Comprehensive Analysis of the Hu-Bao-E-Yu Urban Agglomeration Traffic Network

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Abstract. Aiming at optimizing traffic network structure of Hu-Bao-E-Yu urban agglomeration and promoting coordinated development, this paper study the traffic network in Hu-Bao-E-Yu urban agglomeration by establishing traffic connection degree model and road network density model. Firstly, we study its composition of the internal traffic network, namely, the railway, highway and aviation network. Secondly, we analyze its external traffic network, and because it is located in the “two horizontal and three vertical” position, it has developed railway and highway network and strong traffic access ability. Finally, we construct the traffic connection degree model and road network density model based on the overall analysis. As a result, the traffic connection degree of every node city in Hu-Bao-E-Yu urban agglomeration is imbalanced. And there are not many differences on road density among the Hohhot, Baotou and Yulin, but the road density of Ordos is obviously greater than other three cities.

Introduction

The state council promulgated a file of Hu-Bao-E-Yu urban agglomeration development and planning on February 12, 2018, which marked the beginning of Hu-Bao-E-Yu urban agglomeration development and set a strategic position as the national high-end energy chemical industry base, strategic fulcrum to north and west, ecological civilization cooperation zone in northwest and antecedence development zone of urban-rural integration in ethnic areas [1]. Moreover, traffic facilities are the antecedence and foundation of regional economy development and the important indicator of regional development conditions, and they also provide the convenience for region cooperation and elements agglomeration. Literature [2] comprehensively analyzed the formation and evolution mechanism of Hu-Bao-E urban agglomeration regional transportation with GIS spatial analysis and grid technologies, and finally analyzed the traffic reachability. Literature [3] established road accessibility model and index model of road diversity, and analyzed the transportation accessibility of Hu-Bao-E urban agglomeration. Literature [4] analyzed the nodal cities in the Lan-Xi urban agglomeration and their level of correlation, and studied the traffic network structure using the K-Means algorithm and SVM. Literature [5] constructed the index system of comprehensive evaluation of transportation network and applied traffic connection degree model to analyze the transportation network links between cities so as to build the basic structure of Beijing-Tianjin-Hebei urban agglomeration traffic networks. However, the Hu-Bao-E-Yu urban agglomeration is still in early stage in the construction of traffic network and the transport links among cities within the urban agglomeration are still immature, and the research is still blank.

Therefore, this paper established the traffic connection degree model and road network density model based on the coordinated development of Hu-Bao-E-Yu urban agglomeration. And analyzed the traffic network and put forward development proposals in order to promote the integrated development of urban agglomeration transportation and strengthen internal relations and external radiation capacity, which will be beneficial to Economic integration development.
Internal Traffic Network of Hu-Bao-E-Yu Urban Agglomeration

Railway Network
As an important traffic tool among cities within urban agglomeration, railway is also a vital carrier to realize the concept of "0.5-1 hour traffic circle". It can not only transport passengers quickly, but also integrate the resources within the urban agglomeration effectively, making the urban agglomeration an organic whole. In terms of passenger transportation, we optimized the mainline railway, and built the high-speed railway from Baotou to Yulin with a total length of 294 kilometers. And in terms of freight transportation, Yulin and Ordos are important coal resource cities which supply a large amount of coal to Baotou, so it undertakes the coal transportation among three places as the main tool of transport capacity.

Highway Network
Although railway has an increasing proportion of passenger transportation, highway still undertakes the transportation of buses and private cars as well as some short distances of goods. The G65 and G6 highways are the two main highways in Hu-Bao-E-Yu urban agglomeration, connected Hohhot, Baotou, Ordos and Yulin. Among them, G65 highway runs through Baotou, Ordos and Yulin, and G6 highway runs through Hohhot and Baotou. With these two highways as the axis, a complete road network will be built along with other national and provincial trunk lines within the urban agglomeration.

Aviation Network
To realize the concept of "0.5-1 hour traffic circle", we will speed up the building of an integrated air transport system, foster an aviation hub with Hohhot as the center, increase its radiating capacity to surrounding areas, speed up the construction of new airport in Hohhot, promote the airports reconstruction in Baotou and Ordos, optimize the route network, and improve air transport efficiency. Particularly the establishment of flights between Hohhot and Yulin has greatly shortened the travel time.

