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# *An Empirical Analysis of the Effects of Public Aviation Transport Service Subsidy Policies in China: A Multi-Period DID Approach*

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***Abstract:*** Public aviation transport plays a vital role in the comprehensive transportation system of a country. To ensure the healthy development of the public aviation transport industry, the government has implemented a series of subsidy policies. Evaluating the effectiveness of these subsidy policies is of significant importance for the economic and social development of regions and the improvement of people's quality of life. This paper empirically analyzes the effects of subsidy policies on regional aviation routes using a multi-period Difference-in-Differences (DID) model based on data spanning from 2009 to 2019. The research indicates that subsidy policies have a positive feedback effect on the public aviation transport industry and are likely to continue producing favorable outcomes. However, there are regional variations in the responses to these policies. Furthermore, considering the current policy landscape and research findings, this paper offers recommendations for optimizing subsidy policies, providing valuable insights for policy decision-making.

***Keywords:*** public aviation transport, subsidy, Difference-in-Differences (DID) method

## 1. Introduction

### 1.1. Background and Significance

In recent years, the role of civil aviation in promoting national economic development and enhancing the equity of public services has become increasingly prominent. To promote the implementation of the Basic Aviation Service Plan and drive regional economic and social development, China has formulated corresponding fiscal subsidy policies for regional aviation and regional airports. For example, the "Interim Measures for the Management of Subsidies for Regional Aviation" (CAAC Letter [2013] No. 28) issued in 2013 and the "Interim Measures for the Management of Subsidies for Small and Medium-sized Airports in Civil Aviation" (Caijian [2020] No. 93) issued in 2020 represent normalized subsidy policies formulated at the central level in China. Each year, the government allocates special subsidies for regional aviation routes and regional airports to ensure connectivity in remote areas. However, the lack of an assessment of subsidy effectiveness means that government departments do not have access to relevant performance information and merely disburse subsidies based on relevant standards. Additionally, there is a lack of analysis and research on how subsidies

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can improve efficiency. Therefore, it is necessary to conduct research on how public aviation transport services in China are subsidized and the performance of such subsidies to provide decision-making references for improving subsidy efficiency.

### 1.2. Literature Review

Currently, there is limited research on the performance evaluation of subsidy policies for public aviation transport services in China. Therefore, this paper refers to existing methods for evaluating public policy. Existing methods for evaluating public policy are mainly based on empirical analysis and involve model construction. For instance, Xiangfei Xin and Yi Zhang (2016) [1] used the Trans-log production function to establish equations for the impact factors of grain production and farmer income, and evaluated them with suggested methods and interpretations of the meaning of dummy variables. Ruping Huang (2022) [2] quantitatively evaluated the effects of grain subsidy policies using a Difference-in-Differences (DID) model. Compared to the Trans-log production function, the DID model considers the influence of technological progress and input factors, making it more comprehensive, but the DID model is scientifically set up and can more accurately estimate policy effects. Both methods are reasonable. In the evaluation of subsidy policies for rural household biogas in China, Huanguang Qiu and Yaqing Cai (2013) [3] conducted estimates using the Heckman sample selection model, the Heckman two-step method, and maximum likelihood estimation. The Heckman sample selection model comprehensively considers the characteristics of biogas subsidy beneficiaries. In conclusion, in the research of performance evaluation of subsidy policies for public aviation transport services, the choice of evaluation methods should take into account the characteristics of the research objects and the characteristics of the models themselves. Therefore, for the evaluation of subsidy performance for regional aviation and regional airports in China, this paper employs the Difference-in-Differences (DID) model for quantitative assessment.

## 2. Status of Public Aviation Transport Subsidies

### 2.1. Analysis of Public Aviation Transport Subsidy Policies

Subsidy policies for public aviation transport in China include general subsidies, regional route subsidies, regional airport subsidies, and trunk route (international routes) subsidies. Some of the latest central policies are shown in Table 1.

Table 1: Summary of Central Fiscal Subsidy Policies for Public Aviation Transport.

| Publication Date | Issuing Authority | Policy Name | Core Content |
|---|---|---|---|
| September 2009 | Civil Aviation Administration of China, Financial Department | "Interim Measures for Interest Subsidy Management for Civil Aviation Infrastructure Construction Loans" | Central fiscal subsidies for civil aviation construction investment projects with loan amounts exceeding RMB 5 million. |
| January 2013 | Civil Aviation Administration of China, Financial Department | "Interim Measures for Subsidy Management for Special International Routes" | Central fiscal subsidies provided to domestic aviation transport companies operating policy-oriented international routes and regular international routes with poor economic performance but significant market potential. Subsidies are tilted towards policy-oriented routes, newly opened routes, and routes facing operational difficulties. |

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Table 1: (continued).

| | | | |
|---|---|---|---|
| March 2013 | Civil Aviation Administration of China, Financial Department | "Interim Measures for Subsidy Management for Regional Routes" | Central fiscal subsidies for aviation transport companies with poor economic performance and operational difficulties in regional routes. Subsidies are tilted towards routes connecting central and western regions, economically underdeveloped regions, and routes between regional hub airports and regional airports. |
| April 2020 | Ministry of Finance, Civil Aviation Administration of China | "Interim Measures for Subsidy Management for Small and Medium-sized Civil Airports" | Central fiscal subsidies provided to civil airports with annual passenger throughput of 2 million or less, with a focus on airports in deeply impoverished and border areas, small airports, and those emphasizing safety management. |

In 2009, the Civil Aviation Administration of China (CAAC) revised the "Interim Measures for Interest Subsidy Management for Civil Aviation Infrastructure Construction Loans," expanding the scope of loan interest subsidy projects to include civil aviation science and education construction projects. The revision also lowered the minimum loan size eligible for interest subsidies from RMB 10 million to RMB 5 million.

