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Original Paper

Empirical Study on the Promotion of Industrial Structure Upgrading by Aviation Economy: A Case Study of National Airport Economic Zones

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Abstract

With the rapid growth of civil aviation and economic integration, aviation economic zones centered on large airports have a significant economic impact on surrounding areas. These zones foster the concentration of technology, capital, and labor, leading to the emergence of new regional economic models. This research, based on data from 17 national-level aviation economic demonstration zones, develops an evaluation index system for aviation economic development and constructs a regression model incorporating industrial structure coefficients. It empirically analyzes the relationship between the development of aviation economy and the upgrading of industrial structure in cities with national-level aviation economic zones, revealing the aviation economy's role in promoting industrial structure upgrading and providing policy recommendations for regional economic innovation.

Keywords

aviation economy, aviation economic zones, industrial structure, panel regression

1. Introduction

With the advent of the new era, people's demands for material and spiritual life continue to grow, pursuing a higher quality of life and more efficient services. The aviation economy, as a development of the air transport industry, is gradually becoming an important means to meet these needs. The growth of the aviation economy not only improves transportation methods and service experiences, but also, due to its concentration of high technology, talent, and capital, has become one of the most

competitive industries globally. The impact of the aviation economy on regional development is profound; it not only shapes the regional spatial form and industrial layout but also enhances the livability of cities, attracts high-tech manufacturing enterprises, promotes the transformation and upgrading of industries, and strengthens regional competitiveness. The development of the aviation economy, supported by the air transport industry, is more in line with the trend of the times, and the passenger throughput of the air transport industry is also increasing year.

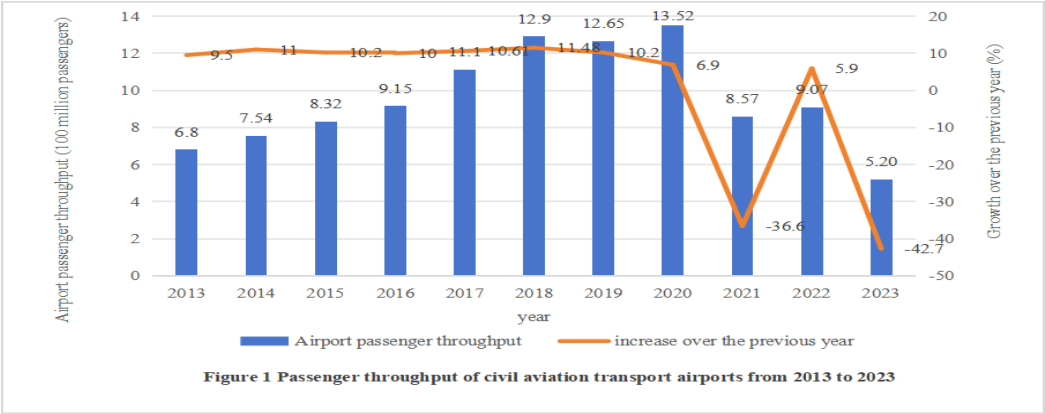

Figure 1 Passenger throughput of civil aviation transport airports from 2013 to 2023

Figure 1. Passenger Throughput of Civil Aviation Transport Airports 2013 to 2023

Currently, major cities around the globe are actively developing the aviation economy, recognizing its key role in promoting high-quality development, constructing a new dual circulation development pattern of domestic and international economies, and achieving long-term development goals. Empirical research indicates that the development of the aviation economy is an important driving force for the transformation and upgrading of regional industries, which is of significant importance for understanding the elements of aviation economic development and utilizing it as a new engine for China's economic growth.

