Research on Factors Affecting Green Airport Development Based on Scale Analysis

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Abstract: This paper adopts the mixed methods of literature survey, expert panel discussion and questionnaire, and makes use of the Likert scale with an aim to select the connotation of green airport from four aspects including resource saving, environment friendliness, efficient operation and people-orientation. An ordered multi-class regression model was used as well to analyze the main factors affecting the development of green airports. According to the results of the study, coordinating airport planning and construction, airspace system reform, APU replacement, and “oil-to-electricity” of airport vehicles are factors that are significantly effective in the establishment of a green airport. The findings of the present study provide both theoretical support and empirical evidence for the design demonstration and interpretation of green airport policies.

1. Introduction
Since the 21st century, the rapid development of China’s national economy has promoted the development of the air transport industry. As an important infrastructure of the transport system, the airport is not only an important node in the air transport network and an important infrastructure for regional economic development, but also an urban and regional economic growth point and a pillar of a pluralistic society. With the advent of new large aircraft and the increase in the number of airports, China has entered into the ranks of large and busy aviation hubs, thus triggering higher demands for airport facilities, safety, capacity and information services together with greater impact on environment due to airport construction and operation. Therefore, building a green and low-carbon airport, improving service support capabilities, advancing technological progress and energy conservation and emission reduction have become the basic principals and goals of China’s civil aviation airport development in today’s China. What kind of airport is considered a green airport? What factors are affecting the green development of the airport? These issues have become the most important research topics in the field of green airport development. This article follows the principles of applicability, advancement, and guidance, aiming at resource conservation, environment friendliness, efficient operation, and people-orientated connotations. It establishes an orderly multi-class regression model, analyzes key factors for achieving green airports, and provides reference for decisions for airport green development programs.

2. Literature Review
Relevant literature research on green airports mainly focuses on the connotation of green airports and
the implementation path of green airports. The connotation of green airports depends, to a large extent, on the connotative characteristics of green development. Hu (2014) believes that the connotation of green development is the harmonious coexistence of economy and ecology; Song and Cui (2015) studied the ecological development of civil aviation airports based on path-dependent models [1]; Shen and Fan (2016) researched and designed the environmental assessment standards and indicator system of civil aviation airport based on the concept of sustainable development[3]; Zhang (2017) believes that goals towards green development cover efficiency, harmony and sustainability.

Existing literature has studied the path of green airport practice from multiple perspectives. Firstly, in terms of mechanism and implementation path, Li (2018) believes that ecological awareness is the precursor of green development, and ecological technology and ecological system are the basic support and guarantee, respectively. Zhao (2015) and others analyzed the background of the EU aviation carbon tax policy and the squeeze on the development space of China’s civil aviation industry; Guo (2017) proposed that the optimization of air traffic routes could achieve fuel saving and consumption reduction; Sun (2018) and others introduced Industry application of sustainable aviation fuel technology.

From the perspective of research content, all of these studies seem to be fragmented themes of green airport development, lacking an overall framework and systematic theoretical exploration. In this paper, questionnaire surveys are used to select green airport connotation and implementation path through Likert scales. An ordered multi-class regression model is used to explore the micro-mechanism of the key implementation path of the main connotation of green airports.

3. Connotation of green airport

The green airport is essentially a development mode, emphasizing the concept of sustainable development in the process of air transport production and operation services, with the meanings of “resource conservation”, “environmental friendliness”, “efficient operation”, and “people-orientation”. The goal is to achieve a harmonious development of the environment, resources, society and the future.

“Resource conservation” realizes the green cycle and low-carbon development of civil aviation. Green airports must adhere to the principle of ecological priority, implement basic national policies to conserve resources and protect the environment, reduce resource consumption and environmental pollution, improve the ecological environment, and realize the green cycle and low-carbon development of civil aviation through measures such as new technology utilization, and route planning.

“Environment-friendliness” realizes the positive interaction between civil aviation development and environmental protection. Within the industry, air transport is a complex multi-system fusion. Only coordinated operation can ensure an efficient and smooth operation mode. Outside the industry, it is necessary to coordinate the development of airlines, the layout and type of airports, and the harmonious coexistence of airport and city overall construction planning and city functions.

“Efficient operation” reflects the high-quality development concept of green airports. Infrastructure resources of China’s civil aviation are still scarce with problems such as insufficient airspace resources, backward industry management mechanisms, and unreasonable route layout. The high-quality development of green airports can show the influence, innovation, radiation and driving force of the industry, forming a new growth point for the development of green airports.