In 2013, the CAAC revised the "Interim Measures for Subsidy Management for Regional Routes," which extended the subsidy scope to government-designated policy-oriented routes, commuter aviation, and short-haul general aviation transport operations. Furthermore, it enhanced support for routes connecting Tibet, Xinjiang, and plateau regions, routes operated by regional aircraft, commuter routes, and short-haul general aviation transport routes. This revision aimed to make the subsidy policy more forward-looking and targeted.

In 2020, the CAAC, in collaboration with the Ministry of Finance, revised the "Interim Measures for Subsidy Management for Small and Medium-sized Civil Airports." This revision established a cumulative withdrawal mechanism for subsidies. It subdivided the "100-200 million annual passengers" category into "100-150 million annual passengers" and "150-200 million annual passengers." Overall, airports with larger passenger throughput could achieve profitability due to their scale advantage. As airports grew in size, their profit-making ability increased, leading to a gradual reduction in subsidies. This revision lowered the subsidy standards for airports with an annual passenger throughput of over 500,000 passengers, allowing for a phased withdrawal of subsidies to avoid abrupt disruptions. It also increased the variable subsidy standards. Under relatively unchanged subsidy sizes, it raised the proportion of variable subsidies to leverage the incentive effect of subsidy policies. Smaller airports with annual passenger throughputs of fewer than 300,000 passengers primarily relied on fixed subsidies, resulting in weaker variable subsidy effects. Hence, the revision maintained existing fixed subsidy standards while increasing variable subsidy standards. Airports with annual passenger throughputs of over 300,000 passengers had a certain scale foundation and stronger variable subsidy effects, necessitating further adjustments to variable subsidy standards. Additionally, the revision adjusted special subsidy policies, increasing support for airports in the four provinces of the Tibetan region, airports in the northeastern region, and airports supporting general aviation flights.

### 2.1.1. Local Fiscal Subsidy Policies for Public Aviation Transport

Under the guidance of central policies, local governments at various levels have provided robust financial support for the development of civil aviation [4]. They have formulated various subsidy policies based on different provincial development needs and priorities. For example, Anhui Province issued the "Management Measures for the Use of Special Funds for the Development of Civil Aviation in Anhui Province," establishing special funds for subsidizing public transport aviation, general aviation, special support for air traffic management, and other projects aimed at promoting civil aviation development. The Sichuan Provincial Government mentioned in the "Opinions of the Sichuan Provincial People's Government on Accelerating the Development of Civil Aviation in Sichuan" that airport construction projects are included in Sichuan Province's key projects and enjoy various preferential policies. Xinjiang Autonomous Region issued a "Notice on the Interim Regulations on Subsidies for Regional Routes in the Autonomous Region," which explicitly provided subsidies for routes that connect (fly through) various regional airports within the autonomous region and have an average passenger seat occupancy rate of over 60%.

In addition to establishing special funds for aviation development, subsidizing airport operations, and contributing to airport construction, many local governments provide subsidies for airlines that open new routes. For example, the Hainan Provincial Government subsidizes domestic regular direct flight routes to and from Haikou Meilan International Airport during non-peak hours (from 22:00 to 7:00 the next day) for different flight seasons and different aircraft seat numbers, starting from the day of operation. Each flight is subsidized for three years. The Gansu Provincial Government stipulates that China Eastern Airlines Gansu Branch receives subsidies of approximately RMB 18 million when each Airbus A320 series aircraft overnight at Lanzhou Airport and operates designated routes. Airlines bear the responsibility for profits and losses.

It is worth noting that many local governments, in their efforts to promote local economic development and enhance urban internationalization, offer substantial subsidies to attract airlines to open international routes. For example, the Qingdao Municipal Government provides subsidies for newly added international (regional) passenger scheduled flights to and from Qingdao Airport during non-peak hours (from 22:00 to 7:00 the next day). Each flight receives a subsidy of RMB 10,000, and each aircraft movement receives a subsidy of RMB 5,000. Continuous subsidies are available for up to three years. To this day, local governments continue to emphasize the development of international routes. Due to the impact of the pandemic, local governments have subsidized the resumption of international routes. For example, Xiamen issued a "Notice on Several Measures to Promote the High-Quality Development of International Air Passenger Transport," which supports the opening of Asian passenger routes, international passenger routes, and international and regional tourism business by travel agencies. It also provides annual operating subsidies for these supported routes and tourism businesses.

In summary, local subsidy policies have a broad scope of subsidy recipients, with significant variations in the entities benefiting from these policies. These subsidies encompass both domestic and international key passenger and cargo air routes, circular and regional flight routes, subsidies for base airlines, subsidies for air traffic management, and rewards for flight clearance rates. Overall, larger hub airports within provinces tend to benefit more from these policies. Additionally, there is considerable disparity in subsidy standards among provinces, with some subsidy policies being determined through case-by-case negotiations ("one-on-one discussions") to allocate subsidy funds flexibly and efficiently. The substantial commitment of local governments to subsidies reflects their active engagement in achieving the central government's goals for the development of public aviation transport.