2. Literature Overview

The promoting effect of aviation economy on industrial structure upgrading is a gradually deepening process, involving multiple research stages. In the initial stage, scholars laid the foundation for the relationship between aviation economy and regional development through theoretical exploration and conceptual definition, such as An Yibin's (2022) research. Subsequently, researchers used quantitative methods, such as the Analytic Hierarchy Process (AHP) adopted by Jinlu (2011), to scientifically analyze the selection of dominant industries in the Hainan Airport Economic Zone, while Song Xinming (2014) proposed an industry selection strategy that combines the development goals of the tourism island for the Hainan Airport Economic Zone. Further research has focused on industrial layout

and strategic planning. The research group of Henan Academy of Social Sciences (2016) conducted a case study to investigate the leading role of Zhengzhou Airport Economic Comprehensive Experimental Zone, providing new ideas for regional economic development.

Entering the empirical analysis stage, Yang Yuanyuan et al. (2022) used principal component analysis to quantitatively study the industrial selection of the air economic zone in Yubei District, Chongqing, and provided strategic suggestions for industrial upgrading. Feng Yan's (2021) empirical research emphasizes the importance of industrial chain synergy in promoting industrial structure upgrading. Han Mingming (2017) and other scholars used the method of analyzing the impact of urban form evolution to evaluate the impact of aviation economic development on urban form, and proposed strategies to optimize urban spatial layout. Scholars such as Xia Xinghua (2011) have emphasized the positive role of aviation economy in upgrading industrial structure, while subsequent empirical studies have more specifically explored the impact of aviation economy on specific aspects such as urban form, industrial selection, and spatial layout. Jiang Yushi et al. (2019) explored the industrial selection and spatial layout planning of the airport economic zone at Chengdu Tianfu International Airport, addressing the issue of interactive integration between the airport economy and regional economy.

3. Theoretical Analysis of Promoting Industrial Structure Upgrading through the Development of Aviation Economy

The aviation economy, as an emerging economic form, is on par with land, ocean, and grassland economies, focusing on the effective allocation and utilization of aviation resources. The development of the aviation economy has inherently promoted the upgrading of the tertiary industry and the transformation and upgrading of industrial structure. It can be divided into three types of industries: first, the aviation core industry, which relies directly on airport resources and is concentrated in the aviation transportation and manufacturing fields; secondly, there are emerging industries that rely on air transportation methods, which require a large amount of technology, information, resources, and knowledge; finally, the supportive service industry composed of resources such as passenger flow, material flow, technological information flow, and capital flow triggered by the first two industries, namely the aviation industry, is becoming an important force in promoting structural upgrading.

This article proposes the idea of optimizing and upgrading the industrial structure based on the aviation industry from the perspective of industrial structure upgrading. The aviation and aerospace industry is a high-end manufacturing industry, with upstream industries including materials, electronics, and other industries, while downstream industries include transportation, communication, tourism, and entertainment. The aviation industry has strong advantages in resource integration, technology integration, and other aspects, which can achieve horizontal, vertical, and all-round extension, thereby improving its width and thickness, and driving the development of aviation and related industries.

Developing a regional aviation and aerospace industry chain will drive the development of the aviation and aerospace industry in terms of scale, employment, and high-tech industries within the region. At the same time, due to the aggregation of technology and capital, the aviation industry's maintenance, logistics, exhibition, leasing, insurance, training, and other related upstream and downstream service industries will develop rapidly and well. As a result, the proportion of high-end service industries and intelligent high-tech industries in the region will increase, gradually achieving the transformation or upgrading of the regional industrial structure.

The air transportation and logistics industries are high value-added industries, with an increased dependence on air transportation methods, and a concentration of fast and high-value industries and service industries. The increasing demand for high-tech, small volume, and high-value civil aviation transportation has driven the upgrading of the aviation economy and industrial structure. The aviation economy has promoted the agglomeration of high-end manufacturing and high-tech industries, with high technological content, promoting the upgrading of related industries. For example, the transformation of Foxconn and the development of China's aircraft manufacturing industry are both driving forces for the formation of aviation hubs. In some cities, such as Shandong, Shaanxi, and Guangdong, the aviation industry has become a new economic growth point, and the agglomeration of aviation hubs is an effective way to improve industrial structure. The aviation induced industry gathers the core aviation industry and related industries, including passenger flow, cargo flow, information flow, and capital flow. For example, the development of cross-border e-commerce and free trade relies on the support of the aviation economy. Under the "going global" strategy, the aviation economy not only helps to explore new markets and resources, but also plays an important role in both international and domestic markets, providing new support and ideas for the overall development strategy of the country.

