Research on the Contribution Degree of China's International Air Routes to Foreign Trade

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ABSTRACT

Against the backdrop of a global trade environment facing multiple challenges such as unilateralism, geopolitical conflicts and public health incidents, the role of the international air transportation industry in promoting international trade and regional economic integration has become increasingly prominent. Based on international direct flight route data and national bilateral trade data from 2010-2019, this study applies the double difference (DID) model to quantitatively assess the contribution of China's opening of international air routes to foreign trade, and explores regional differences by continent. It is found that overall, each opening of an international air route can lead to an increase of about 1.3 billion U.S. dollars in import and export trade, but the regional contribution varies significantly, with European routes contributing the most (3.6~4.9 billion U.S. dollars). Further analysis shows that the level of regional economic development is the key factor influencing the contribution of routes, and geographical distance has a weaker role in constraining air transport trade. Based on this, the study suggests consolidating the layout of European routes to maintain the high contribution effect, adjusting the investment of route resources in Asian emerging markets, and exploring the potential trade demand in Africa and Oceania regions. This study provides data support and decision-making reference for optimizing China's international route network and enhancing the competitiveness of foreign trade, which is of practical significance to the construction of an open economy pattern.

Keywords: International route value; Foreign trade contribution; Double difference

1. Introduction

The development of the international air transportation industry is closely related to international trade, not only reflecting the dynamic degree of a country's foreign trade, but also further promoting

the growth of international trade by enhancing logistics efficiency and expanding market access[1]. The global trade environment has been impacted by unilateralism and geopolitical conflicts, and the international air transportation industry is faced with the dual challenges of efficiency and cost. Against this backdrop, China's international air transportation industry is facing tremendous pressure and is also shouldering the important mission of providing strategic support for the country's new development pattern.

The opening of international air routes is an important engine for promoting the development of foreign trade. Studies have shown that an increase in international air routes can significantly increase the volume of regional import and export trade and promote regional economic integration[2]. In recent years, governments around China have attached great importance to the layout and expansion of international air routes, and actively promoted the opening and encryption of international air routes to enhance the international competitiveness of the regional economy. According to the Guiding Opinions on Promoting the Construction of International Aviation Hubs issued by the Civil Aviation Administration of China (CAAC), China will accelerate the construction of international aviation hubs, optimize the layout of the international route network, and build a multi-level international air transport system with hub airports as the core and regional airports as the support. The Opinions clearly put forward that we should focus on enhancing the function of international aviation hubs in the core regions of Beijing-Tianjin-Hebei, Yangtze River Delta, Guangdong-Hong Kong-Macao Greater Bay Area, etc., strengthening the route connection with countries along the "Belt and Road", expanding the route network to emerging markets such as Southeast Asia, South Asia, the Middle East, Africa, etc., and at the same time, consolidating the coverage of the routes in the traditional markets of Europe and America, so as to improve the global accessibility of the international air transportation network. At the same time, it will consolidate the route coverage of traditional markets such as Europe and the United States, so as to enhance the global accessibility and transit efficiency of the international air transportation network and provide strong support for the high-quality development of China's foreign trade.

The opening of international air routes not only reduces trade costs and improves logistics efficiency, but also promotes industrial upgrading and the coordinated development of regional economies by facilitating people-to-people exchanges and technology exchanges[3]. Therefore, against the background of the complex and changing international trade situation, accelerating the optimization and expansion of the international airline network is of great significance to enhancing the competitiveness of China's foreign trade and promoting the high-quality development of the economy. This study takes the fifth wave theory and the international trade gravity model as its theoretical basis. The former emphasizes the role of air transport as the core infrastructure of a modern economy, while the latter explains bilateral trade flows through geographical distance and economic size. The combination of the two provides dual theoretical support for the direct impact of international air routes on trade.

Based on the data of international direct flight routes and national bilateral trade data from 2010 to 2019, this study applies the double-difference (DID) model to measure the foreign trade contribution of opening an international route, and discusses the foreign trade contribution of international routes at the level of "China-continent" by each continent in the world. It also discusses the contribution of foreign trade of international routes at the level of "China-continent" by continents, which is of reference value and significance for the opening of international routes and the rational layout and adjustment of international route network in China.

