xuzhou	Huaian	Yancheng	Lian yungang
Accessibility	0.87	0.73	0.81	0.82	0.79	0.65	0.74	0.70	0.62

airlines frequency can enhance the competitiveness of airport, which helps the airports in southern Jiangsu to gain an advantage over the airports in northern Jiangsu province.

4.3. Correlation analysis results

(1) Airport classification.

Before analyzing the correlation between airport accessibility and scope of development, airports are classified into two levels according to the Standards of Services Quality of Civil Airport. The first-level class includes the airports in the provincial capital and large cities with more than 1 million annual passenger traffic. The second-level class includes the airports in small and medium-sized cites with no more than 1 million annual passenger traffic. Classifications of the nine airports in Jiangsu province are shown in Table 7.

(2) Model test.

Unit root test: IPS, ADF-Fisher, and PP-Fisher5 were selected from Eviews7 to conduct unit root test of panel data of the nine airports in Jiangsu province. The results showed that all the variables were stable after the first order difference, namely integrated of first order. The detailed results including the corresponding P value are listed in Table 8.

Cointegration test: The data selected in this study belong to none homogeneous panel. Therefore, the Pedroni test was adopted. Cointegration test was conducted to the panel data by using Eviews7. The results are shown in Table 9.

Compared to the Panel statistics, the Ground statistics had more test effects. The results Table 9 showed that the Ground statistic values rejected the original hypothesis, where there was no cointegration relationship at a significant level of 5%. It indicated that there was a co-integration relationship among the passenger throughput, accessibility, gross domestic product (GDP), the number of passengers, and per capita disposable income, etc.. Panel statistic values (except Panel rho-Statistic) also rejected the original hypothesis at a significant level of 5%. Although the Panel rho-Statistic accepted the original hypothesis, overall, it also could reject to the original hypothesis, and considered there was a co-integration relationship between airport passenger traffic index, accessibility index, and economic index. Therefore, there is a long-term equilibrium relationship between the airport scale, accessibility, and the level of regional economic development.

(3) Model estimation.

The panel data models comprise the three types of models (7, 8, 9). The F test is usually conducted to determine whether the mixed model can be adopted or not; while Hausman test is made to decide whether fixed effect model or random effect model should be adopted or not.

F test: According to the model estimation method in 2.2, F test was conducted to determine whether the two sets of data should adopt mixed model or not. The result is shown in Table 10.

The null hypothesis of F test: F value is greater than the critical value F_a (N,NT-N-k) when the significance level reaches to 5% (Table 10). The null hypothesis has been rejected and the mixed effect model is not a good model to study the airport accessibility.

Hausman test: The Hausman test is used to select the model between entity fixed model and entity random effect model. As Table 11 shows:

According to the definition of Hausman test, the null hypothesis is a random effect model, that is, independent variable and individual influence are irrelevant. ($P > 0.05$). Otherwise, the independent variable and the individual influence are correlated.

The P value of first-level airport was less than 0.05 (Table 11), meaning that the independent variable and individual difference were related. Thus, the fixed effect model is adopted. The P value of second-level airport was greater than 0.05 (Table 11), meaning that independent variable and individual difference were irrelevant. Thus, the null hypothesis was accepted, and random effect model

Table 7
Grade classification of airports in Jiangsu province.

Airport level	Airport name	Passenger traffic (million passengers/year)
First-level	Nanjing airport	16.28
	Wuxi airport	4.18
	Changzhou airport	1.86
	Xuzhou airport	1.26
Second-level	Nantong airport	0.93
	Yangzhou airport	0.70
	Lianyungang airport	0.56
	Yancheng airport	0.52
	Huai'an airport	0.51

Table 8
Panel data unit root test of airports in Jiangsu province (2005–2014).

Variable	IPS test	P value	ADF-Fisher test	P value	PP-Fisher5 test	P value
Airport accessibility (A)	−21.3087	0.0000	−9.0493	0.0000	123.746	0.0000
Route number (L)	−11.5350	0.0000	−18.4864	0.0000	204.385	0.0000
Urban GDP (G)	−17.6883	0.0000	−12.3948	0.0000	448.318	0.0000
Gross industrial product (I)	−25.8903	0.0000	−9.3865	0.0000	138.024	0.0000
Disposable income (S)	−20.5469	0.0000	−7.3846	0.0000	298.115	0.0000

Table 9
Panel data co-integration test case of airports.

Test method	Statistic	P value
Pedroni test	Panel v-statistic	0.008
	Panel rho-statistic	0.067
	Panel PP-statistic	0.012
	Panel ADF-statistic	0.001
	Group rho-statistic	0.032
	Group PP-statistic	0.011
	Group ADF-statistic	0.009

Table 10
Test results of F test.

Airport level	Sample number	N-1	Time	Independent Variable	Critical value of significant level 5%Fa (N,NT-N-k)	F value
	N		T	K		
First-level	4	3	9	5	1.4632	5.0983
Second-level	5	4	9	5	2.8346	4.2271

Table 11
Test results of Hausman test.

Airport level	P value
First-level	0.0026
Second-level	0.0864

was selected.

The two sets of data were classified according to scopes of airport: first-level airport established a fixed effect model; and second-level airport established a random effect model. The model estimation results are shown in Table 12.

