ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0050

Explore the Development Status of China's Air-Rail Passenger Transport Network under the "Belt And Road" Initiative in 2018

Jie Xue[1, a]

[1]Transportation planning and management, Shanghai Maritime University, Shanghai, China.

[a]1139849479@qq.com

Abstract

The purpose of this article is to explore the current development status of China's domestic air passenger transport and railway passenger transport network under the influence of the "Belt and Road" initiative in 2018. This paper constructs a complex network of air passenger transport and railway passenger transport that has passenger transportation between China and the Belt and Road countries. Through the analysis of complex network centrality and the improved entropy TOPSIS method, the network is quantitatively analyzed, and the relevant policy environment is considered. Construct the network for quantitative analysis, find out the key airport cities among them, get the trends and characteristics of the network development in 2018, provide literature references and related suggestions for the development of domestic airports, and lay the foundation for further research and discussion of the paper.

Keywords

Belt and Road initiative; passenger transportation; complex network; centrality analysis.

1. INTRODUCTION

The "Silk Road Economic Belt" and "21st Century Maritime Silk Road" are referred to as the "Belt and Road Initiative". Since the “Belt and Road” initiative was proposed, more and more countries have responded enthusiastically. The joint construction of the “Belt and Road” is becoming China’s participation in global open cooperation, improving the global economic governance system, promoting global common development and prosperity, and promoting the building of mankind. China's plan for a community with a shared future. As of the end of January 2020, China has signed 200 cooperation documents for jointly building the "Belt and Road" with 138 countries and 30 international organizations. Under the background of this era, as the foundation of facility connectivity, the external transportation industry has also been greatly developed. In terms of aviation, as of 2018, there are 235 airports in mainland China that are open to air services, of which 82 domestic airports are open to air services with major countries along the Belt and Road route, distributed in 80 cities.

The main passenger transportation modes in China are railway, aviation, highway and waterway. The waterway transportation is more restricted by natural conditions. Although road transportation extends in all directions, it is more suitable for long-distance passenger transportation than railway passenger transportation and air passenger transportation. Passenger turnover and speed are lower than railway passenger transportation and air passenger transportation, so the main research direction is on air passenger transportation and railway passenger transportation network. In previous studies, Liang Dai[1] conducted research on Southeast Asian air transport networks, Wen-Bo Du[2] conducted research on China’s air transport networks, and Wei Wang[3] conducted research on China Research on the

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0050

complex network of the railway system, Wenyi Xia [4] studied under which circumstances can better verify the integration of air and railway, and Linna Li[5] discussed the comprehensive transportation hub in Shanghai Hongqiao ("Hongqiao Hub") and put forward relevant suggestions on the current status of the integrated development of air transport and railway transport. However, there are still gaps in the research literature on the comprehensive development of passenger transport hubs in cities under the influence of the Belt and Road Initiative. So by using the air passenger transportation data of mainland China in 2018 and the train operation diagram of railway passenger transportation, the development status of the air rail passenger transportation network in China is studied, and the key hubs of the air rail passenger transportation network are identified and obtained from them. And the study also provides literature references for China's construction of an international comprehensive transportation hub.

2. AIR-RAIL PASSENGER TRANSPORTATION COMPLEX NETWORK MODEL AND NODE IMPORTANCE

2.1. Hub City Screening

When building a complex network of air passenger transport and railway passenger transport between China and the Belt and Road countries, the network nodes set up must have air passenger transport with the Belt and Road countries. Therefore, in the 235 airports in mainland China as of 2018, there are 82 domestic airports selected for air service with major countries along the Belt and Road. These airports are located in 80 cities in China. According to the distribution capacity of these airport cities, passenger flow distribution capacity, balanced layout, etc., only one airport city in each province or municipality in China will be selected as a node city with countries along the Belt and Road. The screening criteria are based on government policy documents in the context of the "Belt and Road" initiative, and the annual passenger flow of the node cities in 2018. Among them, the relevant government policy documents in the context of the "Belt and Road" initiative include the "China-Europe Railway Express Construction and Development Plan 2016-2020" and the "National Circulation Node City Layout Plan 2015-2020". Among them, the "China-Europe Railway Express Construction and Development Plan 2016-2020" lists in detail the important hubs of the domestic China-Europe Railway Express. These hubs must be important domestic hubs in response to the One Belt One Road policy; in the "National Distribution Node City Layout Plan 2015- 2020" clearly distinguishes circulation node cities at the national, regional, and regional levels, providing a basis for the classification of node cities for research.