Analysis of Internal Urban Agglomeration Traffic Network
From the perspective of the internal urban agglomeration, the distance is relatively short between neighboring cities, such as Hohhot to Baotou and Baotou to Ordos, while other cities are far apart from each other. Therefore, in addition to the construction of highway trunks, it is also necessary to build railway and aviation trunks to realize the "0.5-1 hour commuting circle" within the urban agglomeration. Main highways include G6 Beijing-Tibet highway, G65 highway and national highway and provincial highway. Railway trunk lines include Beijing-Baotou railway connecting Baotou and Hohhot, and Baotou-Yulin high-speed railway connecting Baotou, Ordos and Yulin. And the air routes are mainly from Hohhot to Yulin. Meanwhile, the formation of comprehensive traffic network also makes the resources within the urban agglomeration to be shared, and the mode of transportation resources is realized through the traffic network. Therefore, the accessible traffic network can improve the overall economic benefits of the urban agglomeration.

However, the disadvantages of traffic network in the internal urban agglomerations are also obvious, with uneven distribution of traffic routes and dense traffic routes between neighboring cities. The traffic network among Hohhot, Baotou and Ordos is relatively dense, as well as Baotou, Ordos and Yulin. However, only the air routes directly connected between Hohhot and Yulin, all the rest of the lines arrive in Yulin must through Baotou and Ordos. Because of the expensive aviation and long-time railway and road transportation, it makes low efficiency of the resources transportation between cities and goes against the development of urban agglomeration economy.

External Traffic Network of Hu-Bao-E-Yu Urban Agglomeration

Railway Network
The construction of external railway network of Hu-Bao-E-Yu urban agglomeration can be closely
linked with the Beijing-Tianjin-Hebei, Guanzhong plain, along with the Yellow River in Ningxia and central Shanxi, by promoting the railway construction of Beijing-Baotou, Baotou-Yinchuan and Baotou-Xi’an. The Beijing-Baotou railway is not only an external transportation line of Jin coal, but also a part of an international line connected with Mongolia and Russian. The Baotou-Yinchuan railway is the transport artery and economic corridor connecting northeast and northwest China, which runs through the Hu-Bao-E-Yu urban agglomeration and urban agglomeration along the Yellow River in Ningxia. The Baotou-Xi’an railway runs through Baotou, Ordos, Yulin and Xi’an city. It is the main coal transportation route, also the passenger and cargo transportation route, as well as the main transportation channel of energy and chemical products of Shaanxi province. These three railways along with some other lines of nearby cities together make up the outside railway network of Hu-Bao-E-Yu urban agglomeration. They undertake the freight transportation to the outside of the Hu-Bao-E-Yu urban agglomeration, as well as the resources transportation from other regions to the inner part of urban agglomeration, which is the great lifeline of promoting the economy of Hu-Bao-E-Yu urban agglomeration.

Highway Network
According to the planning of Hu-Bao-E-Yu urban agglomeration, we will focus on the promotion of the Baotou-Maoming, Rongcheng-Wuhai and Qingdao-Yinchuan highway as well as the national and provincial trunk roads. The Baotou-Maoming highway passes through Hu-Bao-E-Yu urban agglomeration, Guanzhong plain urban agglomeration, Chengdu-Chongqing urban agglomeration, Changsha-Zhuzhou-Xiangtan urban agglomeration, and Beibu Gulf urban agglomeration. And Rongcheng-Wuhai highway passes through Shandong Peninsula urban agglomeration, Beijing-Tianjin-Hebei urban agglomeration, Taiyuan urban agglomeration and Hu-Bao-E-Yu urban agglomeration. And Qingdao-Yinchuan highway passes through Shandong Peninsula urban agglomeration, Beijing-Tianjin-Hebei urban agglomeration, Taiyuan urban agglomeration and urban agglomeration along the Yellow River in Ningxia. Those three highway arteries form a relatively close highway network along with some national and provincial highways. Therefore, we can share resources, strengthen the communication, and promote economic development of the Hu-bao-E-Yu urban agglomeration. And Yulin plays the role of transportation hub and transfer as the junction of these three highways.

Aviation Network
For strengthening the construction of aviation network in Huu-Bao-E-Yu urban agglomeration, we should improve the airports level of Baotou, Ordos and Yulin, increase direct flights to Hohhot, Ordos, and the major cities of Mongolia and Russia. And we also should speed up the construction of new airports in Hohhot and general airports in Jingbian to promote the reconstruction of Baotou and Ordos, and plan the construction of feeder airports, general airports and helicopter landing points.