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## 2.2. Analysis of Subsidies in Public Aviation Transport

### 2.2.1. Subsidies for Regional Aviation

This study compiles and summarizes the subsidies provided by the central government for regional aviation from 2013 to 2022, as shown in Table 2. The regions under different management bureaus are as follows:

North China Bureau: Beijing, Tianjin, Inner Mongolia, Shanxi, Hebei.
East China Bureau: Shanghai, Jiangsu, Zhejiang, Shandong, Fujian, Jiangxi, Anhui.
Central South Bureau: Hunan, Hubei, Henan, Hainan, Guangdong, Guangxi.
Southwest Bureau: Yunnan, Guizhou, Sichuan, Chongqing, Tibet.
Northwest Bureau: Shaanxi, Gansu, Ningxia, Qinghai.
Northeast Bureau: Heilongjiang, Jilin, Liaoning.
Xinjiang Bureau: Xinjiang.
Table 2 Subsidies for Regional Aviation (10,000 RMB) from 2013 to 2022

Table 2: Subsidies for Regional Aviation from 2013 to 2022 (in thousands of RMB).

| District | 2013 | % | 2014 | % | 2015 | % | 2016 | % | 2017 | % |
|---|---|---|---|---|---|---|---|---|---|---|
| North China | 4,673.08 | 10.78 | 14,818.00 | 16.25 | 18,372.00 | 16.88 | 18,660.00 | 18.29 | 12,759.00 | 12.92 |
| East China | 1,714.16 | 3.95 | 2,999.00 | 3.29 | 3,904.00 | 3.59 | 2,852.00 | 2.79 | 2,160.00 | 2.19 |
| Central South | 2,084.52 | 4.81 | 4,130.00 | 4.53 | 5,215.00 | 4.79 | 5,449.00 | 5.34 | 4,056.00 | 4.11 |
| Southwest | (Non-Tibet) | 9,616.24 | 22.18 | 15,552.00 | 17.05 | 18,882.00 | 17.35 | 23,396.00 | 22.93 | 22,137.00 |
| Southwest | (Tibet) | 11,325.00 | 26.13 | 15,931.00 | 17.47 | 20,356.00 | 18.70 | 20,311.00 | 19.90 | 26,072.00 |
| Northwest | 4,484.58 | 10.35 | 11,396.00 | 12.49 | 12,164.00 | 11.18 | 8,404.00 | 8.24 | 9,411.00 | 9.53 |
| Northeast | 2,740.09 | 6.32 | 7,852.00 | 8.61 | 8,479.00 | 7.79 | 9,640.00 | 9.45 | 8,986.00 | 9.10 |
| Xinjiang | 6,708.06 | 15.48 | 18,530.00 | 20.32 | 21,460.00 | 19.72 | 13,331.00 | 13.06 | 13,179.00 | 13.34 |
| Total | 43,346.00 | 100.0 | 91,208.00 | 100.0 | 108,832.00 | 100.0 | 102,043.00 | 100.0 | 98,760.00 | 100.0 |

| District | 2018 | % | 2019 | % | 2020 | % | 2021 | % | 2022 | % |
|---|---|---|---|---|---|---|---|---|---|---|
| North China | 13,252.00 | 14.93 | 14,716.00 | 17.33 | 11,638.00 | 10.56 | 16,891.00 | 11.33 | 15,756.00 | 10.25 |
| East China | 2,044.00 | 2.30 | 1,593.00 | 1.88 | 2,188.00 | 1.99 | 2,009.00 | 1.35 | 2,072.00 | 1.35 |
| Central South | 4,224.00 | 4.76 | 3,433.00 | 4.04 | 2,320.00 | 2.11 | 2,969.00 | 1.99 | 3,576.00 | 2.33 |
| Southwest (Non-Tibet) | 21662 | 24.40% | 19194 | 22.61% | 19850 | 18.01% | 23972 | 16.08% | 30979 | 20.15 |
| Southwest (Tibet) | 21154 | 23.83% | 16587 | 19.54% | 30583 | 27.75% | 43145 | 28.94% | 44624 | 29.02 |
| Northwest | 9,415.00 | 10.61 | 10,336.00 | 12.18 | 11,374.00 | 10.32 | 16,464.00 | 11.04 | 12,014.00 | 7.81 |
| Northeast | 8,982.00 | 10.12 | 8,972.00 | 10.57 | 9,245.00 | 8.39 | 5,780.00 | 3.88 | 5,348.00 | 3.48 |
| Xinjiang | 8,035.00 | 9.05 | 10,061.00 | 11.85 | 22,998.00 | 20.87 | 37,876.00 | 25.40 | 39,406.00 | 25.63 |
| Total | 88,768.00 | 100.0 | 84,892.00 | 100.0 | 110,196.00 | 100.0 | 149,106.00 | 100.0 | 153,775.00 | 100.0 |

Note: The percentages in the table represent the proportion of subsidies received by each bureau in a given year relative to the total subsidies for that year from 2013 to

In general, the percentage distribution of subsidies across various regions from 2013 to 2022 exhibited relatively minor fluctuations, primarily concentrated in the Southwest, North China, and

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Xinjiang routes. The combined percentage of subsidies for these routes accounted for approximately 75% of the total subsidies, reaching as high as 85% in 2022.

During the period from 2013 to 2022, the East China bureau consistently held the lowest proportion of subsidy funds, showing an overall declining trend, with only a 1% share in 2021-2022. Over the course of the decade, the Southwest bureau consistently had the highest proportion of subsidy funds, hovering around 40%. The Southwest bureau encompasses both Tibet and non-Tibet routes, with the Tibet route's subsidy share being relatively high, maintaining around 19% and rising to 29% in 2022.