The specific screening process is as follows:

Step 1: There is only one airport city in a province or municipality that has contacts with countries along the Belt and Road. These provinces or municipalities are Sichuan, Tibet, Beijing, Shanghai, Xinjiang, Tianjin, Gansu, Jiangxi, Shanghai, Qinghai, Ningxia, Chongqing; The cities selected as nodes are: Chengdu, Lhasa, Beijing, Shanghai, Urumqi, Tianjin, Lanzhou, Nanchang, Xining, Yinchuan, Chongqing.

Step 2: According to the airport cities mentioned in the "China-Europe Railway Express Construction and Development Plan 2016-2020", the cities selected as nodes are: Xi'an, Xiamen, Zhengzhou, Hefei, Wuhan, Changsha, Harbin; provinces: Shanxi, Fujian, Henan, Anhui, Hubei, Hunan, Heilongjiang.

Step 3: According to the airport cities proposed in the "National Circulation Node City Layout Plan 2015-2020", the cities selected as the node are: Haikou, Guiyang, Kunming, Nanning, Shenzhen, Qingdao, Shijiazhuang, Nanjing, Changchun, Jinan , Hohhot, Taiyuan; Provinces:

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0050

Hainan, Guizhou, Yunnan, Guangxi, Guangdong, Hebei, Jiangsu, Jilin, Shandong, Inner Mongolia, Shanxi.

Step 4. The remaining provinces that have not screened out the airport cities are Liaoning and Zhejiang, because these two provinces have two or more airport cities that have connections with the Belt and Road countries, and these airport cities all meet the Step 2 and Step 3 filter conditions. After comparing the one-year passenger flow between relevant airports in the same province and the Belt and Road countries in 2018, the cities selected as nodes are Hangzhou and Shenyang. The specific numerical comparison results are shown in Table 1.

Table 1. Urban passenger flow in each city in 2018

Provience	Departure City Name	Urban passenger flow	Arrival City Name	Urban passenger flow	Total
Zhejiang	Hangzhou	1476769	Hangzhou	1471114	2947883
Zhejiang	Ningbo	232605	Ningbo	229209	461814
Zhejiang	Wenzhou	95699	Wenzhou	95509	191208
Zhejiang	Yiwu	42954	Yiwu	38264	81218
Liaoning	Dalian	442625	Dalian	442903	885528
Liaoning	Shenyang	751416	Shenyang	749810	1501226

The nodes selected through the above screening process are: Chengdu, Lhasa, Beijing, Shanghai, Urumqi, Tianjin, Lanzhou, Nanchang, Xining, Yinchuan, Chongqing, Xi'an, Xiamen, Zhengzhou, Hefei, Wuhan, Changsha, Harbin, Haikou, Guiyang, Kunming, Nanning, Shenzhen, Qingdao, Shijiazhuang, Nanjing, Changchun, Jinan, Hohhot, Taiyuan, Hangzhou, Shenyang.

Based on the above city selection results, this article will build a basic air passenger and rail passenger transportation complex network, taking the city where the air passenger airport is located as the node, and the opened air passenger line and railway passenger line as the edge connecting these nodes, through these points and Lines can conceptualize air passenger transport and railway passenger transport into related complex networks. Set the transportation topology network as $A=(V,E)$, where, $V=\{1,2,\ldots,n\}$,n represents the total number of nodes in the network; $E=\{\alpha_{ij}\}$, i and j represent different nodes in the network, and:

$$\alpha_{ij}=\begin{cases}1 & node\,i\ and\ node\ j\ is\ adjacent\\ 0 & node\,i\ and\ node\ j\ is\ not\ adjacent\end{cases}$$

Therefore, the complex network of air passenger transportation and railway passenger transportation established is shown in Figure 1 and Figure 2.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0050