“People-orientation” is mainly reflected in high-quality and convenient services. However, the service levels are slightly different from the passenger's expectations. Through scientific and reasonable design and the application of new equipment and technologies, improving the civil aviation green service process and improving the passenger travel experience can not only effectively improve the passenger's sense of acquisition and recognition, but also effectively improve resource utilization.
4. Empirical analysis of the factors affecting the development of green airports

4.1. Scale analysis
This article summarizes the green airport’s realization path into four dimensions of green development including government regulation, management innovation, technological progress, and market mechanism. In the formal questionnaire, experts were asked to follow the five-point scale for the major categories and details of the green airport practice path. And their answers were scored by the Likert scale. Cronbach’s coefficient method and KMO test were used to test the reliability and validity of the questionnaire, and the results were satisfactory.

Table 1  Descriptive statistics of factors affecting green airports

| Indicator type | Code | Indicator Content                          | Mean | Indicator type | Code | Indicator Content                          | Mean |
|----------------|------|-------------------------------------------|------|----------------|------|-------------------------------------------|------|
| Government Regulation | Mean=4.31 | A1 Coordination of airport planning and construction | 3.52 | Technology Development | Mean=4.21 | C1 Engine energy saving retrofit | 3.71 |
|                 |      | A2 Promotion of airspace system reform   | 4.64 |                      |      | C2 Biofuel                                | 1.05 |
|                 |      | A3 Flight normal management system       | 2.93 |                      |      | C3 New energy applications                | 3.79 |
|                 |      | A4 Permission of trial flights            | 2.01 |                      |      | C4 Fleet optimization                      | 4.14 |
|                 |      | A5 Special supporting fund for Civil Aviation development | 1.04 |                      |      | C5 Retrofit wingtip                        | 2.67 |
|                 |      | A6 Advancement of monitoring capabilities | 3.13 |                      |      | C6 Smart engine cleaning                   | 2.89 |
|                 |      | A7 Optimization of industry operation service standards | 2.93 |                      |      | C7 Airborne APU replacement                | 3.91 |
|                 |      | A8 Construction of Green Civil Aviation Standard System | 3.61 |                      |      | C8 Airport vehicles “oil to electricity”   | 3.87 |
|                 |      | A9 Construction of Aviation Industry Park | 2.96 |                      |      | C9 Aircraft weight loss                    | 0.62 |
|                 |      | A10 Reform of ‘Simplifying Business’      | 2.24 |                      |      | C10 Aircraft de-liquid recovery ice         | 0.38 |
|                 |      | A11 Reform of industry mixed ownership   | 1.36 |                      |      | C11 Upgrading of sewage treatment          | 0.31 |
|                 |      | A12 Negotiations upon international climate change | 2.41 |                      |      | C12 System of temporary air route data     | 2.86 |
|                 |      | A13 Construction of Civil Aviation enterprise MRV | 3.19 |                      |      | C13 Soil and water conservation            | 1.92 |
|                 |      | A14 Policy of 24-hour customs clearance  | 1.39 |                      |      | C14 Construction of meteorological          | 2.42 |
| Management Creativity | Mean=3.87 | B1 Fuel saving optimization for flight operation | 2.52 |                      |      | D1 Carbon market                           | 1.09 |
|                 |      | B2 Fleet energy saving management based on QAR | 2.62 |                      |      | D2 Environmental tax                       | 1.03 |
|                 |      | B3 Route network optimization            | 3.44 |                      |      | D3 Third party carbon verification          | 0.78 |
|                 |      | B4 ISO energy management system          | 2.53 |                      |      | D4 Theoretical research and application     | 1.41 |
|                 |      | B5 Perfection of energy management system | 3.16 |                      |      | D5 Third-party governance                  | 0.79 |
|                 |      | B6 Noise control                         | 1.91 |                      |      | D6 Energy audit                            | 0.53 |
|                 |      | B7 Ecological policy and planning        | 2.96 |                      |      |                                           |      |
|                 |      | B8 Application of “Serve with Love” policy | 3.19 |                      |      |                                           |      |

The descriptive statistical results in Table 1 indicate the following findings. First of all, of the four connotative latitudes of green airports, “resource conservation” is the most recognized one; the
average score of “efficient operation” is second only to energy conservation and environmental protection; the average score of “environment friendliness” is 4, which means that coordinated development is also an important indicator of green airports; “people-orientation” has the lowest average score in the importance evaluation, reflecting that different experts have different cognitive awareness upon the types of services, scope of services, service capabilities and service levels that the civil aviation should have. Besides, in terms of government regulations, “Promote Airspace System Reform” has the highest average score among all options, indicating that experts highly agree that airspace institutional contradictions and institutional obstacles are the bottlenecks restricting the development of civil aviation; green airport standard system construction and MRV construction shows the basics; it is very important to coordinate the planning and construction of the airport and the "three capabilities"; the other options have low recognition and the average score is less than 3, indicating that these measures have limited and single effects and belong to non-critical paths. Thirdly, with regard to management innovation, only the three options, namely "route network optimization", “improved energy management system”, and “simplified approach management for departures and departures” with an average value of more than 3 points further demonstrate the key role of air traffic control technology for green airports. Next, from the perspective of scientific and technological progress, airlines have generally scored higher on green environmental protection measures, such as “Fleet Optimization” and “Engine Energy-Saving Reform”. The average scores of “energy-saving products and new energy applications”, “bridge-mounted equipment instead of airborne APU”, and “ground-to-vehicle oil-to-electricity conversion” also exceeded 3 points. Finally, the overall market mechanism is not optimistic in the development path of green airports, and the average score is generally low. At present, the only relatively significant effect in the civil aviation field is the “carbon market trading mechanism”.