4. Measurement of Aviation Economic Development

4.1 A Measure of the Development of the Aviation Economy

Construction of evaluation index system for aviation economic development

The process of evaluating the development of aviation economy is the measurement of national level airspace economic zones and the expectation of improvement. This article sets up two levels of indicators, with the first level reflecting the specific connotation of aviation economic development, as well as the process, mode, and path of aviation economic development. The second level indicator is a refinement of the first level indicator, highlighting problem orientation, and is currently the focus and main direction of promoting aviation economic development. According to the characteristics of the aviation economy, it can be seen that the development level of the aviation transportation industry, the supporting factors of the aviation economy, and the development level of core industries have become important standards and basis for evaluating the high-quality development of national level aviation

economic zones. The following secondary indicators were established by reference and their positive and negative values were clearly defined, as shown in Table 1:

Table 1. Evaluation Index System for Aviation Economic Development

Level 1 indicators	Level 2 indicators	direction
The level of development of the air transport industry	Airport passenger throughput Airport cargo and mail throughput	+
	Aircraft takeoffs and landings	+
	Number of international and domestic routes	+
	Number of operating airlines	+
The level of supporting factors for the aviation economy	GDP per capita	+
	Tertiary industry ratio	+
	Number of college students per 10,000 people	+
	Number of patent applications	+
The level of development of core industries	Industrial output value above designated size	+
	Total import and export of goods	+
	Actual amount of foreign capital utilized	+
	Total number of domestic and foreign tourists	+

4.2 Selection of Evaluation Methods for Aviation Economic Development Level

In order to describe, analyze, and evaluate the development level of the aviation economy industry, due to the intuitive data in this article, the entropy weight method is adopted. Based on the information content of various indicators related to the aviation economy and their degree of variation, the weight of each indicator is calculated. With the help of the established comprehensive evaluation indicator system, an additive model is used to generate an index for the evaluation indicators. Calculate the comprehensive index (I) of the level of aviation economic development, which is, $I=\sum_{i=1}^{n} w_i x_i$

Among them, xi is the aviation economic evaluation indicator of the jth item in the index, wi is the weight of this indicator, and n is the number of evaluation indicators. The determination of wi adopts the entropy weight method to determine the importance of each indicator. Finally, the weights of the 16 cities where the airport economic zone is located were obtained, as shown in Table 2:

Table 2. Weight Index Table

Dimensions	Indicator name	Index Weight
Development level of air transport industry （0.401265）	Airport passenger volume x1	0.0880112
	Airport cargo and mail throughput x2	0.1540702
	Aircraft takeoffs and landings x3	0.0770632
	Number of international and domestic routes x4	0.0622582
	Number of operating aerospace companies x5	0.0531702
Level of aviation economic support factors （0.339137）	GDP per capita x6	0.040068
	Tertiary industry ratio x7	0.054851
	Number of college students per 10,000 people x8	0.071378
	Number of patent applications x9	0.206178
Development level of core industries （0.259598）	Industrial output value above designated size x10	0.063740
	Total import of goods x11	0.129323
	Actual amount of foreign capital utilized x12	0.034951
	Total number of domestic and foreign tourists x13	0.034951

4.3 Evaluation of Aviation Economic Development Level in National Airline Economic Zones

As a new platform for the coordinated development of urban clusters and airport clusters, the national level airport economic zone plays an irreplaceable role in the main development of China's aviation economy. The airport economic zone also promotes regional economic development. Therefore, this article uses 17 national level aviation economic zones as materials to find corresponding indicator data for their cities, and after assigning indicator weights using the entropy weight method, a linear weighting model is used to obtain the economic development level data table of the 17 national level aviation economic zones from 2012 to 2022, and their aviation economic development situation is obtained, as shown in Table 3:

Table 3. Data on the Development Level of Aviation Economy by Region from 2013 to 2023