The subsidy share for the Xinjiang bureau experienced significant fluctuations, with a decreasing trend from 2013 to 2018, reaching as low as 9% in 2018, marking an 11-percentage-point drop compared to 2014. However, from 2018 to 2022, the share gradually increased, with subsidies reaching 39,406,000 RMB in 2022, accounting for a high 26% of the total and ranking second only to the Southwest bureau.

Over the decade, the North China bureau's subsidy share remained around 15%, primarily influenced by the increase in subsidy funds for the Xinjiang bureau. Although the overall subsidy share exhibited a declining trend, historical subsidy amounts for the North China bureau showed a growth trend. The subsidy share for the Central South and Northwest bureaus remained relatively stable, with the Central South bureau maintaining a 4%-5% share from 2013 to 2019, which decreased to 2% from 2020 to 2022. The Northwest bureau consistently held a subsidy share of around 10%.

Over the ten-year period, the subsidy share for the Northeast bureau fluctuated around 10%, reaching a high of 17% in 2018. This study summarizes the top ten airlines receiving subsidies from 2013 to 2022, as shown in Table 3.

Table 3: The top ten airlines receiving subsidies from 2013 to 2022.

| 2013 | | 2014 | | 2015 | | 2016 | | 2017 | |
|---|---|---|---|---|---|---|---|---|---|
| Airlines | Subsidy Amount (in thousands of RMB) | Airlines | Subsidy Amount (in thousands of RMB) | Airlines | Subsidy Amount (in thousands of RMB) | Airlines | Subsidy Amount (in thousands of RMB) | Airlines | Subsidy Amount (in thousands of RMB) |
| China Eastern Airlines | 11066 | China Eastern Airlines | 21067 | China Southern Airlines | 22,778 | China Eastern Airlines | 21,332 | China Eastern Airlines | 17,574 |
| China Southern Airlines | 9852 | China Southern Airlines | 19799 | China Eastern Airlines | 22,039 | China Southern Airlines | 14,840 | Tibet Airlines | 15,204 |
| Tianjin Airlines | 5877 | Tianjin Airlines | 15260 | Tianjin Airlines | 18,265 | Tianjin Airlines | 13,756 | Tianjin Airlines | 13,643 |
| Air China | 4271 | Air China | 7585 | Tibet Airlines | 8,117 | Tibet Airlines | 8,551 | China Southern Airlines | 12,116 |
| Sichuan Airlines | 4002 | Sichuan Airlines | 6210 | Sichuan Airlines | 7,791 | Sichuan Airlines | 8,483 | Hainan Airlines | 9,834 |
| Tibet Airlines | 2225 | Tibet Airlines | 4402 | Air China | 5,348 | Hainan Airlines | 6,636 | Sichuan Airlines | 9,471 |
| Lucky Air | 1218 | Okay Airways | 2890 | China Airlines | 4,213 | Air China | 6,155 | Air China | 4,417 |
| China United Airlines | 759 | Beijing Capital Airlines | 2682 | China United Airlines | 3,598 | China United Airlines | 4,152 | Okay Airways | 3,587 |
| Hebei Airlines | 721 | Hebei Airlines | 2471 | Okay Airways | 3,353 | Okay Airways | 3,880 | West Air | 2,683 |
| Okay Airways | 708 | China United Airlines | 2000 | Beijing Capital Airlines | 2,161 | West Air | 2,975 | China United Airlines | 1,856 |
| Total | 40698 | | 84366 | | 97,663 | | 90,760 | | 90,385 |
| 2018 | | 2019 | | 2020 | | 2021 | | 2022 | |

Table 3: (continued).

| Airlines | Subsidy Amount (in thousands of RMB) | Airlines | Subsidy Amount (in thousands of RMB) | Airlines | Subsidy Amount (in thousands of RMB) | Airlines | Subsidy Amount (in thousands of RMB) | Airlines | Subsidy Amount (in thousands of RMB) |
|---|---|---|---|---|---|---|---|---|---|
| Tibet Airlines | 15,025 | China Eastern Airlines | 16,862 | Hainan Airlines | 21,673 | Hainan Airlines | 29,749 | Hainan Airlines | 29,306 |
| China Eastern Airlines | 13,882 | Hainan Airlines | 11,414 | China Eastern Airlines | 18,608 | China Eastern Airlines | 22,932 | China Eastern Airlines | 25,824 |
| Tianjin Airlines | 11,473 | China Southern Airlines | 10,034 | Tibet Airlines | 14,472 | China Southern Airlines | 19,091 | China Southern Airlines | 19,388 |
| Hainan Airlines | 10,039 | Tibet Airlines | 8,864 | China Southern Airlines | 13,039 | Tibet Airlines | 16,498 | Tibet Airlines | 15,550 |
| China Southern Airlines | 8,907 | Tianjin Airlines | 7,643 | Sichuan Airlines | 8,577 | Sichuan Airlines | 10,196 | Sichuan Airlines | 12,414 |
| Sichuan Airlines | 5,903 | Lucky Air | 5,801 | Air China | 5,119 | West Air | 9,034 | Air China | 6,832 |
| Air China | 5,200 | Sichuan Airlines | 5,181 | Lucky Air | 4,605 | Tianjin Airlines | 8,410 | Tianjin Airlines | 6,618 |
| Lucky Air | 3,672 | Air China | 4,342 | Tianjin Airlines | 4,391 | Air China | 5,738 | Lucky Air | 5,770 |
| China United Airlines | 2,619 | Xiamen Airlines | 1,831 | West Air | 3,146 | Chengdu Airlines | 3,624 | Chengdu Airlines | 5,503 |
| Total | 78,234 | | 73,624 | | 95,927 | | 127,765 | | 132,036 |

