

Research on Evaluation System of Green Civil Aviation Development—Based on Air China

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Abstract. The establishment of a green civil aviation development system is an important measure to promote the long-term, healthy and stable development of the civil aviation industry. In order to objectively evaluate the development level of China's civil aviation industry since the promulgation of the "Thirteenth Five-Year Plan for the Development of Civil Aviation in China", this article selects China International Airline data, comprehensively consider the concept and connotation of green civil aviation, select indicators from the four aspects of environmental protection, conservation, technology, and humanization, and establish a green civil aviation evaluation system. The TOPSI method and the entropy method are combined to obtain the weight of each indicator. Weights. Make a longitudinal comparison to get a score for each year, and analyze it in combination with reality.

Keywords: green civil aviation; evaluation index system; entropy TOPSIS method.

1. Introduction

Adhering to green development is one of the five basic development principles of civil aviation development. Establish the concept of green development, efficiently use resources and energy, optimize the aviation energy-saving operating environment, focus on improving transportation production efficiency, control carbon emissions, reduce negative environmental impacts, and promote the construction of resource-saving and environment-friendly civil aviation. In recent years, with the improvement of the quality of life, the civil aviation industry of China has also ushered in rapid development, which has also brought new challenges to the development of China's green civil aviation^[1]. Therefore, the establishment of a scientific and effective green airport evaluation index system and evaluation method plays a vital role in the development of green civil aviation.

The "13th Five-Year Plan for Civil Aviation Energy Conservation and Emission Reduction" points out that by 2035, the concept of green development should be integrated into the entire industry, the civil aviation green development policy system, standard system, and evaluation system should be mature and complete, and the green development industry system should have a scale and green management level. Significantly improved, basically establishing a civil aviation green development model compatible with the building of a civil aviation power. Judging from the current situation, although the civil aviation industry has ushered in rapid development with the improvement of the quality of people's lives, there is still a big gap between the goals set by the policy in terms of greening, so a scientific and effective green civil aviation evaluation index has been established. The system and evaluation method are particularly important.

Scholars at home and abroad have conducted a lot of research on the development of green civil aviation. Geng Hong^[2] et al. (2014) built an airline carbon emission reduction efficiency evaluation model based on the DEA model, analyzed the carbon emission reduction efficiency, and evaluated the company's energy efficiency development trend. The system focuses on management rather than evaluation, and the indicators are all quantitative indicators, lacking process evaluation. Tian Lijun and Zhao Fengcai^[3] (2015) constructed an airline energy-saving and emission-reduction evaluation index system from the aspects of organization system, data statistics, data monitoring, performance appraisal and system design. San kilkis and Siir kilkis^[4] (2016) developed 25 secondary indicators from five dimensions, which can measure the status of airport green construction based on various indicators. Chen Maoxiu and Yu Jian^[5] (2017) constructed a super-efficiency DEA model to evaluate

the investment efficiency of government-invested energy-saving and emission-reduction projects. Guo Ping ^[6] (2017) proposed the application of technology and management methods to reduce aircraft energy consumption. Tian Lijun and Yu Jian ^[7] (2018) define the essence of green civil aviation as a development method, and its connotations include "conservation and environmental protection", "high-quality development", "coordinated development", and "human-oriented development".

Air China, as a large airline, its work on green civil aviation can reflect to a certain extent the dynamic trend of my country's airlines in the development of green civil aviation. The development status of airlines is analyzed, and the entropy TOPSIS method is used to comprehensively evaluate the development level of green civil aviation and assign weights to each secondary index. Through the analysis of the results of Air China's green civil aviation development in the past ten years, it provides reference suggestions for the company's green construction and development.

2. Overview of Green Civil Aviation

The concept of green aviation was first proposed in European and American countries at the beginning of the 21st century and was widely accepted by the aviation industry. Its four core elements are humanized services, environmental protection, technology, and economy. With the rapid development of China's economy, the people's pursuit of quality of life is also constantly improving, and our civil aviation industry has also faced the dual test of energy conservation, emission reduction and greatly improved demand. The rigid demand for civil aviation transportation will inevitably lead to passive growth in fuel consumption and carbon emissions. The development of green civil aviation is an important content of the ecological civilization construction of China, and it is also an inevitable requirement for the high-quality development of the civil aviation industry of China.