City	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Zhengzhou	46.37	47.45	48.5	51.49	51.13	53.55	54.78	55.15	46.75	50.35	40.99
Beijing	75.49	74.72	75.83	74.88	74.94	76.02	78.24	85.58	75.24	77.65	70.95
Qingdao	46.58	46.21	46.55	46.7	47.09	47.45	47.93	48.38	45.67	47.33	46.21
Chongqing	61.36	60.1	61.04	61.15	61.56	66.44	66.97	67.58	60.32	62.81	59.37
Guangzhou	66.54	66.23	67.39	69.23	69.98	71.05	73.58	74.23	65.95	68.26	67.31

Shanghai	60.43	60.12	60.77	61.38	60.67	62.15	62.97	62.92	58.24	60.11	56.29
Chengdu	59.24	58.89	59.58	59.79	60.59	61.44	62.18	62.72	55.24	60.13	57.56
Changsha	48.53	49.88	49.94	50.19	51.86	52.16	52.81	52.95	46.83	51.29	48.72
Guiyang	45.57	45.43	45.91	46.18	46.59	46.44	46.8	47.4	45.61	46.16	44.29
Hangzhou	54.22	54.38	54.97	55.44	55.92	56.81	57.33	57.74	49.56	53.29	50.62
Ningbo	45.39	45.23	45	45.13	45.29	46.32	46.75	47.87	41.29	43.16	40.28
Xi'an	50.85	51.77	52.31	53.12	54.19	53.57	54.14	55.18	49.28	53.92	50.11
Nanjing	52.47	50.14	53.59	54.1	54.55	54.73	55.05	57.56	51.26	54.92	50.17
Changchun	44.36	44.33	44.53	44.63	44.86	45.11	45.61	45.5	41.23	43.27	42.66
Nanning	43.36	43.49	43.61	43.87	44.18	44.58	44.77	45.07	40.31	43.27	41.62
fuzhou	44.62	44.1	44.34	44.49	44.63	44.85	45.64	45.87	41.05	43.66	42.83

At the same time, the development levels of 17 national level aviation economic zones were reflected in a line chart to show the differences in development among different cities, in preparation for the regression analysis in the following text, as shown in Figure 2.

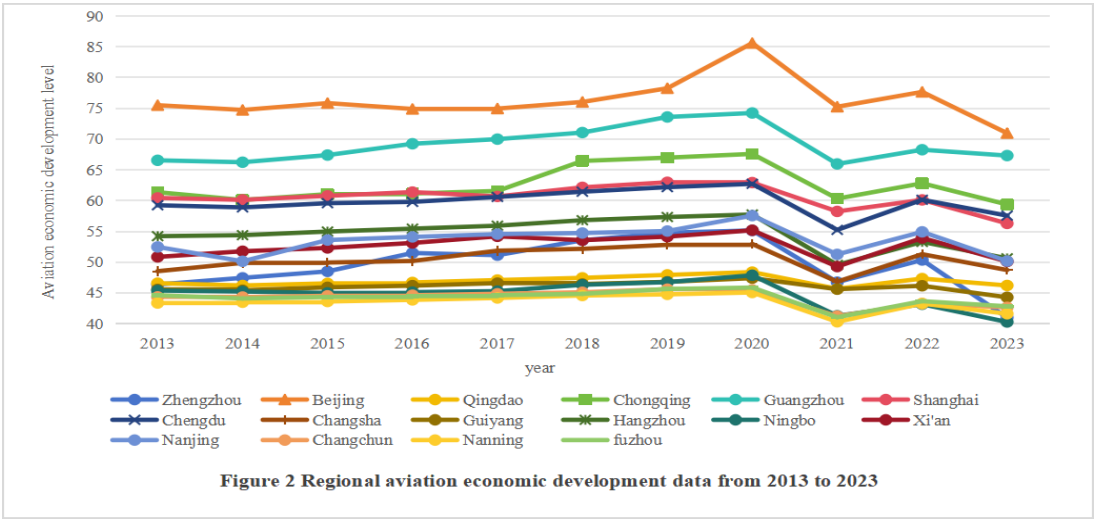

Figure 2. Regional Aviation Economic Development Date from 2013 to 2023

From the above diagram, it can be seen that the development level of each airport economic zone is generally on the rise, with Beijing and Guangzhou, two first tier cities, consistently leading the development level of other cities. Relatively speaking, cities such as Nanning, Qingdao, Chengdu, Fuzhou, and Guiyang have relatively slow and stagnant development, indicating significant differences in the level of aviation economic development among different cities in China at present. As can be

