Optimization of Air Logistics Transport Network of YTO Express

Zeping Tong¹, Fanyue Meng²
¹School of management, Wuhan University of Science and Technology, Wuhan, Hubei, 430081, China
²School of management, Wuhan University of Science and Technology, Wuhan, Hubei, 430081, China
15638328310@163.com

Abstract. In order to improve the overall level and long-term development of YTO Express, according to the development strategy and planning of YTO Express logistics, this paper puts forward the construction of Hub-and-Spoke air logistics transport network with core hub airport, and optimizes YTO Express transport network. Firstly, the cluster analysis function of SPSS is used to divide the region of the air node, and then the center of gravity method is used to select the regional hub point, and the core hub airport and the regional hub airport are determined, so as to design the final transport network, which is conducive to the sustainable development of YTO Express, and improve the proportion of YTO Express in the air field.

1. Introduction
At present, China’s express industry is developing rapidly. Customers’ requirements for the timeliness and service level of express delivery arrival is higher and higher. The status of air logistics transport in the express industry has also been significantly improved. And YTO Express is constantly planning in air field. On July 30, 2018, YTO Express signed a strategic investment agreement with the people’s government of Jiaxing. YTO Express will invest 12.2 billion to build a global air logistics hub at Jiaxing Airport. Super Shared international Transport Centers and Business Distribution Centers in China and around the world. In the process of development planning, it is very important for YTO Express to have a general layout and plan. Therefore, this paper mainly aims at the current air transport network and implementation strategy of YTO Express, optimizing the logistics transport network of YTO Express, improving the logistics transport efficiency.

In recent years, many scholars has studied the air logistics transport network of express companies. Park Y, Choi JK has analyzed the factors affecting the air express service and judged the relative importance of each factor. And He put forward that accuracy and timeliness are still very important factors[1]. Jing Wang pointed out that there is a lack of cooperation among the network nodes of air express, and there are some problems such as the delay of express arrival. The air express network directly affects the service level of express delivery. Scholars in the study pointed out the importance of air express network[2]. Then Kuby MJ proposed that the single hub air network can be more efficient than the pure spoke network[3]. Mingke He pointed out that "hub-radiation" air cargo network is an effective mode to enhance the competitiveness of express enterprises[4]. Xiong Zhang proposed a hybrid hub-and-spoke transport network, and optimized the air logistics transport network of SF Express[5]. Ming Yang proposed that after the completion of the SF Ezhou Airport, make a
hub-and-spoke air transport network with a core hub airport[6]. Wu JP proposed a two-level planning model of air transport hub[7]. Sun H put forward a mathematical model which takes into account the traffic volume, geographical location and convenient transport conditions[8].

The method of selecting hub points and establishing model can not be ignored. Jiaojiao Gao realized the network connection of air logistics transport of express enterprises by P-hub selection model[9]. Wang J, Mo H put forward that the advantages of city’s geographical location are of great significance to the selection of nodes[10]. Xixi Tan proposed that she use principal component analysis and gravity method which determine the distribution and optimization of the main transport network resources of express delivery[11]. Yanwei Zhang and Xibin Xiao compared the Direct-through and hub-spoke networks. The final hub and air network were determined by the multi-hub decision-making method[12]. Huang J, Dang Y discussed the correlation between the degree of network and clustering degree, pointed out the network has the community and hierarchical structure[13].

Based on the research of various scholars, this paper analyses the network structure of YTO Express, and puts forward the construction of hub-spoke air logistics transport network with core hub. It is to say, taking the core hub airport as the important distribution center of the whole logistics transportation network and the regional hub airport as an auxiliary, with the center spreading outwards to form a radiant network to complete the logistics and transportation of goods.

2. Development of YTO Express Logistics Transport

Since the establishment of YTO Express in Xiaoshan in 2014, YTO Express has continued to promote its layout in the air field. YTO Express photographed Xiaoshan Airport Logistics Park in Hangzhou at a price of 304 million. It plans to build an air headquarters and a shipping distribution and transshipment center. In July 2018, YTO Express signed an agreement with the government of Jiaxing City to invest 12.2 billion in the construction of a global air logistics hub at Jiaxing Airport. However, while YTO Express is filling the future with a huge amount of air transport, the growth rate of express business has slowed down in recent two years. The net profit level has decreased, and the position of the industry is also facing downward pressure.

YTO Express currently has a good development strategy, but the layout of YTO Express transport Network is relatively thin at this stage. It will not meet the future air development needs of YTO Express. At present, YTO Express Air Transport Network is shown as follows:
there is no separate distribution, which affects the timeliness of air transport, making the implementation of the strategy of YTO Express have little effect.

3. Cluster Analysis and Location Selection of Transport Network

The establishment of air transport network for express delivery enterprises should be based on the company’s strategy and the particularity of air logistics transport. YTO Express launched a “one-master-eight-follower” air logistics transport development strategy, and the first is “Jiaxing”. The “eight-followers” are eight node cities in China, such as Yiwu, Xi’an, Chengdu, Guangzhou, Nanning and Hangzhou. In the transport network, the airport is divided into three levels: the core hub airport, regional hub airport, ordinary airport. Ordinary airport and regional hub airport are transported by passenger cabin, and the core hub airport and regional hub airport are transported by cargo plane.

