The Analysis of Socioeconomic Adaptability of China’s Civil Aviation Development

Hang He¹,a, Zhu Han*¹b, Xiao He¹, Shuai Wang²d

¹School of airport engineering and transport management, Civil Aviation Flight University of China, Guanghan City, China
²1685682315@qq.com
³707965017@qq.com
⁴806292798@qq.com
⁵709078662@qq.com

Abstract—“Transportation service is convenient, comfortable, economical and efficient” is one of the purposes of “The Program of Building National Strength in Transportation”. The high-capacity and high-efficiency fast passenger and freight services provided by the aviation industry meet this need. Civil aviation industry is not only a social service industry, but also an industry closely related to the economic situation. At present, there is a lack of research on the evaluation of socioeconomic adaptability of civil aviation development. From aspects of civil aviation development and economy and society, this paper constructs the index system of socioeconomic adaptability of civil aviation development. And then in this paper, the method of DEA is used to evaluate its adaptability, and the year with better adaptability is found. At the same time, this paper also briefly analyzes the fluctuation of civil aviation passenger transport market, which lays a theoretical foundation for the subsequent development planning of civil aviation, and promotes the high-quality development of civil aviation to a certain extent. And it will achieve the goal of “people's aviation for the people”, and then promote the process of building a powerful transportation country.

1. INTRODUCTION
The Program of Building National Strength in Transportation proposes to build a “safe, convenient, efficient, green and economic modern comprehensive transportation system”, and precisely positions the functions of civil aviation transportation in the comprehensive transportation system. According to the Program of Building National Strength in Transportation, both civil aviation and high-speed rail are the backbone of the comprehensive transportation system, which could provide high-capacity and fast interval services and solve the problem of passenger transportation with grand corridor. However, transportation demand is a kind of derived demand, which cannot be stored. With the rapid development of high-speed rail, the non-storability to a certain extent increases the substitutability of civil aviation transportation, and weakens the unique advantage of “velocity” of civil aviation transportation, which leads to the increasingly prominent development crisis of civil aviation transportation industry. Therefore, it is imperative to promote the high-quality development of civil aviation.

On the one hand, China Civil Aviation High Quality Development Index Framework System constructs the basic index system of high-quality development of civil aviation from safety level,
guarantee ability, service quality, production scale, operation efficiency and economic benefit; on the other hand, the characteristic index system is constructed from the perspective of “Five Development Concepts”. It can be seen that the study of civil aviation development should not only explore its traffic attributes, but also integrate its social and economic attributes.

At present, on the one hand, there are few researches on the socioeconomic adaptability of civil aviation development abroad, and most of them focus on railway, highway, port and comprehensive transportation in China. Moreover, the researchers mostly adopt Analytic Hierarchy Process(AHP), Data Envelopment Analysis(DEA), Principal Component Analysis(PCA) and Entropy Method. Cao Qingshan (2007) [1], from Southwest Jiaotong University, used DEA to evaluate the adaptability of railway transportation to national economy; Zhang Junwei (2012), from Tianjin University, used AHP to evaluate the adaptability of highway construction and social and economic development in Shandong Province[2]; Yan Zhi (2012) analyzed the adaptability evaluation index of the Yangtze River main line port based on DEA with Grey Correlation Constraint Cone[3]; Zhang Dengjian (2013) adopted DEA to evaluate the coordinated development index of transportation and economy[4]; Chen Yan (2013), from Hebei University of economics and trade, combined with C-D production function, and transformed the research on socioeconomic adaptability of expressway into a comparative analysis on productivity and comprehensive productivity of factors related to social economy of highway[5]. And some domestic scholars have studied the relationship between the development of civil aviation and national economy, and some scholars have studied the socioeconomic adaptability of general aviation. Han Hong (2009) constructed regression equation by using indicators such as the volume of passenger and freight, per capita GDP and population, and analyzed the demand of civil aviation transportation from an economic perspective[6]; Li Xiaojin (2013) and others used Granger Causality test to find the relationship between civil aviation transportation and economy from three aspects: the development of airspace resources, civil aviation transportation turnover and GDP[7]; Zhang Lei (2015) constructed the evaluation system of general aviation socioeconomic adaptability index, and used the Nonlinear Comprehensive Assessment Model of AHP-Entropy to evaluate the adaptability of China’s general aviation and socioeconomic development[8].