3. Index system construction, research methods and data sources

3.1. Construction of index system

Based on the scientific, systematic, quantifiable, and measurable principles of constructing an evaluation index system, and with reference to existing literature research, this article combines environmental protection, technology, conservation, and humanization from four perspectives, combined with the "Civil Aviation Energy Conservation and Emission Reduction 13 Five Plans", select 8 secondary indicators that fit the development characteristics of Air China in the past ten years, and combine the entropy method to obtain a comprehensive evaluation index system and weights for the green development level of Air China. See Table 1 for details.

Table 1 Comprehensive evaluation index system of green development level of Air China

First level indicator	Secondary indicators	Attributes of indicator	Weights
Environmental friendly	Fuel consumption per ton-kilometer X_1	negative	0.195
	Water consumption X_2	negative	0.195
	Electricity X_3	negative	0.083
Saving	Per unit total energy consumption X_4	negative	0.036
Technology	Research and development expenses X_5	positive	0.264
Humanize	Passenger satisfaction X_6	positive	0.065
	Flight execution rate X_7	positive	0.046
	High-end passenger satisfaction X_8	positive	0.116

3.2. Research methods

Evaluation is an important cognitive activity that frequently occurs in human society, and it is a basic decision-making task. In the process of solving practical problems, there are often comprehensive evaluation problems, such as the comprehensive evaluation of environmental quality and the comprehensive evaluation of teaching quality. Evaluation is to construct an evaluation index system for the research object, use certain methods and models to analyze the collected data, and make a quantitative and comprehensive judgment on the evaluation target. There are many methods for comprehensive evaluation, such as analytic hierarchy process, fuzzy comprehensive evaluation method, grey system method, TOPSIS method and so on. Topsis method is a common method for multi-objective decision-making analysis of limited schemes in system engineering. It is based on the normalized original data matrix to find the best and worst plans among the finite plans, and then calculate the distances between the evaluation objects and the best and worst plans to obtain each evaluation object and the best plan. The relative closeness of the two is used as the basis for evaluating the pros and cons.

This article uses entropy weight method and TOPSIS method to analyze. The main principle is to first use the entropy weight method to determine the weight of each secondary index, and then use the TOPSIS method to rate the data of Air China in the past ten years. The main calculation steps for evaluating the development level of Air China by using the entropy method and the TOPSIS method are as follows:

3.2.1 The same trend of indicators.

In the raw data indicators, the lower the values of the four indicators of fuel consumption per ton-kilometer, water consumption, electricity, and per unit total energy consumption, the better, so these four indicators are called low-quality indicators; the higher the values of other indicators, the better, it is called a high-quality index. According to the above data, the four low-quality indicators of X1, X2, X3, and X4 are converted into high-quality indicators through the reciprocal method.

3.2.2 Non dimensional of indicators.

Perform normalization processing according to the same trending data, and the normalization processing formula is shown in Equation 1:

$$x'_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (1)$$

Since the value of 0 cannot appear in the calculation process of the entropy method, it is necessary to perform coordinate translation of the non-dimensional index. The formula is:

$$G_{ij} = x'_{ij} + B \quad (2)$$

Among them, B is the translation amplitude. The smaller the value of B, the more significant the evaluation effect. In this paper, B is 0.0001, and the normalized numerical matrix is shown in Table 2:

Determine the weight of each indicator.

First, obtain the information entropy of each index from Equation 3.

$$e_i = -\frac{1}{\ln n} \sum_{i=1}^n p(x_i) \ln p(x_i) \quad (3)$$

Then bring the information entropy value of each indicator into Equation 4 to determine the corresponding weight w_i of each secondary indicator.

$$w_i = \frac{1 - e_i}{\sum_{i=1}^n (1 - e_i)} \quad (4)$$

Calculated according to the above formula as shown in Table 2:

Table 2 Evaluation index system weight table

	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	Weights
Per unit total energy consumption	1.907	2.351	2.515	2.465	2.418	2.403	2.477	2.423	2.415	2.814	0.036
Fuel consumption per ton-kilometer	2.809	3.378	2.809	3.378	2.809	3.378	2.809	3.378	2.809	3.378	0.195
Research and development expenses	1.794	4.914	1.071	0.945	0.144	0.236	0.282	0.181	0.202	0.350	0.264
Water consumption	2.273	2.031	2.273	2.030	2.273	2.031	2.273	2.031	2.273	2.030	0.195
Electricity	5.429	5.114	5.977	6.656	7.440	7.467	7.730	8.512	9.203	10.510	0.083
Passenger satisfaction	83.000	81.400	90.600	88.000	87.32	87.200	88.900	84.100	79.600	78.100	0.065
Flight execution rate	0.990	0.980	0.980	0.980	0.980	0.990	0.980	0.990	0.980	0.970	0.046
High-end passenger satisfaction	82.100	82.000	89.500	88.200	87.26	87.000	87.120	85.280	83.270	82.140	0.116