2. Literature Review

2.1 Study on the Interaction Between International Air Transportation and International Trade

Existing research on the interaction mechanism between international air transport and international trade can be summarized into two core theoretical perspectives: the theory of transport costs and the theory of network externalities. The former focuses on the fact that air transport drives trade growth by directly reducing transaction costs, while the latter emphasizes that route networks indirectly expand trade potential through scale effects and spatial reconfiguration. The two theories complement each other in terms of their explanatory levels and paths of action, and together they build an analytical framework for the relationship between air transportation and trade.

The theory of network externalities emphasizes that the topological characteristics and spatial layout of the route network indirectly promote trade expansion by expanding market coverage and strengthening the function of hubs, and the "fifth wave theory" put forward by Kasarda (1992) pointed out that the aviation network, through reconfiguring the spatial organization of the global supply chain, forms the "airside economic zone" centered on the hub airport and then expands the scale of trade through industrial agglomeration and factor flow [4].Oum et al. (2014) further systematize this logic by demonstrating that there is a positive circular effect between air traffic growth and the size of the regional economy: economic development drives route encryption, while increased network density promotes trade expansion by reducing unit transport costs [7]..Hakim et al. (2016) argued that either international trade or economic growth can significantly affect the international air transportation industry, but this effect is unidirectional and international air transportation does not work inversely on economic growth or international trade [9].Yang Kaijun and Chu Tianwei (2016) proved through their study that the role of transportation in promoting trade volume is general and obvious [13]. Liu Guangcai and Hu Jing (2015) proved that foreign trade pulls regional economic growth to drive the growth of air transportation industry [14]. Zhao Gang (2011) proved that civil aviation can drive the development of international trade and increase the opportunities of international trade by emphasizing that civil aviation power influences China's economic development through international trade research [15]. Chu Zhaofang and Wang Qiang (2010) found that air cargo volume, international trade and GDP data show a stable correlation whether in long-term or short-term dynamics, and the three are causally related to each other [16].

Transportation cost theory suggests that air transport directly reduces trade barriers by shortening time and space distances and optimizing the efficiency of supply chain coordination. Early studies based on the time cost compression perspective pointed out that the timeliness advantage of air transportation can break through the geographical constraints of traditional modes of transportation.Evans and Harrigan (2005) demonstrated through a general equilibrium model that air transportation significantly reduces firms' inventory costs and market response delays by shortening the delivery time, thus enhancing trade frequency [6]. This conclusion is extended to coordinate cost-cutting mechanisms by Donaldson (2018), whose empirical study based on the Indian Railway network shows that transport efficiency improvement can reduce inter-regional price differences, reduce trading frictions, and create a "trickle-down effect" of trade growth [18]. Further, Abe (2017) quantified this mechanism in a study of East Asian ports, finding that for every 10% increase in port capacity, transportation costs fall by 3%, validating the nonlinear impact of infrastructure efficiency on the marginal cost of trade [21]. In recent years, studies have deepened the understanding of cost heterogeneity. Lu Jian et al. (2020), based on Chinese provincial data, found that the trade promotion

effect of air transportation on high value-added products is significantly higher than that on low value-added goods, indicating a structural differentiation in cost savings [12].

2.2 Quantitative Study of the Extent of the Impact of International Air Transport on International Trade

The impact of international air transport tends to vary in terms of the degree of preference for international air transport as a mode of transportation. There have also been many discussions among scholars at home and abroad on the possible causes and mechanisms of the impact of international air transport on international trade.