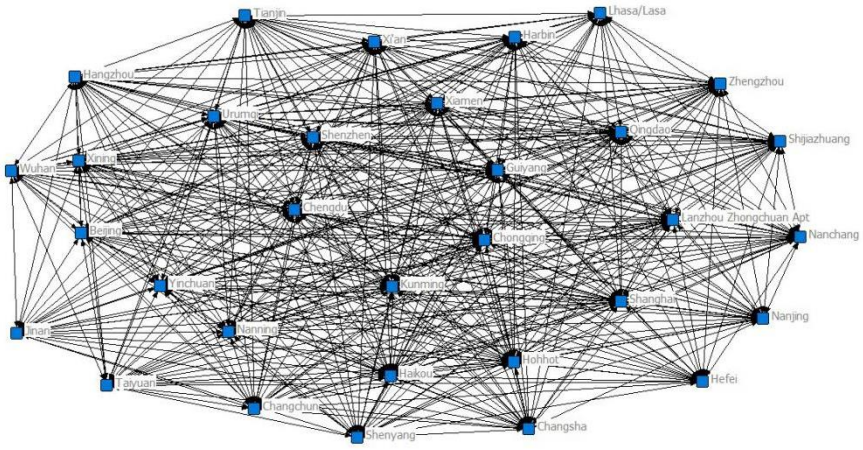

Figure 1. Airline network map of 32 cities in 2018

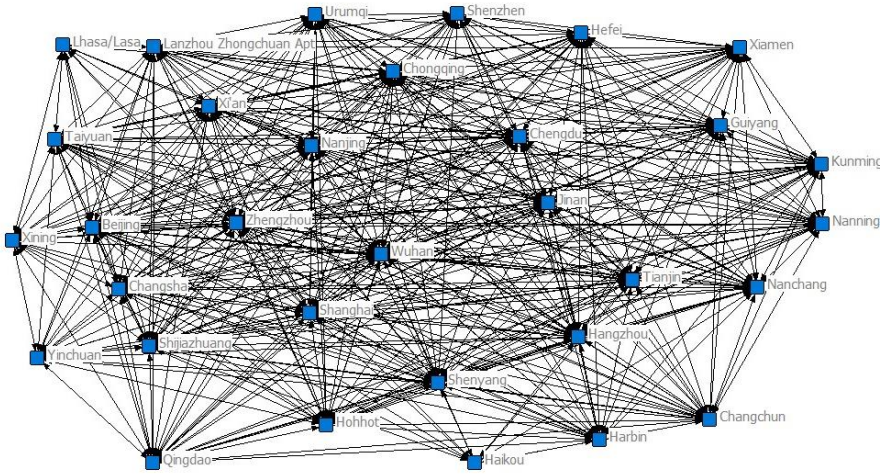

Figure 2. The railway passenger transportation network map of 32 cities in 2018

2.2. Node Importance

Node importance evaluation is to evaluate the distribution ability of nodes in complex networks. Important nodes must be located in the center of the network or near the center of a group of nodes in the network to ensure that passengers can be gathered and distributed to the surrounding area. In order to compare the status of nodes in the network, this paper selects four centrality indexes, namely: degree centrality, closeness centrality, betweenness centrality and eigenvector centrality [6], and through the use of Ucinet software Calculate, then use the improved entropy TOPSIS method [7] to calculate the weight of each centrality index of each city, and then integrate these four indexes to evaluate the importance of each node city in the air passenger transport and railway passenger transport network. The degree centrality of a node is defined as the ratio of the degree of a node to the maximum number of connections in the entire node. The greater the degree centrality of a node in the network, the higher the importance of the node. The closeness centrality of a node is defined as the reciprocal of the average distance along the shortest path from a node to all other nodes in the network. The greater the closeness centrality of a node, the higher the importance of the node. The betweenness centrality of a node is defined as a certain in a complex network the degree of control of the node over the surrounding nodes and quantifies the number of instances of the shortest path bridge between this node and surrounding nodes. The greater the betweenness centrality of the node, the higher the importance of the node. The eigenvector centrality of the feature vector of the node is depending on the importance of other nodes connected to it, the

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0050

state of a single node is regarded as a linear combination with the states of all other nodes in the complex network, and the state is transformed into a linear equation system. Through calculation, the one with the largest eigenvalue represents the importance of each node. The greater the eigenvector centrality of the feature vector of the node, the higher the importance of the node.

After obtaining the four centrality indicators of air passenger transport and railway passenger transport network, the improved entropy TOPSIS method is used to evaluate the weight of each centrality, and a comprehensive ranking of 32 node cities in the air passenger transport and railway passenger transport complex network is obtained. The results are shown in Table 2 and Table 3.

Table 2. The calculation results and rankings of the centrality index of the complex air passenger transport network of 32 cities

Node	Degree	Closeness	Betweenness	Eigenvector	Improved entropy TOPSIS method calculation results	Ranking
Chengdu	100	100	0.39	26.979	0.029856	1
Chongqing	100	100	0.39	26.979	0.029856	1
Guiyang	100	100	0.39	26.979	0.029856	1
Kunming	100	100	0.39	26.979	0.029856	1
Shenzhen	100	100	0.39	26.979	0.029856	1
Urumqi	100	100	0.39	26.979	0.029856	1
Xiamen	100	100	0.39	26.979	0.029856	1
Lanzhou	96.774	96.875	0.375	26.123	0.028401	8
Shanghai	96.774	96.875	0.355	26.175	0.026463	9
Harbin	93.548	93.939	0.348	25.319	0.025783	10
Xining	93.548	93.939	0.348	25.292	0.025783	11
Beijing	96.774	96.875	0.345	26.198	0.025494	12
Xi'an	96.774	96.875	0.344	26.196	0.025397	13
Shenyang	90.323	91.176	0.32	24.481	0.023069	14
Haikou	96.774	96.875	0.308	26.29	0.021909	15
Hohhot	96.774	96.875	0.308	26.29	0.021909	15
Nanning	96.774	96.875	0.308	26.29	0.021909	15
Yinchuan	96.774	96.875	0.308	26.29	0.021909	15
Qingdao	96.774	96.875	0.308	26.278	0.021909	19
Changchun	90.323	91.176	0.276	24.605	0.018805	20
Nanchang	87.097	88.571	0.255	23.757	0.016769	21
Hangzhou	87.097	88.571	0.239	23.774	0.015219	22
Changsha	87.097	88.571	0.21	23.907	0.012409	23
Tianjin	87.097	88.571	0.196	23.934	0.011052	24
Shijiazhuang	83.871	86.111	0.188	23.072	0.010276	25
Zhengzhou	83.871	86.111	0.17	23.152	0.008532	26
Taiyuan	83.871	86.111	0.167	23.139	0.008241	27
Nanjing	83.871	86.111	0.158	23.179	0.007369	28
Wuhan	80.645	83.784	0.155	22.288	0.007077	29
Lhasa	74.194	79.487	0.148	20.374	0.006395	30
Hefei	77.419	81.579	0.082	21.628	0.000002	31
Jinan	74.194	79.487	0.082	20.73	0.000000	32