Most of the existing researches are about the socioeconomic adaptability of other modes of transportation except civil aviation. Although there are some researches on civil aviation and economy, these researches are not only lack of discussion on the influencing factors of civil aviation development in the context of "transportation power", but also lack of systematic discussion on Civil Aviation Development and socioeconomic adaptability. Therefore, it is urgent to study the socioeconomic adaptability of civil aviation development in China.

The socioeconomic adaptability of transportation system is the relationship of coordination and interaction between transportation system and economic system. Therefore, the socioeconomic adaptability of civil aviation development is the relationship of civil aviation development, society and economy. In different periods, the tasks and objectives of civil aviation development are different. But generally speaking, it should be adapted to the development of social economy.

In order to accurately grasp the development direction of civil aviation, first of all, this paper takes the social and economic development of China as the background, aims to achieve the high-quality development of civil aviation, and constructs an appropriate development index system. Secondly, this paper analyzes the social and economic adaptability of civil aviation development. Finally, this paper discusses the rationality of the development of civil aviation transportation industry, which lays a theoretical foundation for the planning and construction of civil aviation, in order to promote the development of civil aviation, and then achieve the goal of a powerful transportation country.

2. CONSTRUCTION OF EVALUATION INDEX SYSTEM OF SOCIOECONOMIC ADAPTABILITY OF CIVIL AVIATION DEVELOPMENT

2.1. Principles of Index System Construction

(1) Systematic principle

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This paper deals with the development of civil aviation and social economy. Therefore, this paper must select indicators from these two aspects, not only considering the development of civil aviation, but also comprehensively reflecting the development of the two aspects, and each indicator should be relevant.

(2) Principle of objectivity
In this paper, the selection of indicators should be based on the actual development of civil aviation, not only considering the impact of civil aviation indicators, but also considering the impact of social economy on the development of civil aviation.

(3) Operability principle
Based on the principles of systematization and objectivity, the principle of operability should also be taken into consideration when selecting indicators. First, index data should be available; second, it is convenient for data processing.

2.2. Establishment of index system
The socioeconomic adaptability analysis of civil aviation development is actually to analyze whether the supply capacity of civil aviation transportation industry meets the needs of social and economic development, and the supply capacity of civil aviation is mainly reflected in the scale, speed and quality of the development of the transportation industry. In this paper, from the perspective of civil aviation development, social development and economic development, based on the above principles, the index system is constructed.

On the one hand, as a transportation industry, the most basic indicators of its development are the transportation volume of passenger and cargo.

In order to reduce the indicator dimension, this paper selects the total transportation volume of passenger and cargo and selects Accumulated operating revenue of the whole industry of civil aviation as the economic indicators of civil aviation development.

At the same time, this paper selects the number of civil transportation aircrafts, The number of civil aviation transportation employees and The number of civil aviation routes as the equipment elements, human elements and transport capacity elements of civil aviation development. On the other hand, GDP has a significant impact on the development of civil aviation. In addition, from the aspect of people’s living level, the consumption level of residents is closely related to the development of civil aviation. The specific index system of this paper is shown in TABLE I.

| The Sequence | The Meaning                                      |
|--------------|-------------------------------------------------|
| 1            | The total transportation volume of passenger and cargo |
| 2            | Accumulated operating revenue of the whole industry of civil aviation |
| 3            | GDP                                             |
| 4            | Consumption level of residents                  |
| 5            | The number of civil transportation aircrafts    |
| 6            | The number of civil aviation routes             |
The number of civil aviation transportation employees

The fixed asset investment of the whole society

3. CONSTRUCTION OF SOCIOECONOMIC ADAPTABILITY EVALUATION MODEL FOR CIVIL AVIATION DEVELOPMENT

DEA is a systematic analysis method based on “relative efficiency evaluation”, which is applicable to evaluate the relative efficiency of each index input and output in the development of the industry. The basic purpose of civil aviation development socioeconomic adaptability analysis is to find out the development process of civil aviation in the context of socioeconomic adaptability, and then promote the development of comprehensive transportation system. The development of civil aviation must adapt to the development of social economy and form a good relationship to promote the development of both sides. If the development of civil aviation is ahead of or behind the development of social economy, it will not be conducive to the development of both sides. Therefore, this paper selects DEA method to find out the relationship between civil aviation development and social economic development through relative efficiency evaluation. In this paper, the most basic CCR model in DEA is selected, and its model is as follows.