At the empirical level, Chen (2024) found that air transportation supports the development of cross-border e-commerce with speed and efficiency and promotes the growth of foreign trade, but there are problems such as high cost and insufficient coverage, and the service capacity needs to be optimized through multimodal transportation and hub construction [17].Wang Qi et al. (2023) selected the total amount of import and export of goods as a relevant indicator that may affect the cargo throughput of the airport when predicting the modeled cargo throughput of Nanjing Lukou International Airport [10]. He Renjie et al. (2021) found in a spatial regression analysis study that the frequency of domestic and international flights and the amount of import and export trade of each province have an impact on the development of air transportation in the surrounding provinces [11]. Gong Q (2018) and others explored the relationship between air cargo network structure and international trade [19].Jacks et al. (2018), in a study using the air transport distance and sea transport distance difference as an instrumental variable on market potential and economic growth, found that the shorter the effective transport distance, the greater the market potential of a country's foreign trade, and air transport greatly reduces the transport distance compared with traditional sea transport [20].Franziska Kupfer et al. (2017) studied the relationship between air cargo demand and its underlying variables using an error correction model in their study of global air cargo development, and concluded that international trade and manufacturing are the main factors influencing the volume of air cargo, on the basis of which they projected the future demand for air cargo under different scenarios [8].Baker et al. (2015) argued that there is a two-way stable causal relationship between both air transport and trade, and economic growth, and that sea transport routes become less influential on trade due to the substitution of air transportation, and the transportation distance is an important reason why air transportation can replace sea transportation [22]. Zhaofang Chu and Qiang Wang (2010) studied the relationship between air logistics and international trade and economic development based on time series model, and found that the impact of air cargo impact on international trade is greater than its impact on economic development [12].

Compared with the established studies, the innovativeness of this study is reflected in the following three aspects: (1) innovation in research perspective: the first time to quantify the trade contribution of international routes by continent, revealing the moderating role of the regional economic development level on the effects of routes; (2) innovation in methodology: adopting a multi-period DID model to solve the estimation bias of traditional DID due to the differences in the time of the implementation of the policy; (3) innovation in data: based on the 2010-2019 complete time window of routes and trade data, to avoid the interference of exogenous shocks such as the new crown epidemic on the results, and at the same time through the design of always non-navigable but continuous trade countries as a control group to control the endogeneity problem.

3. Data Description and Empirical Modeling

3.1 Data Description

This study selects 2010 to 2019 as the time span for the assessment of the contribution of international routes to foreign trade for the following reasons. First, a ten-year time span ensures the stability and completeness of the data, which can reflect long-term trends and changes and provide more representative conclusions. Second, data from multiple years can smooth out the effects of short-term fluctuations or unexpected events and yield more accurate results. In addition, the data for this time period are more readily available and of higher quality, and are well organized, providing a reliable basis for analysis. The choice of this time period also avoids the unusual impact of a new crown epidemic on the global aviation industry in 2020 and beyond, ensuring regularity and consistency in the analysis. Finally, the period from 2010 to 2019 is relatively coherent in terms of policy and technology in China and the global aviation industry, and the results of the study are more comparable. The data on the opening of air routes in this study come from the Statistical Yearbook of Civil Aviation of China, and the data on international trade come from the National Bureau of Statistics. Since international trade is realized not only by air transport, but also by sea transport, land transport and other modes of transportation, international direct flight routes are not necessarily opened between China and countries with trade exchanges, and in order to ensure the comparability of the treatment group and the control group, this study adopts the following screening criteria: (1) Treatment group: remove the international direct flight routes in the Civil Aviation Statistical Yearbook of China 2010-2019 remove the Repeatedly opened and closed routes, only the routes that were opened for the first time and continuously operated are included, and the temporary navigation caused by seasonal adjustment or political factors are excluded; (2) Control group: select the countries that always did not open direct flight routes during the same period but had continuous growth in the trade volume to exclude the interference of the substitution effect of sea and land transportation. The contribution of international routes to foreign trade is measured by comparing the difference in international trade before and after the opening of the routes and discussed by continent. This choice not only ensures the breadth and representativeness of the sample, but also provides a solid data foundation for the conclusions of this study and ensures the reliability and accuracy of the analysis results.