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0050

It can be seen from the Table 2 that the top ten cities calculated using the entropy TOPSIS method are Chengdu, Chongqing, Guiyang, Kunming, Shenzhen, Urumqi, Xiamen, Lanzhou, Shanghai, Harbin, among which Chengdu, Chongqing, Guiyang, Kunming, Shenzhen , Urumqi and Xiamen tied for first place. This shows that these ten airports have higher status in the network.

Table 3. Calculation results and rankings of centrality indicators of the complex network of railway passenger transport in 32 cities

Node	Degree	Closeness	Betweenness	Eigenvector	Improved entropy TOPSIS method calculation results	Ranking
Beijing	100	100	1.119	27.93	0.064020	1
Changsha	100	100	1.119	27.93	0.064020	1
Shanghai	100	100	1.119	27.93	0.064020	1
Wuhan	100	100	1.119	27.93	0.064020	1
Zhengzhou	100	100	1.119	27.93	0.064020	1
Shijiazhuang	96.774	96.875	1.009	27.145	0.057729	6
Nanjing	96.774	96.875	0.731	27.513	0.041833	7
Xi'an	96.774	96.875	0.731	27.513	0.041833	7
Shenyang	93.548	93.939	0.685	26.647	0.039200	9
Chongqing	93.548	93.939	0.603	26.829	0.034512	10
Taiyuan	90.323	91.176	0.6	25.815	0.034338	11
Lanzhou	90.323	91.176	0.593	25.82	0.033938	12
Hangzhou	93.548	93.939	0.578	26.852	0.033082	13
Tianjin	93.548	93.939	0.578	26.852	0.033082	13
Changchun	87.097	88.571	0.486	25.087	0.027818	15
Nanchang	90.323	91.176	0.449	26.168	0.025704	16
Chengdu	93.548	93.939	0.38	27.099	0.021761	17
Jinan	93.548	93.939	0.38	27.099	0.021761	17
Urumqi	87.097	88.571	0.286	25.449	0.016382	19
Hohhot	87.097	88.571	0.284	25.445	0.016268	20
Qingdao	83.871	86.111	0.284	24.471	0.016266	21
Harbin	77.419	81.579	0.269	22.768	0.015404	22
Hefei	83.871	86.111	0.246	24.573	0.014093	23
Xining	64.516	73.81	0.193	18.781	0.011051	24
Guiyang	83.871	86.111	0.121	24.885	0.006946	25
Kunming	80.645	83.784	0.103	23.972	0.005914	26
Shenzhen	80.645	83.784	0.091	24.058	0.005228	27
Nanning	80.645	83.784	0.09	24.032	0.005171	28
Xiamen	74.194	79.487	0.062	22.185	0.003566	29
Yinchuan	64.516	73.81	0.052	19.335	0.002989	30
Haikou	38.71	62	0	11.778	0.000000	31
Lhasa	38.71	62	0	11.701	0.000000	32

It can be seen from Table 3 that the top ten cities calculated using the improved entropy TOPSIS method are Beijing, Changsha, Shanghai, Wuhan, Zhengzhou, Shijiazhuang, Nanjing, Xi’an, Shenyang, Chongqing, among which Beijing, Changsha, Shanghai, Wuhan, Zhengzhou tied for first place. The higher concentration of these ten railway passenger transport hub is located in the network status.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0050

In order to facilitate the integration of the calculation results of the air passenger transport and railway passenger transport complex networks, the calculation results of the two networks will be standardized respectively, and the calculation formula is as follows:

$$\beta = \frac{x - x_{\min}}{x_{\max} - x_{\min}}$$

And β represents the result of standardized processing, x represents the result calculated by each node using the improved entropy TOPSIS method, $x_{\min}$ represents the minimum value of the result calculated by all nodes using the improved entropy TOPSIS method, and $x_{\max}$ represents all nodes using the improved the maximum value of the result calculated by the entropy TOPSIS method.