According to Table 3, it is evident that traditional airlines dominated the subsidy amounts from 2014 to 2017. In 2014, China Eastern Airlines received the highest subsidy, approximately 211 million RMB, followed by China Southern Airlines at 198 million RMB, and Air China ranked fourth with 62.10 million RMB. Apart from major traditional airlines, several small and medium-sized airlines, including Sichuan Airlines, Okay Airways, China United Airlines, Hainan Airlines, and Tibet Airlines, received subsidy amounts exceeding 10 million RMB in 2014 for their regional routes.

In 2015, China Eastern Airlines, China Southern Airlines, and Tianjin Airlines maintained subsidy amounts above 100 million RMB, with slight increases. China Southern Airlines, in particular, saw its subsidy rise from 190 million RMB to 230 million RMB, becoming the airline with the highest subsidy amount.

In 2016, China Eastern Airlines received the highest subsidy of approximately 210 million RMB, while China Southern Airlines and Tianjin Airlines continued to receive subsidies exceeding 100 million RMB.

In 2017, China Eastern Airlines received the highest subsidy of around 176 million RMB. Tibet Airlines, Tianjin Airlines, and China Southern Airlines also received subsidies exceeding 100 million RMB. However, the subsidy amounts for the four major airlines (Air China, China Eastern Airlines, China Southern Airlines, and Hainan Airlines) decreased compared to the previous four years. Notably, smaller airlines such as Tibet Airlines received substantial subsidies, totaling 152 million RMB, second only to China Eastern Airlines. Hainan Airlines received the most substantial subsidy among the four major airlines, amounting to approximately 139 million RMB. However, its subsidy decreased significantly by 78% compared to 2017.

From 2019 to 2022, the top four airlines receiving subsidies remained consistent: China Eastern Airlines, China Southern Airlines, Hainan Airlines, and Tibet Airlines. Moreover, their subsidy amounts showed an increasing trend year by year.

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Table 4 provides a summary of the accumulated subsidies and rankings for the listed airlines over the ten-year period.

Table 4: Accumulated Subsidies and Rankings for 15 Airlines Over Ten Years.

| Rank | Airlines | Accumulated Subsidies (in thousands of RMB) | Rank | Airlines | Accumulated Subsidies (in thousands of RMB) |
|---|---|---|---|---|---|
| 1 | China Eastern Airlines | 1,911,860 | 9 | Lucky Air | 165,710 |
| 2 | China Southern Airlines | 1,498,440 | 10 | China United Airlines | 149,840 |
| 3 | Hainan Airlines | 1,260,560 | 11 | Okay Airways | 144,180 |
| 4 | Tibet Airlines | 1,089,080 | 12 | Chengdu Airlines | 130,760 |
| 5 | Tianjin Airlines | 1,053,360 | 13 | Yunnan Xiangpeng Airlines | 69,880 |
| 6 | Sichuan Airlines | 796,030 | 14 | Beijing Capital Airlines | 48,430 |
| 7 | Air China | 536,320 | 15 | Xiamen Airlines | 18,310 |
| 8 | Western Airlines | 226,690 | | | |

Analyzing Tables 3 and 4 together, it becomes evident that five airlines accumulated subsidies exceeding 1 billion RMB from 2013 to 2022. Among these, China Eastern Airlines received the highest accumulated subsidy over the decade, totaling 19 billion RMB, consistently ranking among the top three airlines in subsidy amounts each year. China Southern Airlines ranked second, with subsidies ranging from 1 to 2 billion RMB annually. The subsidy amount for Hainan Airlines, ranking third in total accumulated subsidies, exhibited a significant upward trend. Starting from 7.21 million RMB in 2013, it reached approximately 3 billion RMB in 2021, marking a historic peak.

Tibet Airlines, ranking fourth in total accumulated subsidies, showed steady growth over the decade. Its subsidies increased exponentially from 2013 to 2017 and remained around 150 million RMB from 2017 to 2022. Tianjin Airlines, ranking fifth, consistently maintained subsidy amounts around 1 billion RMB from 2013 to 2017 but experienced a downward trend from 2019 to 2022, with only 46.05 million RMB in 2020.

### 2.2.2. Regional Airport Subsidies

Based on the economic development levels of various provinces (autonomous regions, municipalities directly under the central government) and in accordance with regional classifications outlined in national fiscal policies, civil airports are categorized into three types: eastern, central, and western regions.

Eastern Region includes Beijing, Tianjin, Shanghai, Zhejiang, Jiangsu, Shandong, Fujian, Guangdong, and Liaoning.

Central Region includes Hebei, Shanxi, Henan, Hubei, Hunan, Anhui, Jiangxi, Jilin, Heilongjiang, and Hainan.

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Western Region includes Inner Mongolia, Guangxi, Chongqing, Sichuan, Yunnan, Guizhou, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang.