N decision objects are selected as decision making units (DMU), each DMU has m input indicators and p output indicators, and indicators of the assessment of efficiency are calculated.

\[ h_j = \sum_{i=1}^{m} v_i x_{ij} \]

In this formula, \( h_j \) is the efficiency evaluation index of the jth DMU, \( v_i \) is the weight of the ith input index, \( x_{ij} \) is the input index data of the jth DMU, \( u_r \) is the weight of the rth output index, and \( y_{rj} \) is the output index data of the jth DMU. \( v_i \) and \( u_r \) are variables.

Similarly, according to the efficiency evaluation index, the relative efficiency optimization model is constructed.

\[ \max h_{j0} = \sum_{r=1}^{p} \mu_r y_{rj0} \]

Where, \( h_{j0} \) is the relative efficiency index of the j0 DMU, and the rest is the same as above. The j0 calculated DMU efficiency is the relative value compared with other DMUs.

In order to solve the above model, it must be transformed into a linear programming model.

\[ \mu_r = \frac{1}{\sum_{i=1}^{m} v_i y_{i0j}}, \mu_r = t u_r, w_t = t v_t \]

Let \( \mu_r = t u_r, w_t = t v_t \), the relative efficiency optimization model is transformed into:

\[ \max h_{j0} = \sum_{r=1}^{p} \mu_r y_{rj0} \]

Its vector form is:

\[ \max h_{j0} = \mu^T Y_0 \]

Then it is transformed into dual form:
If the above optimal solution is $\lambda^*$, the following conditions will occur.

1. When $\theta^* = 1$, the DMU is weak DEA effective;
2. When $\theta^* = 1$ and $s^+ = 0$, the DMU is DEA effective;
3. When $\sum_{i=1}^{n} \lambda_i^* = 1$, the benefits of the DMU scale remain unchanged; When $\sum_{i=1}^{n} \lambda_i^* < 1$, the benefits of the DMU scale increase; when $\sum_{i=1}^{n} \lambda_i^* > 1$, the benefits of the DMU scale decrease.

4. The Empirical Analysis of Socioeconomic Adaptability of China's Civil Aviation Development

In DEA model, the index should satisfy the mutual influence of input indicators and output indicators. According to the development of civil aviation in China, this paper selects the total transportation volume of passenger and cargo, accumulated operating revenue of the whole industry of civil aviation, GDP and consumption level of residents as the output indicators and the number of civil transportation aircraft, the number of civil aviation routes, the number of civil aviation transportation employees and the fixed asset investment of the whole society as the input indicators.

This paper selects the data from 1999 to 2018 (the actual values of indicators are shown in the table II and table III), taking each year as DMU, and substitutes it into the software of MaxDEA to obtain the efficiency value, scale income and target value of each indicator of each Decision-Making Unit. See table IV, table V and table VI for specific results.