3.2.3 Constructing a weighted normalization matrix.

Use the above entropy method to determine the weight of each index and the normalized matrix to construct a weighted normalized matrix.

$$Z = (r_{ij})_{m \times n}$$

$$z_{ij} = w_i P_{ij} \tag{5}$$

3.2.4 Determine the set of positive and negative ideal solutions Z1 and Z2.

Determine the maximum value and minimum value of the index respectively. The maximum value of the index constitutes the set Z1 of positive ideal solutions; the minimum value of the index constitutes the set Z2 of negative ideal solutions.

$$\begin{cases} Z1 = (r_1^+, r_2^+, \dots, r_n^+) \\ Z2 = (r_1^-, r_2^-, \dots, r_n^-) \\ r_j^+ = \max r_{ij} \\ r_j^- = \min r_{ij} \end{cases} \tag{6}$$

3.2.5 Calculate the Euclidean distance of the sample.

Calculate the Euclidean distances d^+ and d^- to the positive ideal solution and the negative ideal solution for different schemes. The specific calculation is as follows:

$$\begin{cases} d_i^+ = \text{dist1} = \sqrt{\sum_{j=1}^n (r_{ij} - r_j^+)^2} \\ d_i^- = \text{dist2} = \sqrt{\sum_{j=1}^n (r_{ij} - r_j^-)^2} \end{cases} \tag{7}$$

3.2.6 Determine the closeness Ci of each year to the ideal solution.

The closeness reflects the closeness of different schemes to the positive ideal solution and the negative ideal solution in the change of the situation.

$$C_i = \frac{d_i^-}{d_i^+ + d_i^-} \tag{8}$$

3.2.7 Sort by year.

The larger the value of C_i , the closer the solution to the positive ideal solution, which means that the comprehensive score of the year is closer to the ideal value, indicating that Air China has optimized the development of the green civil aviation industry in that year.

3.3. Data source

The original data of all indicators are derived from the "China International Airlines Social Responsibility Report", "Air China Annual Report" and "China Statistical Yearbook" during 2011-2020.

4. Empirical analysis of Air China's international aviation green civil aviation development

4.1. Calculation results of relative closeness

This article relies on the matlab2018 software and uses the above methods to obtain the relative closeness of Air China in the past 10 years. The results are shown in Table 3 and Figure 1:

Table 3 The relative proximity table of Air China in recent 10 years

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Relative closeness	0.232	0.219	0.225	0.237	0.233	0.229	0.290	0.311	0.745	0.374