clearly seen from the graph, the development level of Zhengzhou's aviation economy has made rapid progress, reaching the maximum growth among these aviation economic zones. The reasons behind this are worth exploring. Meanwhile, the development level of Lukou Airport in Nanjing experienced a rare decline in 2013. The aviation development level in Fuzhou has also steadily improved after a slight decline in the same year. Overall, the development prospects of aviation economy in various regions are showing a positive trend.

5. Empirical Analysis of Aviation Economy Development Promoting Industrial Structure Upgrading

5.1 Data Source

5.1.1 A Measure of the Development of the Aviation Economy

This paper conducts an empirical study based on the data of 17 national airport economic demonstration zones. These data are used to establish the evaluation index system of aviation economic development, and analyze the relationship between aviation economic development and industrial structure upgrading through regression model. In order to empirically analyze the relationship between the development of aviation economy and the upgrading of industrial structure, it is necessary to support specific and reliable data. By citing previous research, we can provide theoretical basis and methodological support for the research of this paper. The data from 2010 to 2022 can reflect the trend and characteristics of aviation economic development in recent years, and the national airport economic zone has a good representativeness.

The data comes from the website of the Civil Aviation Administration of China, the National Bureau of Statistics of China, and airport survey data. The air passenger and cargo volume data of the airports in the sample cities are all from the Statistical Bulletin of Civil Aviation Airport Production.

5.1.2 Variable Selection and Model Design

At present, according to existing literature, it mainly manifests in two methods: evaluation index system and single index. And this article uses a single indicator that has emerged and been widely used in recent years—the industrial structure coefficient. The specific calculation method is to assign weights 1, 2, and 3 to the first, second, and third industries in sequence, and then add them up. The specific formula is: industrial structure coefficient (Y)=1 * proportion of primary industry output to GDP+2 * proportion of secondary industry output to GDP+3 * proportion of tertiary industry output to GDP.

Regarding the classification of the tertiary industry, both international and domestic economists believe that in the process of economic development, the proportion of the primary industry is likely to gradually decrease, while the proportion of the secondary industry will gradually increase, stabilize, and gradually decrease. The proportion of the tertiary industry will continue to increase, ultimately

forming a “three, two, and one” industrial pattern. The larger the coefficient of industrial structure, the higher the industrial structure, therefore the level of industrial structure (Y) is used as the dependent variable.

According to the evaluation index system, it will be able to specifically reflect the level of economic development, openness to the outside world, and urbanization as one of the main factors affecting the upgrading of China’s industrial structure. Therefore, in order to study the net or real contribution of aviation economic development to industrial structure upgrading, these three variables are introduced as control variables: the degree of economic development (eco): the per capita GDP of each region is used as an indicator to evaluate China’s economic development; Open degree (ope): using the ratio of the total import and export value to GDP of each region in the current year as an indicator; Urbanization process (UR): This article uses quantitative indicators of the degree of urbanization development to measure. The level of urbanization is generally expressed as the proportion of urban population in a country or region to the total population.

Establish a basic regression model based on the dependent variable, core explanatory variable, and control variable as follows:

$$Y_{it} = \alpha + X_{it}\beta_{it} + \delta_i + y_t + \varepsilon_{it} \quad , i = 1,2,3 \cdots T \quad (2.1)$$

Among them, Y_{it}represents the level of industrial structure (industrial structure coefficient), α represents the constant term of the model, δ_i refers to fixed or random cross-sectional effects, $y_t$refers to fixed or random time effects, X_{it}refers to the observationvector of the explanatory variable, β_{it} refers to the coefficient vector of the explanatory variable, and ε_{it}refers to the independent and identically distributed random error term.