### TABLE II. The Actual Values of Output Indicators

| DMU(year) | $y_1$ | $y_2$ | $y_3$ | $y_4$ |
|-----------|-------|-------|-------|-------|
| 1999      | 118.3 | 538.0 | 90564.4 | 3346 |
| 2000      | 136.2 | 638.6 | 100280.1 | 3721 |
| 2001      | 140.4 | 758.0 | 110863.1 | 3987 |
| 2002      | 163.9 | 899.7 | 121717.4 | 4301 |
| 2003      | 169.8 | 1068.0 | 137422 | 4606 |
| 2004      | 229.6 | 1586.0 | 161840.2 | 5138 |
| 2005      | 260.0 | 1901.0 | 187318.9 | 5771 |
| 2006      | 304.2 | 2276.0 | 219438.5 | 6416 |
| 2007      | 363.6 | 2657.0 | 270092.3 | 7572 |
| 2008      | 374.9 | 3153.9 | 319244.6 | 8707 |
| Year | $x_1$ | $x_2$ | $x_3$ | $x_4$ |
|------|-------|-------|-------|-------|
| 1999 | 510   | 1115  | 125000| 29854.7|
| 2000 | 527   | 1165  | 117000| 32917.7|
| 2001 | 566   | 1143  | 121499| 37213.5|
| 2002 | 602   | 1176  | 120515| 43499.9|
| 2003 | 664   | 1155  | 178820| 55566.6|
| 2004 | 754   | 1279  | 205023| 70477.4|
| 2005 | 863   | 1257  | 209868| 88773.6|
| 2006 | 998   | 1336  | 221193| 109998.2|
| 2007 | 1134  | 1506  | 231127| 137323.9|
| 2008 | 1259  | 1532  | 252953| 172828.4|
| 2009 | 1417  | 1592  | 252779| 224598.8|
| 2010 | 1597  | 1880  | 272023| 251683.8|
| 2011 | 1764  | 2290  | 335260| 311485.1|
| 2012 | 1941  | 2457  | 376100| 374694.7|
| 2013 | 2145  | 2876  | 494397| 446294.1|
| 2014 | 2370  | 3142  | 507789| 512020.7|
| 2015 | 2650  | 3326  | 553358| 561999.8|
| 2016 | 2950  | 3794  | 595301| 606465.7|
| 2017 | 3296  | 4418  | 624318| 641238.4|
| 2018 | 3639  | 4945  | 645957| 645675.0|

TABLE IV. THE TARGET SCORE OF SOCIAL AND ECONOMIC ADAPTABILITY INDICATORS OF CIVIL AVIATION DEVELOPMENT

| Year | Score | Lambda | DMU | Score | Lambda |
|------|-------|--------|-----|-------|--------|
| 1999 | 0.996 | 0.903  | 2009| 1     | 1      |
| 2000 | 1     | 1      | 2010| 1     | 1      |
| 2001 | 1     | 1      | 2011| 1     | 1      |
| 2002 | 1     | 1      | 2012| 1     | 1      |
| 2003 | 1     | 1      | 2013| 0.997 | 1.101  |
| 2004 | 1     | 1      | 2014| 0.994 | 0.310  |
| 2005 | 1     | 1      | 2015| 0.994 | 0.441  |
| DMU(year) | x₁ | x₂ | x₃ | x₄ |
|-----------|----|----|----|----|
| 1999      | 476| 1052| 105664| 29728|
| 2000      | 527| 1165| 117000| 32918|
| 2001      | 566| 1143| 121499| 37214|
| 2002      | 602| 1176| 120515| 43500|
| 2003      | 664| 1155| 178820| 55567|
| 2004      | 754| 1279| 205023| 70477|
| 2005      | 863| 1257| 209868| 88774|
| 2006      | 998| 1336| 221193| 109998|
| 2007      | 1134| 1506| 231127| 137324|
| 2008      | 1259| 1532| 252953| 172828|
| 2009      | 1417| 1592| 252779| 224599|
| 2010      | 1597| 1880| 272023| 251684|
| 2011      | 1764| 2290| 335260| 311485|
| 2012      | 1941| 2457| 376100| 374695|
| 2013      | 2138| 2706| 414250| 412702|
| 2014      | 2357| 3001| 454635| 445950|
| 2015      | 2633| 3305| 493177| 474116|
| 2016      | 2918| 3700| 540260| 501468|
| 2017      | 3247| 3968| 576871| 534620|
| 2018      | 3639| 4945| 645957| 645675|

**TABLE V. THE TARGET VALUES OF INPUT INDICATORS**

| DMU(year) | y₁ | y₂ | y₃ | y₄ |
|-----------|----|----|----|----|
| 1999      | 123| 577| 90564| 3360|
| 2000      | 136| 639| 100280| 3721|
| 2001      | 140| 758| 110863| 3987|
| 2002      | 164| 758| 110863| 3987|
| 2003      | 170| 900| 121717| 4301|
| 2004      | 170| 1068| 137422| 4606|
| 2005      | 230| 1586| 161840| 5138|
| 2006      | 260| 1901| 187319| 5771|
| 2007      | 304| 2276| 219439| 6416|
| 2008      | 364| 2657| 270092| 7572|