The results showed a good fitting with 0.946 and 0.905 of R_2 value (Table 12). For the F-test values, four variables (accessibility, route number, GDP, per capita income) were significantly related with the passenger traffic in both levels of airports. The gross industrial production was significantly related to the passenger traffic for second-level airports. The aircraft movements were not related to the passenger traffic. The detailed analysis of airports in different levels is as follows:

Seen from the regression of accessibility, it exerted greater impacts on the scope of first-level airports than on second-level airports. The Regression coefficients for first and second level-airports were 2.1498 and 1.5762 respectively. This indicated that when the level of airport accessibility raised by 1%, the passenger traffic of first-level airports and second-level airports increased by about 2.1% and 1.5% respectively. The number of airlines has greater impacts on second-level airport than on first-level airports. When the scope of airport is comparatively small, the key elements of civil airport transportation such as airline network, or fleet scale etc. play important roles in enhancing the attractiveness of airport. However, the external conditions such as landside traffic facilities or level of accessibility has little impact on the development of airport. When the airport reaches to a certain scale (annual average passenger traffic > 10 million) with sufficient flights, the landside traffic facilities becomes more important for the airport development since higher the airport accessibility becomes, lower the cost for passengers becomes and more appealing of airport becomes to passengers.

By analyzing the regression of GDP, it has greater impacts on second-level airports than first-level airports. When GDP grew by 1%, the passenger traffic of airports of the both levels increased by 1.8% and 0.7% respectively. When the airport is at its primary stage of development, it is greatly affected by the development of local economy instead of driving the economy forward. Therefore, the development of small and medium-sized airports should be closely linked to urban industries. As the airport expands in scale and becomes a regional hub, an economic circle will be gradually formed around the airport; and the development of airport could bring more opportunities for the airport, for its future development. The regression results of gross GDP regression, which only exerted impacts on the development of second-level airports, whose passengers mainly come from secondary industries and foreign trade areas, indicates that the industries near the airport

Table 12
Estimation of panel data model of airports in Jiangsu province.

Variable	Regression coefficient		Standard error		t-statistic		P value	
	First-level	Second-level	First-level	Second-level	First-level	Second-level	First-level	Second-level
c	1.3387	2.4386	0.0385	0.1237	9.3864	11.6435	0.0000	0.0002
A	2.1498	1.5762	0.1038	0.0846	12.7365	6.9903	0.0000	0.0000
L	5.9374	9.1745	0.0464	0.0297	9.9863	25.9365	0.0000	0.0000
G	1.8465	0.7857	0.3945	0.2984	2.7364	5.9013	0.0032	0.0000
I	2.4744	1.6430	0.3564	0.6854	1.0483	2.4633	0.0832	0.0077
S	2.3655	1.0037	0.6863	0.2745	8.2843	12.8365	0.0000	0.0000

will promote air travel, thus will bring more opportunities for the airport. Industrial development has become an important support for the development of small and medium-sized airport.

Seen from the regression of per capita disposable income, it had greater impact on first-level airports than the second-level airports. As per capita disposable income increased by 1%, the passenger traffic would increase by 2.3% and 1.0% respectively. It indicates that for passengers whose annual average income is more than 80,000 Yuan (85,000 in Nanjing city and 92,000 in Wuxi city), traveling by air is more favored. In developed cities, the demand for traveling by air is mainly reflected by tourism, leisure and commuting etc.; while for small and medium-sized cities, it reflected by official business and business affairs.

5. Conclusions

This paper, indexes such as cost of expense, cost of time, cost of fatigue have been proposed to quantify levels of fastness, economy and amenity during the period of passengers' arrival at airport and logit model has been adopted to mark and rectify parameters of different people and different traffic means so that the accessibility of arrival at airport in valid service area can be calculated. The relevant tests showed that the average arrival time of the nine large airports in Jiangsu province was 1.38 h, and 87% of the region was reachable within 1.5 h. Also, the level of accessibility of passengers to arrive at airport from southern Jiangsu province was about 30% higher than that in northern Jiangsu province due to the fact that southern Jiangsu owns developed economy and sophisticated traffic network. So for airport managers, accelerating airport external transport system construction in northern Jiangsu province, improving the density of road network and road grade and enhancing the convenience of travelers arriving at the airport are of great significance that can strengthen the airport competitiveness in northern Jiangsu province and realize the coordinated development of nine major airports in the province.

Meanwhile, this paper introduces the index of accessibility to the airport passenger scale evaluation model based on the panel data of nine large airports in Jiangsu province. The relationship between the passenger scale and the indexes such as accessibility, number of airlines and economic level were studied by analyzing data co-integration. The result has shown that the four variables (accessibility, route number, GDP, and per capita income) are significantly related with the passenger traffic. Accessibility and per capita income have greater impacts on first-level airports than second-level airports. This demonstrates that when an airport develops to a certain scale, passengers might pay more attention to the convenience of arrival at airport. When the level of accessibility rises by every 1%, the passenger traffic of airport would increase by 2% and the competitiveness of the airport would be significantly improved. Thus, in order to promote the development of the airport, in addition to increase flights and air routes, airports should actively improve the external transport system and airport accessibility to enhance the overall attractiveness of the airport. The research conclusion in this paper not only provides scientific methods for managers to accurately measure the accessibility of the airport and predict the future development of the scale through the combination of the airport characteristically external and internal data, but also can actively promote the management department, to improve airport external transport service levels so as to enhance the overall airport competitiveness.

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