Since there is currently no relevant literature or government document to provide the air passenger flow and railway passenger flow ratio of these node cities, in order to integrate the air passenger network and the railway passenger network, this article will determine the ratio based on the existing air passenger flow data and the ratio of air and rail passenger traffic in relevant cities in 2018. The specific values are shown in Table 4.

Table 4. Railway and air passenger traffic and their ratios in 32 cities in 2018

	Railway/10k	Aviation/10k	Ratio
Kunming	2712.95	4708.8	0.58
Haikou	2990.2	3645.3	0.82
Yinchuan	409.49	443.1	0.92
Xiamen	2795.55	2655.34	1.05
Urumqi	3811.5	3367.99	1.13
Xi'an	5523	4465	1.24
Xining	922.83	714.88	1.29
Chengdu	7640.5	5484.3	1.39
Qingdao	3455	2453.6	1.41
Beijing	14273	9123	1.56
Shenzhen	8197	5022	1.63
Lanzhou	2550.96	1385.82	1.84
Guiyang	3962	2009	1.97
Shanghai	12267	5921	2.07
Tianjin	5057	2359.14	2.14
Taiyuan	2966.24	1358.84	2.18
Chongqing	7706.79	3046.76	2.53
Nanchang	3769	1352.4	2.79
Hangzhou	7353	1956	3.76
Harbin	4239.3	1028.3	4.12
Nanjing	5440.93	1272	4.28
Changsha	5392.32	1196.43	4.51
Nanning	3506.36	771	4.55
Shenyang	4978.1	714	6.97
Hefei	4299.1	607.5	7.08
Zhengzhou	5780.5	813.1	7.11
Wuhan	18220.3	1551.58	11.74
Jinan	14547.7	894.1	16.27
Total	337493.67	61172.77	5.52
Average ratio			3.53

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0050

Table 5. Status and ranking of exchanges between 32 cities and countries along the Belt and Road in 2018

Node	Number of countries	Air passenger flow	Ranking
Shanghai	27	33954738	1
Beijing	36	33105803	2
Shenzhen	14	24659721	3
Chengdu	20	20830266	4
Kunming	20	18527579	5
Xi'an	15	17936002	6
Chongqing	13	17099788	7
Hangzhou	13	15626009	8
Xiamen	9	13840047	9
Haikou	11	13809089	10
Urumqi	16	12313012	11
Harbin	5	12161534	12
Qingdao	7	11625706	13
Nanjing	9	11360745	14
Changsha	9	10904968	15
Shenyang	7	10419473	16
Zhengzhou	10	10227796	17
Wuhan	12	9915076	18
Guiyang	7	9399666	19
Tianjin	10	9030093	20
Changchun	4	8551997	21
Nanning	12	8466981	22
Lanzhou	3	7604047	23
Jinan	7	7585437	24
Taiyuan	3	6922357	25
Nanchang	5	6707745	26
Hohhot	5	6185515	27
Yinchuan	4	5969883	28
Hefei	6	5091520	29
Shijiazhuang	3	4830102	30
Xining	2	4238142	31
Lhasa	1	3117693	32

The data in Table 4 comes from the relevant statistical bulletins and statistical yearbooks of the National Bureau of Statistics and the statistical bureaus of various cities in 2018. Among them, the 2018 statistical yearbooks of Hohhot, Changchun, Shijiazhuang, and Lhasa have not been published yet. The statistical bulletin also temporarily did not mention relevant statistical data. According to the above table, it can be seen that the average ratio of railway passenger flow to air passenger flow in all cities in 2018 is 3.53 (the result is two decimal places), and the ratio of railway passenger flow to air passenger flow in the country in 2018 is 5.52. Due to data limitations, this study explores the complex network of air and rail passenger transportation in cities that have connections with the Belt and Road countries. The study in Table 5 compares the number of cities with countries with the road in 2018 and the number of passengers on the road in 2018. To determine the average ratio of railway passenger flow to air passenger flow in 2018, the top 20 cities that have relatively close contacts with the countries that lead the way

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0050

are Shanghai, Beijing, Shenzhen, Chengdu, Kunming, Xi'an, Chongqing, Hangzhou, Xiamen, Haikou, Urumqi, Harbin, Qingdao, Nanjing, Changsha, Shenyang, Zhengzhou, Wuhan, Guiyang, Tianjin, these cities lead to a large passenger flow and many countries to interact with. But Harbin only has contacts with 5 leading countries in 2018, while Nanning, ranked 22nd, has contacts with 12 countries in 2018. Nanning has better international openness, so excluding Harbin. The 20 cities that are finally related to the determined ratio are Shanghai, Beijing, Shenzhen, Chengdu, Kunming, Xi'an, Chongqing, Hangzhou, Xiamen, Haikou, Urumqi, Qingdao, Nanjing, Changsha, Shenyang, Zhengzhou, Wuhan, Guiyang, Tianjin, Nanning. Dividing the total passenger flow of railway transportation in these cities by the total passenger flow of air transportation in 2018, the ratio of the national railway passenger flow to air passenger flow in 2018 is 2.1.