4.2. Model construction
Due to the multiple connotation characteristics of green development, its implementation path must also be multi-pronged and comprehensive. In order to verify the action mechanism, to influence path and the overall effectiveness of specific route measures, this paper makes use of the four specific connotation goals of the green airport as the dependent variables and forty-two route measures as the independent variables to construct an ordered multi-class “logit” regression model:

\[ Y_i = \beta_0 + \beta_1 A_j + \beta_1 B_j + \beta_1 C_j + \beta_1 D_j + \varepsilon \]

Among them, Yi represents the four specific goals of “resource conservation”, “efficient operation”, “environment-friendliness”, and “people-orientation” of green airports, and Aj, Bj, Cj, and Dj respectively represent government regulation (14 variables) and management innovation (8 variables), technological progress (14 variables) and market mechanism (6 variables), \(\beta_0\) is the intercept term and \(\varepsilon\) is the random perturbation term.

4.3. Regression analysis of factors affecting green airports
The analysis of the Model regression shows that the R2 of the four models is 0.429, 0.387, 0.415, and 0.368 respectively, and the goodness of fit is satisfactory. The chi-square statistics of the model are divided into 41.908, 90.037, 80.151, and 38.341, all of which are significant at the 1% significance level, and the D-W value is close to 2, which indicates that the model has significant statistical significance and has a good explanatory power. Table 2 shows that the regression results of the model largely fit the conclusions of the descriptive statistics. Coordinating the planning and construction of the airport and promoting the reform of the airspace system show significant statistical significance in the four models, indicating that infrastructure construction is still an important bottleneck which constrains the development of China’s civil aviation. The preliminary planning of the national airport’s macro overall layout, individual airport scientific location, and rational design of functional areas can reduce energy consumption, emissions, and damage to the ecological environment during later operations. The safe, efficient, intelligent, and coordinated modern air traffic control system is an important symbol of a strong civil aviation country, and also an important support for the coordinated
development of civil aviation and the development of humanities. The replacement of airborne APU by bridge-borne equipment and “oil-to-electricity” of airport vehicles are all substitution measures, which are significantly effective in energy conservation and environmental protection goals and high-quality development goals, showing that experts highly recognize the substitution measures. APU alternative measures use ground power and air-conditioning units to supply air to the aircraft, which can effectively reduce fuel consumption, engine noise and carbon emissions, and improve passenger comfort. “Optimizing industry service standards” is a key measure in the coordinated development of civil aviation and the development of humanities. Service is an essential feature of the civil aviation industry. Standardizing service methods and service processes can improve the operational efficiency of transportation companies, the efficiency of service unit support, the command efficiency of air traffic control units, and the efficiency of industry communication and collaboration.

| model | dependent variable | independent variable | estimate | Std.Error | Wald | Sig |
|-------|--------------------|----------------------|----------|-----------|------|-----|
| 1     | Resource Conservation | A2 | 0.582 | 0.273 | 5.684 | 0.028 |
|       |                    | A6 | 0.499 | 0.305 | 4.506 | 0.032 |
|       |                    | A8 | 0.598 | 0.317 | 6.583 | 0.028 |
|       |                    | B5 | 0.411 | 0.245 | 2.719 | 0.105 |
|       |                    | C3 | 0.471 | 0.318 | 8.290 | 0.058 |
|       |                    | C7 | 0.492 | 0.301 | 4.698 | 0.025 |
|       |                    | C8 | 0.683 | 0.311 | 5.604 | 0.014 |
|       |                    | C4 | 0.57 | 0.302 | 2.358 | 0.066 |
| 2     | Efficient Operation | A1 | 0.522 | 0.213 | 4.011 | 0.083 |
|       |                    | A3 | 0.613 | 0.576 | 3.433 | 0.052 |
|       |                    | A6 | 0.674 | 0.359 | 4.084 | 0.054 |
|       |                    | A7 | 0.432 | 0.256 | 3.801 | 0.073 |
|       |                    | A14 | 0.114 | 0.347 | 2.564 | 0.113 |
|       |                    | C4 | 0.625 | 0.319 | 6.786 | 0.023 |
|       |                    | C12 | 0.802 | 0.311 | 9.345 | 0.001 |
| 3     | Environment Friendliness | A2 | 0.462 | 0.217 | 3.272 | 0.018 |
|       |                    | A7 | 0.564 | 0.341 | 3.415 | 0.069 |
|       |                    | A8 | 0.683 | 0.374 | 4.107 | 0.058 |
|       |                    | A13 | 0.469 | 0.310 | 4.394 | 0.105 |
|       |                    | B6 | 0.624 | 0.374 | 2.837 | 0.116 |
|       |                    | D1 | 0.216 | 0.259 | 14.117 | 0.003 |
| 4     | Human Orientation | A2 | 0.613 | 0.274 | 4.524 | 0.081 |
|       |                    | A3 | 0.621 | 0.296 | 6.619 | 0.063 |
|       |                    | A5 | 0.582 | 0.278 | 5.728 | 0.024 |
|       |                    | A7 | 0.365 | 0.219 | 4.192 | 0.041 |
|       |                    | A10 | 0.116 | 0.412 | 6.279 | 0.091 |
|       |                    | B8 | 0.705 | 0.308 | 5.702 | 0.084 |