Table 5 shows the subsidies for regional airports from 2013 to 2022:

Table 5: Subsidies for Regional Airports from 2013 to 2022 (in thousands of RMB).

| Region | 2013 | Percentage | 2014 | Percentage | 2015 | Percentage | 2016 | Percentage | 2017 | Percentage |
|---|---|---|---|---|---|---|---|---|---|---|
| Eastern Region | 10,613 | 20.24% | 19,686 | 18.25% | 21,044 | 17.38% | 21,655 | 16.48% | 24,753 | 17.32% |
| Growth Rate | | | 85.49% | | 6.90% | | 2.90% | | 14.31% | |
| Central Region | 12,443 | 23.74% | 25,863 | 23.98% | 28,988 | 23.93% | 30,347 | 23.09% | 33,686 | 23.57% |
| Growth Rate | | | 107.85% | | 12.08% | | 4.69% | | 11.00% | |
| Western Region | 29,367 | 56.02% | 62,305 | 57.77% | 71,081 | 58.69% | 79,431 | 60.43% | 84,463 | 59.11% |
| Growth Rate | | | 112.16% | | 14.09% | | 11.75% | | 6.34% | |
| Total | 52,423 | 100% | 107,854 | 100% | 121,113 | 100% | 131,433 | 100% | 142,902 | 100% |
| Growth Rate | | | 105.74% | | 12.29% | | 8.52% | | 8.73% | |

| Region | 2018 | Percentage | 2019 | Percentage | 2020 | Percentage | 2021 | Percentage | 2022 | Percentage |
|---|---|---|---|---|---|---|---|---|---|---|
| Eastern Region | 15,945 | 11.43% | 19,728 | 13.00% | 18,973 | 12.16% | 18,357 | 7.54% | 25,403 | 12.00% |
| Growth Rate | 35.58% | | 23.73% | | -3.83% | | -3.25% | | 38.38% | |
| Central Region | 36,904 | 26.45% | 43,168 | 28.44% | 45,006 | 28.85% | 56,304 | 23.11% | 60,354 | 28.51% |
| Growth Rate | 9.55% | | 16.97% | | 4.26% | | 25.10% | | 7.19% | |
| Western Region | 86,701 | 62.13% | 88,883 | 58.56% | 92,010 | 58.98% | 168,953 | 69.35% | 125,974 | 59.50% |
| Growth Rate | 2.65% | | 2.52% | | 3.52% | | 83.62% | | 25.44% | |
| Total | 139,550 | | 151,779 | | 155,989 | | 243,614 | | 211,731 | |
| Growth Rate | -2.35% | | 8.76% | | 2.77% | | 56.17% | | 13.09% | |

Note: The growth rate in the table represents the year-over-year percentage change in airport subsidy amounts for each region.

The percentage in the table represents the percentage of airport subsidy amounts for each region in the total subsidy amount for the respective year.

Table 5 reveals that subsidies for regional airports experienced stable growth from 2013 to 2017, with the fastest growth occurring in 2014, at an impressive 105.74% year-over-year increase. Subsidy amounts for eastern, central, and western regional airports all saw substantial increases during this period. From 2018 to 2020, subsidy amounts fluctuated within a normal range, with total subsidies remaining around 1.5 billion RMB. In 2021, there was a significant increase in subsidies, particularly noticeable in the central and western regional airports, which saw year-over-year growth rates of 25.1% and 83.62%, respectively. In 2022, subsidy amounts decreased slightly but remained within the normal range.

Analyzing the proportion of airport subsidies for each region, it is evident that the western region consistently had the largest share of subsidies from 2013 to 2022, with a growing trend each year. Central region airports received slightly higher subsidies than eastern region airports during this period.

## 3. Empirical Analysis

In this section, we conduct empirical research using the example of subsidies for regional air routes. Based on an analysis of existing literature and an examination of subsidy status, this study proposes the following hypotheses:

Hypothesis 1: Subsidy policies for regional air routes can increase passenger transport volume and promote the development of regional air routes.

### 3.1. Data and Models

#### 3.1.1. Data Sources

The time span of the data in this study covers the years 2009 to 2019 and includes 274 air routes. The core explanatory variable, data on the implementation of subsidies for regional air routes, is derived from the "Interim Measures for the Administration of Subsidies for Regional Air Routes." Data for the dependent variable, passenger transport volume on air routes, is sourced from the "Civil Aviation Statistical Yearbook."

#### 3.1.2. Difference-in-Differences Model (DID)

The Difference-in-Differences (DID) method is employed to evaluate the effectiveness of policy implementation [5]. The core idea behind DID is to divide the study subjects into an experimental group subject to policy intervention and a control group not subject to policy intervention. It calculates the changes in the experimental group before and after policy intervention and also calculates the changes in the control group before and after policy intervention. The difference between these two sets of changes is used as the estimate of the double difference— the difference in differences. The double difference estimate reflects the net effect of the policy and can assess whether the policy implementation has achieved its intended objectives.

In this study, the subsidy policy for regional air routes is treated as a quasi-natural experiment. Subsidized routes are considered the treatment group, while non-subsidized routes serve as the control group. A counterfactual reference is constructed for the treatment group, and the difference in passenger transport volume before and after the subsidy for the treatment group is compared to the difference in passenger transport volume before and after the subsidy for the control group. This reveals the impact of the subsidy policy on passenger transport volume. Compared to other empirical methods used in previous studies, the advantage of the DID method is that it considers differences between the treatment and control groups before and after the policy intervention and controls for the influence of other factors, thereby generating the net effect of the policy.