3.1. Transport Network Model

There are two main modes of transport: 1. Airport A and Airport B in different regions need to transport goods from A to the regional hub airport of Airport A for centralization. Firstly from the regional hub to the core hub, then through the core hub airport transit to the regional core hub of Airport B, and finally to the destination airport B. As shown in Figure 2:

![Figure 2. Transport patterns in different regions.](image)

2. Two airports in the same region, cargo is transported from Airport A to Regional Hub Airport for concentration and then to Destination Airport B. As shown in the figure 3:

![Figure 3. Transport patterns in the same region.](image)

3.2. Selection of transport Network Hub Points

According to the existing transportation network node and development strategy of YTO Express, Jiaxing airport is determined as the core hub airport. Fuzzy clustering is applied to 12 urban nodes, and then the method of center of gravity is used to determine the regional hub points for the same type of cities.

3.2.1. Location Factor Analysis. Considering the basic situation of YTO Express air node, two main characteristics are considered: the geographical distribution and development potential of air node. The geographic distribution of nodes is expressed by the longitude and latitude of the cities where the nodes are located; the development potential is measured by the annual freight throughput of nodes in 2018. The annual freight throughput is less than 100,000 tons with a weight of 1. 100,000-200,000 tons with a weight of 2. 200,000-300,000 tons with a weight of 3. 300,000-400,000 tons with a weight of 4. More than 400,000 tons with a weight of 5.

Because each feature factor has different influence on clustering degree, the feature factors are given different weights, which are 4:4:2. The table of feature factors of YTO Express Network Node is obtained, as shown in Table 1.
Table 1. Characteristic Factor Table of Round Pass Air Network Nodes.

| City | East longitude | North latitude | Development potential |
|------|----------------|----------------|-----------------------|
| YC   | 425.08         | 153.88         | 2.0                   |
| SJZ  | 457.04         | 152.12         | 2.0                   |
| YT   | 485.00         | 149.20         | 2.0                   |
| YA   | 435.80         | 137.08         | 8.0                   |
| CD   | 416.28         | 122.68         | 10.0                  |
| CZ   | 478.32         | 125.88         | 10.0                  |
| HZ   | 480.40         | 120.80         | 10.0                  |
| CS   | 452.00         | 112.88         | 4.0                   |
| YW   | 477.96         | 116.08         | 2.0                   |
| SZ   | 456.28         | 90.48          | 10.0                  |
| NN   | 429.80         | 88.52          | 4.0                   |
| GZ   | 452.68         | 95.20          | 10.0                  |

Using the clustering function of SPSS software, the square-Euclidean distance clustering is selected. And the clustering results are set to four categories according to the existing nodes of YTO Express air transport. The final clustering scheme is obtained. The results are shown in Figure 4.

![SPSS Tree](image)

Figure 4. SPSS Tree.

According to the cluster analysis of SPSS software, the 12 nodes are divided into four categories, as shown in Table 2:

Table 2. Regional Division of YTO Express Transport Network.

| Region  | City                        |
|---------|-----------------------------|
| Region 1| Shenzhen, Guangzhou, Changsha, Nanning |
| Region 2| Yinchuan, Xi’an, Chengdu     |
| Region 3| Changzhou, Yiwu, Hangzhou   |
| Region 4| Shijiazhuang, Yantai        |

3.2.2. Selection of Regional Hub Points. This paper uses the center of gravity method of analytical method to select regional hub Points.

1. Modeling

The longitude and latitude of each city are used to represent the plane coordinates of the existing air nodes of YTO Express. The coordinates of each node are set as \((X_i, Y_i)\). The model is as follows:

\[
C_x = \frac{\sum D_{ix}V_i}{\sum V_i}
\]

\[
C_y = \frac{\sum D_{iy}V_i}{\sum V_i}
\]
The results obtained by EXCEL show that the optimal solution is \( X = 113.2869 \) and \( Y = 23.52046 \). Because Guangzhou is the nearest node to the optimal solution. So Guangzhou as the hub of region one.

Similarity, we can get the hub of region two and four. Chengdu is the hub of region two. Shijiazhuang is the hub of region four.

The basic situation of three regional nodes is shown in Table 4.

| City | East longitude | North latitude | Freight throughput in 2018 (Ten thousand tons) |
|------|---------------|----------------|-----------------------------------------------|
| CS   | 113.00        | 28.22          | 15.6                                          |
| SZ   | 114.07        | 22.62          | 121.9                                         |
| NN   | 107.45        | 22.13          | 11.8                                          |
| GZ   | 113.17        | 23.80          | 189.1                                         |
| CZ   | 119.58        | 31.47          |                                               |
| HZ   | 120.10        | 30.20          |                                               |
| YW   | 119.49        | 29.02          |                                               |
| JX   | 120.75        | 30.75          |                                               |

The longitude and latitude of these three nodes are shown in Table 4, which are close to Jiaxing. Therefore, this paper considers that Jiaxing Airport should be set as the hub airport of Region 3. Jiaxing Airport is not only the core airport of YTO Express, but also the regional hub airport of region 3.