Table 6. Comprehensive calculation results of air passenger transport network and railway passenger transport network in 32 cities

Ranking	Node	Air passenger transport network standardization results	**Railway** passenger transport network standardization results	**Comprehensive calculation results**
1	Shanghai	1.00000	0.88635	2.86134
2	Beijing	1.00000	0.85390	2.79319
3	Chongqing	0.53908	1.00000	2.63908
4	Lanzhou	0.53012	0.95127	2.52777
5	Chengdu	0.33991	1.00000	2.43991
6	Xi'an	0.65344	0.85065	2.43980
7	Urumqi	0.25589	1.00000	2.35589
8	Shenyang	0.61231	0.77268	2.23493
9	Guiyang	0.10850	1.00000	2.20850
10	Kunming	0.09238	1.00000	2.19238
11	Shenzhen	0.08166	1.00000	2.18166
12	Xiamen	0.05570	1.00000	2.15570
13	Harbin	0.24061	0.86358	2.05413
14	Xining	0.17262	0.86358	1.98613
15	Changsha	1.00000	0.41563	1.87282
16	Hohhot	0.25411	0.73382	1.79514
17	Qingdao	0.25408	0.73382	1.79510
18	Changchun	0.43452	0.62986	1.75722
19	Shijiazhuang	0.90173	0.34419	1.62452
20	Nanning	0.08077	0.73382	1.62180
21	Zhengzhou	1.00000	0.28577	1.60012
22	Yinchuan	0.04669	0.73382	1.58772
23	Hangzhou	0.51674	0.50975	1.58721
24	Nanchang	0.40150	0.56166	1.58099
25	Haikou	0.00000	0.73382	1.54103
26	Wuhan	1.00000	0.23704	1.49778
27	Tianjin	0.51674	0.37018	1.29412
28	Nanjing	0.65344	0.24682	1.17175
29	Taiyuan	0.53636	0.27602	1.11602
30	Lhasa	0.00000	0.21419	0.44981
31	Jinan	0.33991	0.00000	0.33991
32	Hefei	0.22013	0.00007	0.22028

From the above calculation process, the railway and air passenger transport ratios of the 32 cities in 2018 are obtained, and then the normalized value of the railway passenger transport

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0050

network of the 32 cities is multiplied by the ratio plus the air passenger transport network normalized value, and the final calculation results and rankings shown in Table 6 are obtained.

The greater the calculation result, the greater its air and rail transportation capabilities, and the greater its ability to distribute passengers to other cities and regions. According to the above table, the top ten cities are: Shanghai, Beijing, and Chongqing, Lanzhou, Chengdu, Xi'an, Urumqi, Shenyang, Guiyang, Kunming.

2.3. Further selection of passenger hubs

In the previous calculations, we have obtained 10 cities with the potential to develop integrated air-rail passenger transport hubs. However, among the selected 32 cities, some cities are airport-type logistics hub cities. There are still differences between these cities. Some cities have greater development potential. In order to single out these cities, further screening will be conducted. The specific selection criteria and the source of the criteria are as follows.

Table 7. Further screening conditions and ranking of 32 cities

Ranking	Node	Criteria 1	Criteria 2	Criteria 3	Criteria 3	Criteria 4	Total score
1	Beijing	1	1	1	1	1	5
2	Xi'an	1	1	1	1	1	5
3	Shenzhen	1	1	1	1	1	5
4	Tianjin	1	1	1	1	1	5
5	Chengdu	1	1	1	1	1	5
6	Urumqi	1	1	1	1	1	5
7	Chongqing	1	1	1	1	1	5
8	Wuhan	1	1	1	1	1	5
9	Xiamen		1	1	1	1	4
10	Shanghai	1		1	1	1	4
11	Kunming	1		1	1	1	4
12	Hangzhou	1	1	1	1		4
13	Zhengzhou	1	1	1		1	4
14	Nanjing	1	1	1	1		4
15	Changsha		1	1	1		3
16	Qingdao		1	1	1		3
17	Harbin		1	1		1	3
18	Guiyang	1		1			2
19	Shenyang	1	1				2
20	Hefei	1	1				2
21	Lanzhou		1				1
22	Haikou				1		1
23	Jinan		1				1
24	Yinchuan			1			1
25	Lhasa			1			1
26	Nanning	1					1
27	Hohhot						0
28	Nanchang						0
29	Changchun						0
30	Shijiazhuang						0
31	Taiyuan						0
32	Xining						0