The regression results of Model 1 also show that fleet optimization and engine energy saving transformation can better explain the changes in energy saving and environmental protection, but the effects of measures such as aircraft weight reduction, sewage treatment, and deicing liquid recovery are not obvious. This shows the “anchoring effect” of corporate strategic planning on green development. If strategic mistakes in route planning and aircraft procurement are difficult to make up for by tactical measures such as engine cleaning and aircraft weight reduction, the regression results of Model 2 have no additional information with a comparison to the descriptive statistics. The regression results of Model 3 shows extra findings that “industry operation service standards”, “international climate change negotiations”, “ecological policy and planning” and “carbon trading market” are key factors affecting the coordinated development of civil aviation. Actively responding to international climate change negotiations can secure development space for China’s civil aviation and protect the rights and interests of developing countries. Scientific ecological planning is the “constitution” of the
coordinated development of civil aviation, the environment, and society. Good ecological policies are the institutional guarantee for the construction of green airports, and are also a yardstick for evaluating the development quality of green airports. The carbon trading market provides alternative solutions for air transport companies with high emission reduction costs, poor self-adjustment capabilities, and slow adaptation to emission reduction requirements. The regression results of Model 4 include “normal flight management system” and “simplified business”. Change is the key path of human development. Flight normality is a barometer of industry management and a core concern of air passenger travel. E-tickets, self-service check-in, barcode identification of boarding passes, electronic luggage tags, electronic freight and other “simplified business” changes can not only reduce paper documents in the air transport chain, reduce business costs, and most importantly, simplify passenger access Port process, shorten the transit time of passengers at the hub airport, improve transportation efficiency, and optimize passenger service experience. The price mechanism, as the most sensitive and effective adjustment mechanism in the market mechanism, is not statistically significant in the model because the current rigid and distorted energy and environmental prices cannot internalize the ecological environment costs in civil aviation companies.

5. Conclusion
Scientific planning is the top design for the development of green airports. “Fixing the first button” is the most important for green airport construction. Airport planning and route network planning are the guidelines for green airport construction. They are the top-level design that promotes the solution of airspace and time resource constraints and corrects the distortion of the configuration of elements. Airlines are the industry’s largest energy users and emitters, and they are the “bull noses” for green airport construction. Scientific planning is needed for the top-level design of green airport development.

Scientific and technological innovation is still the “engine” of green airport construction. The application of new technologies such as ARVR technology, PBN, biometric technology, A-CDM, simulation technology, ADS-B, RRID and IoT technology, MLAT, GIS / BIM, EMAS, cloud computing, and FOD detection, not only effectively reduces security threatens but also improves operational efficiency, saves energy consumption and reduces greenhouse gas emissions. Accelerating the deep integration of civil aviation with the Internet, big data and cloud computing, and artificial intelligence technologies can enhance the degree of greening of the civil aviation industry and promote new forms of civil aviation.

To vigorously develop green airports, market mechanisms should be implemented in the carbon emission reduction system. Environmental taxes can internalize the cost of pollution and enhance the endogenous motivation for green development of enterprises. Third-party environmental governance can improve the professional level of energy conservation and emission reduction and reduce supervision costs. The carbon trading market promotes energy conservation and consumption reduction for civil aviation transportation enterprises by setting total carbon emission quotas and trading emission quotas. Aviation carbon verification can ensure the integrity and authenticity of carbon inventory data, prevent illegal stealing and omission of emissions by enterprises, and is also the basis for enterprises to participate in carbon trading, fight for carbon quotas, manage carbon assets and explore space for emission reduction.

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