**TABLE VI. THE TARGET VALUES OF OUTPUT INDICATORS**
The efficiency values from 2000 to 2012 and 2018 are all 1, and the Slack Movement of input and output indicators are all 0. Therefore, these DMUs are of strong effectiveness with DEA, which shows that China's civil aviation development has a good social and economic adaptability. From 2013 to 2017, the efficiency values are less than 1, which have certain volatility and their socioeconomic adaptability of China's civil aviation development is slightly worse than the previous years. In those five years, although the total transportation volume of passenger and cargo still showed an increasing trend, its growth rate was relatively flat, and the growth rate of the fixed asset investment of the whole society declined sharply in 2013.

The lambda values from the above table are relative values. The results show that the lambda values in 2013, 2016 and 2017 are 1.101, 1.240 and 1.280, respectively, which are greater than 1, indicating that the scale gains in these three years are decreasing; the lambda values in 1999, 2014 and 2015 are 0.903, 0.310 and 0.441, respectively, which are less than 1, indicating that the scale gains in these three years are increasing; the lambda values in other years are equal to 1, and the scale gains are unchanged.

Based on the above table, this paper compares the actual value and target value of each input and output index, and finds that in the past 20 years, the actual value of most indicators is almost the same as the target value, while the actual value of some indicators is slightly different from the target value. This paper compares the difference between the actual value and the target value of the three indicators of accumulated operating revenue of the whole industry of civil aviation, the number of civil aviation routes and the number of civil aviation transportation employees, as shown in figure 1, figure 2 and figure 3.

| Year | Input 1 | Input 2 | Input 3 | Output |
|------|---------|---------|---------|--------|
| 2009 | 425     | 2971    | 348518  | 9514   |
| 2010 | 538     | 4115    | 412119  | 10919  |
| 2011 | 577     | 5001    | 487940  | 13134  |
| 2012 | 610     | 5561    | 538580  | 14699  |
| 2013 | 672     | 6126    | 593211  | 16190  |
| 2014 | 748     | 6736    | 653475  | 17778  |
| 2015 | 852     | 7347    | 718216  | 19397  |
| 2016 | 963     | 8085    | 793716  | 21285  |
| 2017 | 1083    | 8678    | 860335  | 22935  |
| 2018 | 1207    | 10143   | 900310  | 25002  |

Figure 1. The comparison between the actual value and the target value of the accumulated operating revenue of the whole industry of civil aviation
Before 2013, accumulated operating revenue of the whole industry of civil aviation was basically consistent with the target value. From 2013 to 2017, the target value increased in a straight line, while the actual value decreased slightly in 2014 compared with 2013, and grew slowly in 2015.

Figure 2. The comparison between the actual value and the target value of the number of civil aviation routes

In the past 20 years, except that the actual number of routes in 2017 is slightly higher than the target value, the actual value in other years is basically consistent with the target value.

Figure 3. The comparison between the actual value and the target value of the number of civil aviation transportation employees

Before 2012, the actual number of civil aviation employees is basically consistent with the target value. After 2012, except 2018, the actual value of this indicator is significantly higher than the target value, and the difference peaked in 2013.

5. CONCLUSION
In this paper, through the establishment of the evaluation index system of the socioeconomic adaptability of civil aviation development, and the selection of 20-year data, using DEA, the analysis of the overall socioeconomic adaptability of civil aviation in China is carried out, and the conclusion that the socioeconomic adaptability of civil aviation development in China is better in 2000-2012, but it is more volatile in 2013-2017. In the more volatile years, although the actual number of civil aviation employees and routes is greater than the target value, as an output indicator, the operating revenue of the whole industry of civil aviation has not reached the target value. Based on the year, this paper explores the socioeconomic dynamic adaptability of the development of civil aviation, and the later
research can analyze the social and economic static adaptability of the national regional administrations, so as to make a horizontal comparison.

Acknowledgment
The 13th five year plan of social science research in Sichuan Province (SC19TJ025); Civil Aviation Flight University of China Science Innovation Fund for Graduate Students(No.X2020-17).

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