For panel data, there are generally three models, namely mixed effects model, fixed effects model, and random effects model. This article first conducted a unit root test on the sample data, and found that the p-values of ADF and LLC were both less than 0.05, indicating stability. The F-test results are shown in Table 4. It can be seen that the P-value is 0.0000, which overturns the original hypothesis. Therefore, it is believed that the fixed effects model is more suitable for this set of data than the mixed effects model; Based on this result, we conducted a Hausman test and displayed it in Table 4. The results show that a random effects model cannot be used, but a fixed effects model should be used for regression.

Table 4. F-test and Hausman Test Results

	P value	result
F test	0.0000***	Reject mixed effects model
Hausman test	0.0000***	Reject random effects model

Based on this test result, it is believed that it is more reasonable to abandon the original assumption and adopt a fixed effects model. Therefore, when establishing the panel model, we used a fixed effects model.

(3) Construction of panel data model

This article takes the level of industrial structure upgrading (Y) as the dependent variable and the level of aviation economic industry development (DE) as the explanatory variable. The panel models constructed are as follows:

$$Y_{it} = \alpha + \beta_1 DE_{it} + \beta_2 ECO_{it} + \beta_3 OPE_{it} + \beta_4 UR_{it} + \delta_i + \varepsilon_{it}$$

5.2 Panel Regression Analysis of Aviation Economic Development to Promote Industrial Structure Upgrading

Descriptive analysis

In order to gain a preliminary understanding of the characteristics of variables, this section provides a detailed introduction to mean, median, standard deviation, and maximum and minimum values. As shown in Table 5:

Table 5. Descriptive Statistics of Variables

variable	N	mean	sd	min	median	max
Industrial structure coefficient	160	250.09	16.24	181.38	248.2	301.79
Aviation economic development level	160	54	9.52	43.28	52.01	85.58
Openness to the outside world	160	50.21	25.44	2.36	50.45	174.8
urbanization level	160	68.4	11.84	33.81	68.85	89.6
foreign economic development level	160	4.93	0.18	4.41	4.95	5.22

Regression analysis

Regression analysis shows that the model has passed the significance test and has an overall good degree of conformity. The regression results of the model are analyzed in Table 6:

Table 6. Regression Results

Variable	Coefficient	Std.Error	t-Statistic	Prob.
ECO	3.080250*	2.604214	1.182795	0.0587
X	0.803824***	0.06419	12.52257	0
UR	0.416013***	0.04818	8.634485	0
OPE	-0.05159**	0.018383	-2.802021	0.0207
C	166.3629***	11.19639	14.85863	0

Note: The significance levels corresponding to tables *、**、*** are 10%, 5%, and 1%, respectively

5.2.1 Analysis of the Impact of Aviation Economic Development on Industrial Structure Upgrading

This article empirically analyzes China's industrial structure using the aviation economic development index as the main explanatory variable. With the development of China's aviation industry, the industrial structure of our country is also gradually improving. Under constant control of other factors, for every 1 unit increase in the level of aviation economic development, the upgrading of industrial structure increases by 0.8038 units. Therefore, developing the aviation economy is of great significance to China's industrial structure.

5.2.2 Analysis of the Impact of Controlling Variables on Industrial StructureUpgrading

Among them, the control variable with the largest elasticity coefficient is the level of economic development, which can most affect the industrial structure. For every 1 unit increase in its level, the industrial structure coefficient increases by 3.080250 units. At the same time, the elasticity coefficient of urbanization process also shows a positive trend and is significantly positively correlated with the improvement of industrial structure. The degree of openness will have a negative impact on the improvement of industrial structure (-0.05159), because China's degree of opening-up mainly focuses on the secondary industry, while investment in the tertiary industry is relatively less. The inclination of industries related to opening up to the outside world is the main factor causing industrial structure upgrading.