3.2 Modeling

The double-difference-in-differences (DID) method can well assess the effect of policy implementation. Since China has opened international air routes to different countries in different years, this study belongs to the multi-period DID model with different implementation times of the "policy". In this study, the following model is established with whether or not to open international direct flight routes as the explanatory variable and the volume of import and export trade as the explanatory variable:

$$Trade_t = \beta_0 + \beta_1 \times Route_{it} + \beta_2 \times Controls + \mu_i + \mu_t + \varepsilon_{it}$$

where $Trade_t$ denotes the import and export trade from our country to each country in year t.

$Route_{it}$ indicates whether our country and country i opened international routes in year t, taking 0 for opening and 1 for not opening. β_1, the coefficient of $Route_{it}$,indicates the difference between the trade volume of the two sides with routes and that of the two sides without routes, that is, how much additional growth in trade volume can be brought about by international routes.

Controls are control variables, in international trade the factors affecting the amount of international trade between two countries are usually the level of economic development of the two

countries and the distance between the two places, so the international air routes corresponding to China's GDP ($ billion), national GDP ($ billion), and the distance between the countries are used as the control variables. μ_i is an individual fixed effect, μ_t is a year fixed effect, and ε_{it} is the error term.

4. Empirical Results and Analysis

4.1 Overall Analysis

The results of the benchmark regression of China's exports and imports with the global level as a whole are shown in Table 1.

Table 1. Benchmark regression results at the global aggregate level

norm	m1	m2	m3	m4
dit	17.23** (2.69)	17.23** (2.69)	13.70* (2.17)	13.70* (2.17)
gdpa		0.000314*** (3.58)	0.000295*** (3.04)	0.000295*** (3.04)
gdpb			0.0147*** (6.66)	0.0147*** (6.66)
distance				0 (0.0)
_cons	37.73*** (17.07)	18.61*** (4.43)	7.260 (1.62)	7.260 (1.62)

Note: t-values in parentheses, * indicates $p < 0.1$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$.

Benchmark regressions at the overall national level show that each international route opened can lead to an average annual increase in trade of 1.37 billion, indicating that although the role of air transportation in promoting trade is significant, it needs to be unleashed to a greater extent through network synergies and policy support. m1 represents the growth of total import and export trade of 1.7 billion U.S. dollars that can be brought by each international route opened in China on average when no control variables are added, and m2 and m3 represent the foreign trade contribution of international routes after adding the control variables of China's GDP and national GDP, respectively. According to the results, it can be seen that the degree of influence of international routes on international trade volume becomes lower after adding China's GDP and national GDP control variables, indicating that the economic development level of the navigating countries has a direct influence on the foreign trade contribution of international routes. After adding the distance control variable (m4), the foreign trade contribution of international routes does not fluctuate indicating that the geographical distance between two places is not a decisive factor in deciding to open international routes due to the long transportation distance and fast transportation speed of air transportation.

4.2 Interregional Comparative Analysis

In selecting the sample data for inter-regional comparative analysis of air routes opened by each continent, the continents that also meet the criteria of not opening air routes in the first few years and continuing to open them stably in the second few years during the period of 2010-2019 as the treatment group, and the continents that have not opened any international direct air routes but have

always had trade transactions as the control group during the period of 2010-2019 are Asia, Europe, Africa, and Oceania, so that the four continents are analyzed for inter-regional comparisons. Four continents are analyzed for inter-regional comparison.

The results of the benchmarking regressions are summarized for each continent, as shown in Table 2.

Table 2. Summary of benchmark regression results by continent

continents	trade	gdpa	gdpb	distance
Asian	-13.22 (-1.23)	-13.22 (-1.23)	-20.90* (-2.34)	-20.90* (-2.34)
European	49.06*** (5.14)	49.06*** (5.14)	36.06*** (4.22)	36.06*** (4.22)
African	25.95 (1.78)	25.95 (1.78)	9.060 (0.65)	9.060 (0.65)
Oceania	39.86*** (6.99)	39.86*** (6.99)	4.009 (1.26)	4.009 (1.26)

Note: t-values in parentheses, * indicates $p < 0.1$, ** indicates $p < 0.05$, and *** indicates $p < 0.01$.