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0050

Screening criteria:

1. Comprehensive railway hub cities (Development and Reform Commission 2016 "Medium and Long-term Railway Network Planning");

2. Node cities of China-Europe Railway Express (National Railway Administration's 2016 China-Europe Railway Express Construction and Development Plan (2016-2020));

3. Airport-type national logistics hub carrying city (National Development and Reform Commission, Ministry of Transport, 2018 "National Logistics Hub Layout and Construction Plan");

4. Three-level airports in IATA (list source: files downloaded from the IATA website);

5. International comprehensive transportation hub cities (The State Council's 2017 "Thirteenth Five-Year" Modern Comprehensive Transportation System Development Plan");

According to the above screening criteria, score the 32 cities. For cities with this condition, fill in 1 in the corresponding table, and 0 if there is no. The total score is the sum of the criteria. And the score is higher, the air and railway transportation of the city have the better transportation infrastructure and policy conditions. The specific ranking results are shown in Table 7.

According to the above table, it can be concluded that the top 8 cities that meet the above selection criteria are Beijing, Xi'an, Shenzhen, Tianjin, Chengdu, Urumqi, Chongqing and Wuhan. The top 14 cities are Beijing, Xi'an, Shenzhen, Tianjin, Chengdu, Urumqi, Chongqing, Wuhan, Xiamen, Shanghai, Kunming, Hangzhou, Zhengzhou and Nanjing.

3. DISCUSSION

From the analysis results of Table 6 and Table 7, it can be concluded that there are 17 relevant airports, namely Beijing, Xi'an, Shenzhen, Tianjin, Chengdu, Urumqi, Chongqing, Wuhan, Xiamen, Shanghai, Kunming, Hangzhou, Zhengzhou, Nanjing, Lanzhou, Shenyang, Guiyang. In practice, due to limited resources, it is impossible for all cities to develop. The following analysis will be conducted to select the most suitable objects for priority development among the above 17 cities. The analysis is mainly based on the radiation range of the node city and the convenience of transportation. According to the "Opinions of the National Development and Reform Commission on Promoting the Linkage of Hub Airports with Rail Transit", it can be known that international hub airports should be connected to arterial railways or intercity railways or urban (suburban) railways or urban rail transit, effectively radiating within 800~1000 kilometers of the surrounding areas; regional hub airports should connect with trunk railways or intercity railways or urban (suburban) railways or urban rail transit as much as possible, effectively radiating the surrounding areas within 300 to 500 kilometers. Therefore, we should first examine the radiation range of the node city, and then consider whether the city is on the main railway line.

First of all, both Shanghai and Beijing have international hub airports, first-tier cities in China. Beijing also satisfies the five screening criteria of a comprehensive railway hub city, a China-Europe express train node city, an airport-type national logistics hub carrying city, a city that includes third-level airport in IATA, and an international comprehensive transportation hub city. Shanghai is not a node city for the China-Europe Express train, which makes the degree of exchanges with countries along the Belt and Road relatively weak. However, Shanghai is the most important city in the entire transportation network, so we retain Shanghai and Beijing. Beijing is only 109 kilometers away from Tianjin, so Tianjin can be replaced by Beijing. Shanghai is only 286 kilometers away from Nanjing. There are no flights from Hangzhou to Shanghai, so Nanjing and Hangzhou can be replaced by Shanghai. So there are twelve candidate cities left:

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0050

Xi'an, Shenzhen, Chengdu, Urumqi, Chongqing, Wuhan, Xiamen, Kunming, Zhengzhou, Lanzhou, Shenyang, Guiyang.

Among the remaining cities, Lanzhou is the closest to Urumqi, with a flight distance of 1593 kilometers, so Urumqi and Lanzhou are reserved. Chengdu and Chongqing are 275 kilometers apart. As table 6 shows that Chongqing is ahead of Chengdu, Chongqing is retained. Kunming and Guiyang, which are also among the candidate cities, are 629 kilometers and 354 kilometers away from Chongqing, respectively. Chongqing can be used to replace Guiyang and Kunming. Seven candidate cities are left: Xi'an, Shenzhen, Wuhan, Xiamen, Zhengzhou, Lanzhou, and Shenyang.