Analysis of External Urban Agglomeration Traffic Network
Because Hu-Bao-E-Yu urban agglomeration is located in the “two horizontal and three vertical” position and has developed railway and highway network which construct the traffic transportation channel, it has strong traffic access ability. Hohhot, Baotou, Ordos and Yulin all play an important role of traffic nodes, among which, Yulin has a number of channels in this intersection, which is an important traffic node and transit station point. The whole urban agglomeration can reach the border ports to the north of Erenhot and Mandula, the coastal port cities to the east, the Guanzhong urban agglomeration and the southern coastal cities to the south, and the economic belt cities along the Yellow River to the west such as Wuhai and Yinchuan. Developed transportation networks not only improve the speed of freight transportation, but also the speed of passenger transportation. Coal producing cities such as Jungar Banner and Wuhai can also transport their coal resources to eastern cities through the external transportation channels of Hu-Bao-E-Yu urban agglomeration. These traffic networks strengthen the communication with the economic developed urban agglomeration which can improve economic strength of the Hu-Bao-E-Yu urban agglomeration.
The Overall Analysis of Hu-Bao-E-Yu Urban Agglomeration

The analysis of urban agglomeration traffic network should not only analyze each city within the urban agglomeration, but also analyze the connection between cities. This paper analyzes the traffic network of Hu-Bao-E-Yu urban agglomeration by the traffic connection degree model and road network density model.

Traffic Connection Degree

The traffic connection degree is in analogy with the law of universal gravitation $F = G \frac{Mm}{R^2}$, and we construct the traffic connection degree model of Hu-Bao-E-Yu urban agglomeration which the main traffic indicators are highway and railway [5], as formula (1)

$$F_{ij} = K_{ij} \cdot \frac{P_i P_j G_i G_j}{R_{ij}^2}.$$  \hspace{1cm} (1)

Where $F_{ij}$ is the traffic connection degree between city i and city j. $P_i$ and $P_j$ are the number of economically active people of city i and city j, $G_i$ and $G_j$ are the GDP of city i and city j, $R_{ij}$ is the total length of highways and railways between city i and city j, and $K_{ij}$ is the coefficient of traffic connection degree between city i and city j, as formula (2).

$$K_{ij} = \frac{1}{2[(Q_i + C_i)/Q + (C_j + C_j)/C]}.$$ \hspace{1cm} (2)

Where $Q_i$ and $Q_j$ are the total highway passenger volume of city i and city j, $C_i$ and $C_j$ are the total highway freight volume of city i and city j, $Q$ and $C$ are the average value of passenger volume and freight volume in Hu-Bao-E-Yu urban agglomeration. The data are shown in table 1 and table 2.

Table 1. The statistical data of node city in Hu-Bao-E-Yu urban agglomeration.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hohhot</td>
<td>169.1</td>
<td>3173.6</td>
<td>465.6</td>
<td>16886.7</td>
</tr>
<tr>
<td>Baotou</td>
<td>164.3</td>
<td>3867.6</td>
<td>656.8</td>
<td>29803.3</td>
</tr>
<tr>
<td>Ordos</td>
<td>150.2</td>
<td>3579.81</td>
<td>578.3</td>
<td>19688.6</td>
</tr>
<tr>
<td>Yulin</td>
<td>155.8</td>
<td>2773.05</td>
<td>2870</td>
<td>24698</td>
</tr>
</tbody>
</table>

Table 2. The highway mileage between cities in Hu-Bao-E-Yu urban agglomeration.

<table>
<thead>
<tr>
<th></th>
<th>Hohhot</th>
<th>Baotou</th>
<th>Ordos</th>
<th>Yulin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hohhot</td>
<td>0</td>
<td>148.7</td>
<td>213</td>
<td>382.1</td>
</tr>
<tr>
<td>Baotou</td>
<td>148.7</td>
<td>0</td>
<td>74.9</td>
<td>231.4</td>
</tr>
<tr>
<td>Ordos</td>
<td>213</td>
<td>74.9</td>
<td>0</td>
<td>144.3</td>
</tr>
<tr>
<td>Yulin</td>
<td>382.1</td>
<td>231.4</td>
<td>144.3</td>
<td>0</td>
</tr>
</tbody>
</table>

According to the data in table 1 and table 2, we calculated the traffic connection degree between cities in Hu-Bao-E-Yu urban agglomeration, as shown in table 3.