Table 2 shows that the contribution of foreign trade of "China-Asian" international routes is not significant before the addition of control variables, but is significantly negative after the addition of control variables, i.e., international direct flight routes to the Asian region can not bring about a significant increase in the volume of international trade, which may result from the complexity of the trade network in the Asian region. Asian countries and China's geographic proximity, trade has long relied on land and maritime channels, the opening of the route did not significantly reduce the overall cost of transport, but may be due to the substitution effect of the original mode of transport to crowd out the volume of trade. In addition, some countries in the Asian region have homogenized competition, the opening of the route may exacerbate market segmentation, weakening economies of scale. This finding is consistent with the "proximity trap" phenomenon proposed in some literature, where geographical proximity may lead to diminishing marginal returns due to competitive substitution.

The insignificant contribution of "China-Africa" to foreign trade suggests that the opening of the route has not yet had a significant impact on China-Africa trade. This may be limited by the structural characteristics of African economies: on the one hand, Africa's exports to China are dominated by bulk commodities, which are more dependent on maritime rather than air transportation; on the other hand, Africa's internal infrastructure is weak, and the "last-mile" connectivity of the route network is insufficient, which undermines the practical utility of air transportation. In addition, the marginal effect of the opening of air routes is limited by the high proportion of government-led projects in China-Africa trade and the low dynamism of market-driven trade. This finding echoes Rodrik's (2012) theory of "institutional distance" constraining trade, whereby differences in institutional environments may offset the benefits of lower transportation costs.

The "China-European" international route has the highest contribution to foreign trade, but the data are unstable and fluctuate considerably when control variables are added. The increase in trade volume brought about by the opening of an international route to Europe is high, ranging from 3.6 billion to 4.9 billion dollars. After adding the level of China's GDP as a control variable, the degree of influence of international routes on international trade volume is unchanged, indicating that the level of China's GDP does not have a large degree of influence on the degree of trade contribution to the opening of international routes, and after eliminating the influence of China's GDP as a control variable, we continue to add the GDP of navigable countries as a control variable. After adding the control variable of the level of GDP of the navigating countries, the degree of influence of international air routes on the international trade volume deepens, and the reason for the relatively large span may be due to the large difference in the level of economic development between Northern Europe and Eastern Europe. This phenomenon suggests that China's international routes to Europe are mainly based on the increase in the level of economic development of European countries and driven by the demand for trade with European countries.

The foreign trade contribution of the international routes of "China-Oceania" brings 3.9 billion dollars on average before adding the control variables of GDP of the navigating countries, and it is not significant after adding the control variables of GDP of the navigating countries and inter-country distance, which indicates that there may be other influencing factors, such as the international routes to Oceania are more passenger routes or tourist routes. tourism routes.

4.3 Endogeneity Test

Although this study has added control variables such as China's GDP, GDP of navigable countries, and the distance between China and navigable countries, it is still difficult to avoid the problem of variable omission. Moreover, the opening of air routes helps to promote the development of China's foreign trade, but the development of foreign trade also promotes the opening of air routes, so the opening of air routes and the development of foreign trade may have a causal relationship, which leads to the endogeneity problem.

In this study referring to the research idea of Yang Bo and Cui Qi (2018) [23], the core explanatory variables, the previous one-period value (L.x) and the previous two-period value (L2.x), are included as instrumental variables in the model for parameter estimation. Columns (1) through (3) of Table 3 report the results of parameter estimation under two-stage least squares (2SLS) with the introduction of the instrumental variables L.x, L2.x separately versus the introduction of both L.x and L2.x simultaneously.