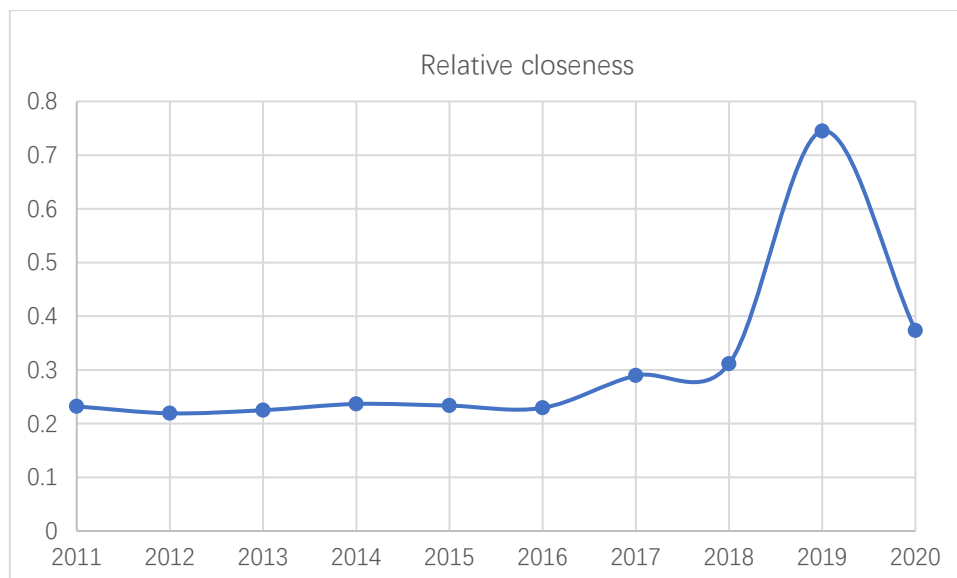


Fig.1 The relative proximity chart of Air China in recent 10 years

4.2. The results of data analysis

The relative closeness is the quantitative performance of Air China in terms of green civil aviation. The higher the relative closeness, the better that Air China has optimized the development of the green civil aviation industry in that year. The value range of relative closeness is between 0 and 1. From an overall point of view, the relative closeness of Air China's sample years is mostly small, which shows that Air China has not performed well in green civil aviation in most years. According to the relative closeness ranking results in Figure 1, from 2011 to 2018, Air China's performance in green civil aviation showed an overall upward trend, but the speed was relatively slow and there was no significant difference. In 2019, Air China's relative closeness growth rate in green civil aviation was very high. The relative closeness reached 0.745 that year. To a certain extent, this shows that Air

China has made a lot of efforts to respond to the green civil aviation policy this year. Although the relative closeness in 2020 is still higher than that from 2011 to 2018, there is still a substantial decline compared with 2019.

Regarding the above results, this article believes that before the National Civil Aviation Administration issued the "General Aviation Thirteenth Five-Year Plan" in December 2016, airlines were not very clear about the concept of green civil aviation and made fewer changes in response to this, which also led to Air China's green civil aviation score did not increase significantly from 2011 to 2016. After the promulgation of this policy, the Civil Aviation Administration issued the "Thirteenth Five-Year Plan for Civil Aviation Energy Conservation and Emission Reduction" in March 2017. The successive policies made various airlines, including Air China, begin to pay more attention to green civil aviation. With the correct guidance from the country, airlines have a certain degree of certainty in taking various measures. This also led to a steady increase in Air China's green civil aviation score from 2017 to 2018, breaking through 0.3 for the first time. When the time came to November 2018, the Civil Aviation Administration issued the "Implementation Opinions on Further Promoting the Green Development of Civil Aviation", proposing that a green civil aviation policy and standard system should be initially established in 2020. Due to time constraints, this document more specifically lists green Many key points for the development of civil aviation, so it directly led to a significant increase in Air China's green civil aviation score in 2019, reaching 0.745. In the last year of the sample year, due to the impact of the new crown epidemic, the entire air transport industry showed a downturn. Airlines encountered great difficulties in operation and performance, which was not conducive to green civil aviation to a certain extent. Development, this is also one of the main reasons Air China's relative closeness will drop sharply in 2020.

5. Conclusion and inspiration

From the above analysis, we can see that, as a very representative domestic airline, Air China has made considerable progress in the development of green civil aviation in the past ten years, but such progress is obviously not enough. Using Air China's data as a sample study, it can be concluded that the entire civil aviation industry still has a long way to go in terms of environmental protection. Only by choosing the right method and implementing it firmly can we go further in the future. The following is the enlightenment that this article puts forward:

5.1. Actively respond to the pressure to reduce emissions

As more and more passengers choose air transportation to meet their own travel needs, the total energy consumption and carbon emissions are bound to increase year by year. China's international commitments to address climate change and the ICAO's aviation carbon emission reduction targets have caused my country's aviation industry to face increasingly stringent hard constraints on carbon emissions. Therefore, airlines should take precautions, fully estimate future pressures to reduce emissions, and prudently deal with uncertainties brought about by policy and environmental changes, such as the sudden epidemic. Establish a set of emergency plans to enable efficient operations without neglecting energy conservation and environmental protection when these uncertainties occur.

5.2. Establish a stable financial support system for green civil aviation

In the critical period when the investment effect of the financial special funds for energy conservation and emission reduction is beginning to show, we should not stop at it. Under the principles of economic feasibility, financial affordability, and social acceptability, incentives and restraints and benefit adjustments should be continuously strengthened, and the screening, process monitoring and post-evaluation of green civil aviation construction projects should be strengthened to form a comprehensive civil aviation infrastructure. Build a green civil aviation financial support system for civil aviation transportation equipment, and civil aviation transportation production. Only

in this way can airlines experience the country's importance and support for green civil aviation, and cooperate more actively with the country's vigorous development of green civil aviation.

5.3. Optimizing technology to achieve green civil aviation

Green civil aviation must adhere to the principle of ecological priority and implement the basic national policy of saving resources and protecting the environment. Through organization, planning, management and operation technology, such as flight planning, optimization of flight routes, utilization of new technologies, aircraft optimization, ground equipment replacement APU and other measures, Reduce resource consumption and environmental pollution, improve the ecological environment, and realize the green, circular and low-carbon development of civil aviation.

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