This study employs a multi-period DID model, with the model designed as follows:

$$Y_{i,t} = \beta_0 + \beta_1 D_{i,t} + \beta_2 X_{i,t} + a_i + b_t + \varepsilon_{i,t} \tag{1}$$

In Model (1), i (i=1,…,137) represents the 137 air routes that received subsidies for regional air routes from 2013 to 2019, and t (t=2009,…,2019) represents the time span for assessing the subsidy effect. The dependent variable $Y_{i,t}$ is the level of passenger transport volume for route i in year t. $a_i$ represents route-specific dummy variables, $b_t$ represents time-specific dummy variables, and $\varepsilon_{i,t}$ is the random disturbance term. $D_{i,t}$ represents a treatment period dummy variable that varies by individual i. When $D_{i,t} = 1$, it indicates that route i had received subsidies for regional air routes in year t. When $D_{i,t} = 0$, it indicates that route i had not received subsidies for regional air routes in year t.

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The future outcome for individual i is defined as $Y_{i,t}$, representing the level of passenger transport volume for route i in year t. Based on whether individual i was affected by the policy or not, there are two possible outcomes: $Y_{i,t} = Y_0(D_{i,t} = 0)$, which represents the level of passenger transport volume for route i in year t when it had not received subsidies for regional air routes; and $Y_{i,t} = Y_1(D_{i,t} = 1)$, which represents the level of passenger transport volume for route i in year t when it had received subsidies for regional air routes.

The coefficient $\beta_1$ of $D_{i,t}$ is the average treatment effect (ATE) of interest in this study, which is demonstrated as follows:

Average Treatment Effect for the Treated $(ATT) = \{E[Y_1|D_{i,t} = 1] - E[Y_0|D_{i,t} = 1]\}$ Average Treatment Effect for the Untreated $(ATU) = \{E[Y_1|D_{i,t} = 0] - E[Y_0|D_{i,t} = 0]\}$ Average Treatment Effect $(ATE)$

$$=(\{E[Y_1|D_{i,t} = 1] - E[Y_0|D_{i,t} = 1]\}) - (\{E[Y_1|D_{i,t} = 0] - E[Y_0|D_{i,t} = 0]\})$$

$$= (\beta_1 + b_t) - b_t$$

$$=(\{E[Y_1|D_{i,t} = 1] - E[Y_1|D_{i,t} = 0]\}) - (\{E[Y_0|D_{i,t} = 1] - E[Y_0|D_{i,t} = 0]\})$$

$$=(\beta_1 + a_i) - a_i = \beta_1$$

In summary, the coefficient $\beta_1$ represents the impact of the subsidy policy for regional air routes on passenger transport volume, which is the treatment effect. If $\beta_1$ is significantly positive, it indicates that the subsidy policy for regional air routes significantly increased passenger transport volume. If $\beta_1$ is significantly negative, it suggests that the subsidy policy for regional air routes significantly reduced passenger transport volume.

## 3.2. Empirical Analysis

### 3.2.1. Baseline Regression Results

The multi-period DID model in this study is set as a two-way fixed-effects model, and the analysis is performed using the "Panel Model" feature within the SPSSAU econometrics module.

Table 6: Summarizes the results of the tests (n=934).

| Test Type | Test Description | Test Statistic | p-value |
|---|---|---|---|
| F-Test | FE Model vs. POOL Model Comparison | F (273,659)=11.372 | 0.000 |
| BP Test | RE Model vs. POOL Model Comparison | $\chi 2(1)$=5074.857 | 0.000 |
| Hausman Test | FE Model vs. RE Model Comparison | $\chi 2(1)$=88.948 | 0.000 |

(Note: FE = Fixed Effects, RE = Random Effects, POOL = Pooled OLS)

The results indicate that the FE model is appropriate for this analysis, suggesting that it effectively controls for unobservable differences across routes and years, making it suitable for evaluating the subsidy policy's impact on passenger transport volume.

Panel Model Construction

In this study, the variable "treated*time" is utilized as the explanatory variable, with the dependent variable "Y" serving as the response variable for constructing panel models. The panel models encompass three types: the Mixed POOL model, Fixed Effects (FE) model, and Random Effects (RE) model. Model tests are initially conducted to determine the optimal model [6]. From the table above, it can be observed that:

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The F-test demonstrates significant results at the 5% level (F(273,659)=11.372, p=0.000<0.05), indicating that the FE model is superior to the POOL model.

The BP test exhibits significant results at the 5% level (χ2(1)=5074.857, p=0.000<0.05), implying that the RE model is superior to the POOL model.

The Hausman test shows significant results at the 5% level (χ2(1)=88.948, p=0.000<0.05), signifying that the FE model is superior to the RE model.

Considering the comprehensive analysis above, the FE model is chosen as the final result.

Table 7: Summary of Panel Model Results.

| Item | POOL Model | FE Model | RE Model |
|---|---|---|---|
| Intercept | 122362.090** (17.460) | -3543.182 (-0.267) | 67929.377** (7.422) |
| treated*time | -28020.368* (-2.340) | 339465.644** (8.967) | 4623.387 (0.352) |
| $R^2$ | 0.006 | -0.999 | -0.064 |
| $R^2$ (within) | -0.019 | 0.109 | 0.003 |
| Sample Size | 934 | 934 | 934 |
| Test | F (1,932)=5.477, p=0.019 | F (1,659)=80.415, p=0.000 | χ2(1)=-54.674, p=1.000 |
| Dependent Variable | Y | Y | Y |

(* p<0.05, ** p<0.01; Values in parentheses are t-values)

Based on Table 7, concerning “treatedtime,” it demonstrates significant results at the 0.01 level (t=8.967, p=0.000<0.01), and the regression coefficient value is 339465.644, which is greater than 0. This implies that “treatedtime” has a significant positive impact on the dependent variable “Y.” In other words, the subsidy policy for regional air routes has a significant positive influence on passenger transport volume.