5.2.3. Empirical Analysis Summary

Firstly, this article proposes a new evaluation method by evaluating the level of development of the aviation economy. The results show that from 2012 to 2022, the overall level of aviation economic development in each province was in a stable growth state, but there was a significant gap in development between regions, with the overall performance being higher in the east and lower in the west.

Secondly, an analysis was conducted on the level of industrial structure upgrading in China, and it was found that the upgrading of industrial structure in China is constantly improving, with significant

differences among provinces, but this gap is constantly narrowing. Finally, this article uses panel data from various cities in the national level aviation economic zone from 2010 to 2019 to conduct empirical analysis. Regression analysis shows that.

The development of aviation economy has a significant promoting effect on the upgrading of industrial structure. At the same time, the level of economic development and urbanization process also have a positive impact on industrial upgrading. The degree of openness to the outside world has a certain degree of inhibitory effect on the upgrading of industrial structure. So, we must seize the development opportunities of the aviation economy and accelerate the optimization and upgrading of the industrial structure.

6. Research Conclusions and Countermeasures

6.1 Research Conclusion

Through theoretical analysis, the mechanism and path of promoting industrial structure upgrading through aviation economic development were obtained. Using data from national level aviation economic zones as materials, an empirical regression model was established to verify that aviation economic development can effectively promote industrial structure upgrading. Through a combination of theoretical analysis and empirical analysis, in-depth analysis has shown that the development of aviation economy can indeed promote the upgrading of regional industrial structure. Not only does it understand the mechanism of action, but it also provides practical basis.

There are rules to follow in the development of aviation economy:

Empirical analysis was conducted using national level aviation economic zones as materials, and the evaluation results showed that the development of aviation economy has the following main elements and starting points:

The development of the aviation transportation industry is the foundation of the aviation economy. In recent years, many regions have been expanding or starting to build second airports to expand their capacity. The modern high-end logistics system mainly relies on air transportation, which inevitably leads to the disappearance of low-level and low competitive industries. The huge passenger flow, logistics, and personnel travel of air transportation have greatly promoted the development of modern service industry. Therefore, the development zones of the aviation transportation and logistics industries can promote the increase of their industrial proportion, thereby achieving the improvement of the aviation economy level and promoting the upgrading of industrial structure.

Due to the fact that the aviation economy can promote the development of related industries and lead to their growth, and form industrial hubs represented by aviation hubs, we can improve the level of supporting factors for the aviation economy, such as per capita GDP, the proportion of the tertiary industry, and the number of patent applications. To promote the improvement of aviation economy

level and further promote the upgrading of industrial structure.

At the same time, the aviation economy relies on airlines, so we can promote the development and economic level of operating airlines by increasing the industrial output value above a certain scale, increasing the total import and export volume, increasing the actual utilization of foreign investment, and increasing the total number of domestic and foreign passengers. This is also a direct way to improve the development level of the aviation economy and promote industrial structure upgrading.

6.2 Reflection on Countermeasures

6.2.1 Governments at all Levels should Strengthen their Attention to the Aviation Economy

Our country's development system requires corresponding policy guidance and promotion, targeted formulation of corresponding countermeasures, and proper top-level design. The institutional advantages of our country determine that we can invest all our resources and energy into this matter in a short period of time, especially in the aerospace industry, which is closely related to our country's strategic and economic development. Therefore, as a pillar industry of the aviation industry, the civil aviation industry should vigorously develop and grow, promote the development of the aviation industry with a national strategic perspective, and accelerate the construction of airports. As managers of the country, we should strengthen our support for the aviation industry, whether through policy formulation or institutional management.

6.2.2 *Release Airspace Control and Liberate the Market*

The current civil aviation industry is developing rapidly, but due to airspace management issues, the development of civil aviation is relatively lagging behind. As of today, the scale of China's civil aviation development has jumped to the second place in the world, but the development of low altitude areas has not been fully developed, and the market prospects are broad. Intuitively speaking, as the market expands, there is a demand for airplanes.

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