Table 3. The traffic connection degree of node cities in Hu-Bao-E-Yu urban agglomeration.

<table>
<thead>
<tr>
<th></th>
<th>Hohhot</th>
<th>Baotou</th>
<th>Ordos</th>
<th>Yulin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hohhot</td>
<td>0</td>
<td>2.1</td>
<td>1.1</td>
<td>0.09</td>
</tr>
<tr>
<td>Baotou</td>
<td>2.1</td>
<td>0</td>
<td>7.6</td>
<td>0.5</td>
</tr>
<tr>
<td>Ordos</td>
<td>1.1</td>
<td>7.6</td>
<td>0</td>
<td>1.6</td>
</tr>
<tr>
<td>Yulin</td>
<td>0.09</td>
<td>0.5</td>
<td>1.6</td>
<td>0</td>
</tr>
</tbody>
</table>

As can be seen from table 1, the traffic connection degree between different node cities in Hu-Bao-E-Yu urban agglomeration is unbalanced. The scores of Hohhot-Baotou and Baotou-Ordos
are relatively high indicating that they have strong traffic network and high traffic connection degree. Because Yulin is geographically far away from other cities and administratively belongs to Shaanxi province, it has lower traffic connection degree, which leads to the insufficient connection with other cities. So we should strengthen the traffic links between Yulin and other cities in the subsequent process of urban agglomeration traffic construction.

**Road Network Density**

Road network density\(^6\) is an important parameter reflecting the scale of road network construction. We evaluate the road network of Hu-Bao-E-Yu urban agglomeration by using road network density, as shown in formula (3).

\[
    r = \frac{\sum_{i=1}^{n} l_i}{S}
\]

Where \( l_i \) is the length of road i, and s is the region area. The data is shown in table 4.

<table>
<thead>
<tr>
<th></th>
<th>Hohhot</th>
<th>Baotou</th>
<th>Ordos</th>
<th>Yulin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road length</td>
<td>7295</td>
<td>9004</td>
<td>23509</td>
<td>31348</td>
</tr>
<tr>
<td>Build-up area</td>
<td>2054</td>
<td>2965</td>
<td>2883</td>
<td>11096</td>
</tr>
</tbody>
</table>

According to the data in table 4, we calculated the road network density of Hohhot, Baotou, Ordos and Yulin by formula of road network density, as shown in table 5.

<table>
<thead>
<tr>
<th></th>
<th>Hohhot</th>
<th>Baotou</th>
<th>Ordos</th>
<th>Yulin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road network density</td>
<td>3.6</td>
<td>3</td>
<td>8.1</td>
<td>2.8</td>
</tr>
</tbody>
</table>

It can be clearly seen from table 5 that the road network density of Hohhot, Baotou and Yulin differs little, while Ordos is significantly higher than other three cities. The higher the network density is, the higher the coverage rate of the traffic network is, but it also means that the longer the mileage is, the more construction funds and maintenance and management costs are needed, and the greater impact on environment. Therefore, the road network density should be in a reasonable range, otherwise, it will affect the planning and construction of the entire urban agglomeration.

**Summaries**

This paper constructed the basic structure of traffic network based on the connection degree among cities, and studied the structural characteristics of traffic network quantitatively, which is conducive to strengthening the traffic network links within the urban agglomeration and promoting the transportation and economic integration development in the Hu-Bao-E-Yu urban agglomeration.

1. The traffic connection degree between different node cities in Hu-Bao-E-Yu urban agglomeration is unbalanced. The traffic connection degree of Hohhot, Baotou and Ordos is high, while Yulin has a lower traffic connection degree. Therefore, in the process of urban agglomeration traffic construction, we should focus on strengthening the traffic links between Yulin and other cities to improve the integrity of urban agglomeration.

2. The road network density of Hohhot, Baotou and Yulin differs little, while Ordos is significantly higher than other three cities. Therefore, the road network density should be in a reasonable range and the road network construction should not be too much.

3. The traffic connection degree model is improved based on the gravity model without the analysis of human travel behavior. But it only preliminarily simulates the traffic connection, and needs to be improved and analyzed based on the actual traffic flow.
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References