### 3.2.2. Parallel Trend Test

In this study, a regression model test method is employed to conduct a parallel trend test. The results, processed using SPSSAU, are presented in the table below. The years 2010 to 2012, a total of three years, are considered as the “pre-treatment” period, with the year 2009 as the reference, and therefore, it is not included in the analysis.

Table 8: Summary of Panel Model Results.

| Item | POOL Model | FE Model | RE Model |
|---|---|---|---|
| Intercept | 230335.273** (9.250) | 167669.106** (12.012) | 158693.151** (9.659) |
| year_2019.0 | -176232.415** (-6.570) | -64638.399** (-4.084) | -104590.293** (-6.205) |
| year_2018.0 | -150538.955** (-5.320) | -61925.914** (-3.817) | -88750.962** (-5.051) |
| year_2017.0 | -108307.944** (-3.461) | -59221.827** (-3.347) | -73327.235** (-3.800) |
| year_2016.0 | -83061.912* (-2.542) | -57155.350** (-3.120) | -64791.169** (-3.230) |
| year_2015.0 | -110796.638** (-3.524) | -69603.943** (-3.940) | -81291.362** (-4.210) |
| year_2014.0 | -113800.467** (-3.551) | -92048.530** (-5.170) | -97570.780** (-4.992) |
| year_2013.0 | -114466.611** (-3.582) | -80569.333** (-4.586) | -88310.462** (-4.565) |
| year_2012.0 | -38093.606 (-1.049) | -7371.371 (-0.375) | -14524.298 (-0.668) |
| year_2011.0 | -27488.008 (-0.729) | 493.812 (0.024) | -1749.179 (-0.078) |
| year_2010.0 | 11550.619 (0.332) | 18111.968 (0.979) | 17066.537 (0.829) |
| $R^2$ | 0.109 | 0.058 | 0.061 |

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Table 8: (continued).

| Item | POOL Model | FE Model | RE Model |
|---|---|---|---|
| $R^2$ (within) | -0.051 | 0.106 | 0.084 |
| Sample Size | 934 | 934 | 934 |
| Test | F (10,923)=11.321, p=0.000 | F (10,650)=7.670, p=0.000 | χ2(10)=34.570, p=0.000 |

Dependent Variable: Y
(* p<0.05, ** p<0.01; Values in parentheses are t-values)

Based on the FE model, it can be observed from the table that, for "year_2010.0," "year_2011.0," and "year_2012.0," none of them exhibit significance. In other words, the coefficients for the interaction terms before the policy time points are mostly non-significant, indicating a satisfactory parallel trend.

## 4. Conclusion and Recommendations

### 4.1. Conclusion

(1) Affirmation of Policy Effects: Through empirical analysis, this study confirms the positive effects of the regional air route subsidy policy. Specifically, after the policy implementation, there is a significant increase in passenger transport volume, indicating a more vibrant aviation transport market. This suggests that the subsidy policy has contributed to the development of public aviation transportation to a certain extent.

(2) Regional Disparities Exist: The article points out that there are variations in responses between different regions. Some regions experience a more significant increase in transport volume, while others may be constrained by geographical, economic, and other factors, resulting in relatively weaker effects. Therefore, when formulating policies, attention should be paid to regional characteristics, and a differentiated policy strategy should be adopted.

(3) Policy Sustainability: Long-term observations reveal that the effects of the public aviation transport service subsidy policy persist for a certain period after implementation. This implies that the policy's impact on the aviation transport market is not short-lived but rather sustainable within a specific timeframe, contributing to the long-term stability and development of the market.

### 4.2. Recommendations

(1) Differentiated Policy Formulation: Given the differential responses to the policy in various regions, it is advisable for the government to adopt a differentiated policy formulation strategy when implementing the public aviation transport service subsidy policy. This means that in the policy-making process, regional characteristics should be more fully considered, and corresponding policy solutions should be tailored to achieve better results.

(2) Comprehensive Transportation Network Planning: To further enhance policy effectiveness, combining the public aviation transport service subsidy policy with comprehensive transportation network planning is recommended. By strengthening coordination between different modes of transportation and improving interconnectivity, passenger travel needs can be better met, promoting the comprehensive development of the aviation transport market.

(3) Effect Monitoring and Adjustment: To ensure the effective implementation of the policy, it is recommended to establish a sound policy effect monitoring and adjustment mechanism. Regularly assessing the policy's implementation effects allows for the timely identification of issues and shortcomings, and adjustments can be made according to the actual situation to ensure that the policy consistently plays a positive role.

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(4) Sustainable Development Consideration: In the long-term perspective, there should be a gradual reduction in dependence on subsidy policies, with encouragement for the public aviation transport market to strive towards sustainable development. The government can promote industry growth through means such as encouraging technological innovation and improving operational efficiency, thereby achieving long-term stable market growth.

In summary, through a multi-period DID empirical analysis, this study has identified the positive effects of China's public aviation transport service subsidy policy and provided recommendations in areas such as differentiated policy formulation, transportation network planning, effect monitoring and adjustment, and sustainable development. These recommendations offer valuable insights for optimizing and developing China's public aviation transport market.

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