Through the above analysis and solution, the hub-and-spoke air transport network diagram of YTO Express with core hub airports can be obtained as shown in Figure 5.
3.3. **Modeling of transport Network Cost**

The YTO Express logistics transport network designed in this paper is based on Jiaxing Airport as the core hub. Jiaxing Airport is scheduled to be put into use in 2021. So there is no specific data at present. This paper gives a model for calculating the network cost as a reference.

3.3.1. **Basic Hypothesis**
- There is no direct connection among ordinary airports;
- Ordinary airports cannot be directly connected with core hub airports;
- There is no direct connection between regional airports, and the regional hub is connected with at least one common airport;
- Extension lines are transported in passenger cabin;
- Trunk lines are transported by cargo aircraft, less than one aircraft is calculated by one aircraft;
- The construction cost of airport is not considered.

3.3.2. **Symbolic Description**
- \( W_{ij} \) - represents the freight volume between airport I and airport j;
- \( C_k \) - represents the unit transport cost from airport I to regional hub airport K through the passenger cabin;
- \( I_{ik} \) - represents the scale factor of transport from airport I to regional hub airport K through passenger cabin;
- \( C_k \) - represents the variable cost of transport by full cargo aircraft from regional hub airport K to core hub airport;
- \( C_f \) - Represents the fixed operating cost of each take-off of the whole cargo aircraft;
- \( Q_f \) - Represents the loading capacity of the whole cargo machine.

3.3.3. **Establishment of Mathematical Model**

\[
W_1 = \sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{m=1}^{n} \sum_{k=1}^{n} (I_{ik}C_k + I_{mj}C_m)W_{ij} \tag{1}
\]

\[
W_2 = \sum_{k=1}^{n} \sum_{m=1}^{n} \left( W_k C_f / Q_f + W_k C_k + W_m C_f / Q_f + W_m C_m \right) \tag{2}
\]
In the formula: (1) The branch transport cost including taking parts and dispatching parts cost. The branch transport includes transport between general airports and regional hub airports; (2) Trunk transport cost includes fixed operation cost and variable cost related to cargo volume from aircraft take-off and landing. Trunk transport includes transport between regional hub airport and core hub airport.

4. Conclusion
This paper divides the region by SPSS software cluster analysis method, chooses the regional hub points by the method of center of gravity location and designs the logistics transport network suitable for YTO Express. It has a great role in improving the logistics service level and air development of YTO Express. The innovation of this paper is to optimize the logistics transport network of YTO Express. According to the current situation and future trend of YTO Express, we design a more conducive transport network for the development of YTO Express.

References
[1] Park, Y., Choi, J.K., Zhang, A. (2009) Evaluating competitiveness of air cargo express services.J.transport Research Part E: Logistics and transport Review., 45(2):0-334.
[2] Jing, W. (2015) Research on Optimization of Air Express Backbone Network Based on Scale Effect.D.Beijing Jiaotong University.(in chinese)
[3] Kuby, M.J., Gray, R.G. (1993) The hub network design problem with stopovers and feeders: The case of Federal Express.J.transport Research part A: Policy and Practice., 27(1):1-12.
[4] Mingke, H., Hongjing, C. (2013) Construction of Air Freight Network for Express Enterprises.J.Operational Research and Management., 22(06):232-242. (in chinese)
[5] Xiong, Z. (2011) Research on Air transport Network Layout and Optimization of SF Express Enterprises.D.Southwest Jiaotong University.(in chinese)
[6] Ming, Y. (2017) Research on Air Transport Network Design of Express Enterprises in China.D.Southwest Jiaotong University.(in chinese)
[7] Wu, J.P. (2014) Research on Air transport Network with Information Technology for Express Logistics Enterprise.J. Advanced Materials Research., 1014:4.
[8] Sun, H., Xiao, L., Liu, Q. (2011) Research and Programming of the air Network of One Express Company. In: Icte. Chengdu. 165-178.
[9] Xiaojiao, G. (2011) Research on the optimal design of air transport network of express enterprises in China.D.Beijing Jiaotong University.(in chinese)
[10] Wang, J., Mo, H., Wang F. (2011) Exploring the network structure and nodal centrality of China, air transport network: A complex network approach.J.Journal of Transport Geography., 19(4):0-721.
[11] Xixi, T. (2016) Research on the Optimal Allocation of Resources in the Hub-and-spoke Express Trunk transport Network.D.Beijing Jiaotong University.(in chinese)
[12] Yanwei, Z., Xibin, X., Hanbin, X. (2016) Research and Application of Multi-hub Radial Air Express Network Model Planning.J.Journal of Wuhan University of Technology:Information and Management Engineering Edition., 15(3):25-30. (in chinese)
[13] Huang, J., Dang, Y. (2009) Research on the Complexity of Weighted Air transport Network of Express Enterprise. In: International Conference on Information Science & Engineering.Nanjing.125-130.