Table 3. Estimation results of instrumental variables

explanatory variable	(1) y	(2) y	(3) y
x_IV	L.x	L2.x	L.x vs. L2.x
x	11.6441	9.5893	9.1826
control variable	be	be	be
Individual and year fixed effects	be	be	be
L.x	0.971233		0.9700359
L2.x		0.9534252	-0.0016846

On the basis of 2SLS regression, the robustness of instrumental variables needs to be tested. In order to achieve this, a WeakInstruments Test (WIT) was conducted on the instrumental variables (explanatory variables lagged by one period) of this study. The original hypothesis of this test is that the instrumental variables are weak instrumental variables. As shown in Table 4, the WeakInstruments Test is significantly not equal to zero, so the original hypothesis is rejected. Therefore, the instrumental variable used in this study is not a weak instrumental variable, the instrumental variable can be used, and it also shows again that the opening of air routes has a significant positive impact on promoting China's foreign trade.

Table 4. Weak Instrumental Variable Tests

Variable	R-sq	Adjusted R-sq	Partial R-sq	Robust F(2,1146)	Prob F>
x	0.6103	0.6086	0.5885	4353.78	0.0000

5. Conclusions and Recommendations of the Study

5.1 Conclusions of the Study

Overall, each international air route opened in China can bring an average of 1.3 billion to 1.7 billion U.S. dollars of total import and export growth. The European region has the highest trade contribution from opening international routes, at $3.6 billion to $4.9 billion; the regional benchmark regression results for Asia and Africa are not significant.

Through the above analysis, it can be seen that: First, the foreign trade contribution of China's international routes has a large inter-regional difference; second, the foreign trade contribution of international routes is greatly affected by the level of economic development of the navigable cities; third, the foreign trade contribution of the European region is higher, and needs to be further opened up to the international routes, Asia is a negative growth, and the trade contribution of international routes in Africa and Oceania is not significant, and due to the limitations of the model can not make a reasonable estimation.

5.2 Recommendations

Research on the contribution of international routes to foreign trade is of great significance to the development of China's international routes. According to the above conclusions, it can be seen that for Africa and Oceania, we should take measures to explore trade demand and focus on increasing the opening of international routes; for Europe, based on the high marginal returns of the European routes, we need to maintain the dual-track evolution of "deep plowing in traditional markets + breakthroughs in emerging regions", increase the frequency of flights on existing international routes, and intensify investment in route resources, prioritize the encryption of the China-Europe Advanced Manufacturing Corridor, promote tariff and logistics synergy reform based on the China-Europe Comprehensive Investment Agreement (CAI), and further reduce trade barriers to air transportation.; for the Americas, we need to maintain the double track of "deep plowing in traditional markets + breakthroughs in emerging regions". On the whole, the company has a wait-and-see attitude on whether to further open up international direct flight routes to American countries. In response to the need to shift route resources from low-value-added commodities to high-value-added commodities in the Asian region in order to enhance annual trade earnings, the layout of the international route network has been further adjusted.

This study puts forward the following thoughts and suggestions on the development of China's international air routes from the level of international air routes' contribution to foreign trade.

5.2.1 Solidifying existing developments in the European region

China's international routes to the European region are opened out of the need to develop the economy and upgrade the industrial structure. For the European region, it can be seen that although the contribution of international trade routes is high, but in the current international context, the diplomatic situation between China and the European countries presents the characteristics of cooperation opportunities and challenges coexist. Therefore, for the European region, we should focus on considering the level of economic development of the navigating countries, and whether the trade product structure is complementary, and stabilizing the existing trade development situation and the layout of the international route network.

5.2.2 Adjustment of the layout of the international route network in the Asian region

The Asian region should give due consideration to cost-effectiveness and trade stability when launching air routes. On the one hand, the opening of air routes should be carefully assessed in terms of its substitution effect on the original mode of transportation and the resulting cost changes, so as to avoid inhibiting the trade of low value-added commodities and affecting the total trade volume due to the higher cost of air transportation. On the other hand, attention should be paid to the stability and long-term nature of China's trade with Asian countries. Based on a comprehensive analysis of trade data, market demand, cost-effectiveness and other factors, the layout of the international route network in the Asian region should be reasonably planned and laid out in order to achieve sustainable development and stable growth. Our country should accelerate the development of its own economy, upgrade the structure of trade products to maximize the use of existing resources, and carry out more trade exchanges and exchanges to the developed countries.

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