Xiamen is only 488 kilometers away from Shenzhen. Shenzhen is an international transportation hub, and after the second round of screening, Shenzhen ranks ahead of Xiamen, so Shenzhen can replace Xiamen. From the map, we can see that the cities around Xi'an are Lanzhou, Zhengzhou, Wuhan, and Chongqing. Among them, Xi'an is 465 kilometers away from Lanzhou, 465 kilometers away from Zhengzhou, and 560 kilometers away from Chongqing, so the surrounding cities can replace Xi'an. And because Wuhan is 906 kilometers away from Shenzhen and 735 kilometers away from Chongqing. In addition, Wuhan is relatively close to Zhengzhou, and there is no air passenger transportation, so the surrounding cities can replace Wuhan. At this time, only Zhengzhou remained in the Central Plains, so Zhengzhou was retained. Since Shenyang is only 605 kilometers away from Beijing, and Beijing is higher than Shenyang in both its strategic position and the overall transportation network, Beijing can be used instead of Shenyang. However, because comprehensive evaluation of Xi'an in table 7 is much higher than that of Lanzhou, and Urumqi, Lanzhou, and Xi'an are all located on the Lan Xin line, Xi'an will eventually replace Lanzhou.

In summary, among all the airport cities in the country that have connections with the leading countries, the seven cities of Shanghai, Beijing, Urumqi, Xi'an, Chongqing, Shenzhen and Zhengzhou will be selected as the focus of the development of air passenger transportation and railway passenger transportation. It is possible to study the related research topics of the joint development of airport hubs and railway hubs to further explore the impact of the relevant policy environment of leading the way on the importance of each node of China's hub network.

4. CONCLUSION

In the context of the One Belt One Road Initiative, this article will filter and rank all relevant cities through the analysis of China's domestic air passenger transport and railway passenger transport network in 2018, and identify the domestic cities with the most potential to develop the Belt and Road air and rail passenger transport to help China Establish an international hub, and provide advice on the development of key hubs along the Belt and Road with superior resources. According to the Belt and Road related policies issued by the Chinese government since 2013, we have selected 32 cities and constructed an air and rail passenger transport network based on complex network theory, and then assessed the importance of these cities using four central indicators , And then use the improved entropy TOPSIS to evaluate the air passenger transport and railway passenger transport capacity of these 32 cities, and then use the air-rail passenger flow ratio of each city to determine the comprehensive ratio, so as to combine the air passenger transport and railway passenger transport network. Finally, the results were qualitatively analyzed in combination with relevant policy documents, and finally the seven cities of Shanghai, Beijing, Urumqi, Xi'an, Chongqing, Shenzhen, and Zhengzhou were selected as key development cities for air passenger transportation and railway passenger transportation.

However, some of the issues raised in this study need to be further studied. For example, more factors should be considered when choosing a key development city, such as transportation

ISSN: 2472-3703 DOI: 10.6911/WSRJ.202010_6(10).0050

costs and the economic development of the city; when constructing a transportation network, it may be possible to build a The network considers more indicators, such as passenger flow and transportation distance, to further analyze the air-rail passenger transportation network in these cities. The analysis results will provide suggestions for the Chinese government to better plan and build an international comprehensive passenger transport hub under the "Belt and Road" initiative.

REFERENCES

[1] Liang Dai, Ben Derudder, Xingjian Liu: The evolving structure of the Southeast Asian air transport network through the lens of complex networks, 1979–2012, Journal of Transport Geography, Vol. 68(2018), P.67-77.

[2] Wen-Bo Du, Xing-Lian Zhou, Oriol Lordan, Zhen Wang, Chen Zhao, Yan-Bo Zhu: Analysis of the Chinese Airline Network as multi-layer networks, Transportation Research Part E: Logistics and Transportation Review,Vol. 89(2016),P.108-116.

[3] Wei Wang, Kaiquan Cai, Wenbo Du, Xin Wu, Lu (Carol) Tong, Xi Zhu, Xianbin Cao: Analysis of the Chinese railway system as a complex network, Chaos, Solitons & Fractals, Vol.130(2020),109408.

[4] Wenyi Xia, Anming Zhang: Air and high-speed rail transport integration on profits and welfare: Effects of air-rail connecting time, Journal of Air Transport Management, Vol.65(2017), P.181-190.

[5] Linna Li, Becky P.Y. Loo: Towards people-centered integrated transport: A case study of Shanghai Hongqiao Comprehensive Transport Hub, Cities, Vol.58(2016), P.50-58.

[6] Yaru Dang, Lina Peng:Air cargo network hierarchical structure based on complex network centrality, Transportation System Engineering and Information, Vol.12(2012)No.3, p.109-114.

[7] Deqiang Li, Laijun Zhao, Chenchen Wang, Wenjun Sun, Jian Xue: Selection of China's imported grain distribution centers in the context of the Belt and Road initiative, Transportation Research Part E: Logistics and Transportation Review, Vol.120(2018), P.16-34.