Traffic accessibility analysis of major cities in the Yangtze River Delta under the integration of regional development

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Abstract. The Yangtze River Delta region is one of the regions with the highest economic development dynamics in China, and the importance of its transportation hub status is self-evident. This paper selects the indicator of traffic accessibility and adopts the weighted time cost method to analyze the traffic accessibility and equilibrium of major cities in the Yangtze River Delta region, and draws the following conclusions: (1) the improvement of traffic accessibility can drive the economic development of the city (2) the highway accessibility of cities in the Yangtze River Delta is high, which proves that the city roads in the region are well paved and the road travel is convenient; (3) the railroad accessibility of the Yangtze River Delta city cluster is low, so the railway paving needs to be accelerated in the regional city development planning, and thus the shortage of road travel needs to be completed. accessibility is low, so in the regional urban development planning, railroad paving needs to accelerate the pace, and then make up for the shortcomings.

Keywords: Yangtze River Delta region; traffic accessibility; equilibrium level

1. Introduction

The Yangtze River Delta (hereinafter referred to as the Yangtze River Delta) region is one of the regions with the most active economic development, the highest degree of openness and the strongest innovation capacity in China, and it has a pivotal strategic position in the overall national modernization and all-round opening pattern. Promoting the integrated development of the Yangtze River Delta, enhancing the innovation capacity and competitiveness of the Yangtze River Delta region, improving economic agglomeration, regional connectivity and policy synergy efficiency are of great significance in leading the national high-quality development and building a modern economic system [1].

Transportation is an important way to connect places. The development of transportation accessibility can promote the reorganization of regional economic structures for more coordinated development, and different transportation modes have different impacts, for example, chen zhenhua (2020) et al. found through empirical analysis that the improvement of transportation accessibility contributes to the development of regional economic integration in the Greater Bay Area of China, and that road and rail accessibility improvements have different degrees of economic impact [2]. Most of the regions with better economic development showed a positive correlation between traffic accessibility and economic development level [3]. In the Yangtze River Delta region, the development of high-speed railroads will comprehensively improve the accessibility level of the Yangtze River Delta region, shorten the spatial and temporal distances between cities, and help promote the integrated development of the Yangtze River Delta [4]. In order to comprehensively understand the economic development level of the Yangtze River Delta region and promote regional coordination, it is necessary to study the accessibility of transportation.

This article focuses on the traffic accessibility among major cities in the Yangtze River Delta (including Shanghai, Nanjing, Suzhou, Hangzhou, Ningbo, and Hefei), and how the traffic accessibility differs among different modes of transportation. The study of the above issues is of practical significance in promoting the integrated development of higher quality transportation in the Yangtze River Delta, with a view to providing reference for transportation planning and transportation resource allocation by transportation-related departments.

2. Traffic accessibility and evaluation methods

2.1 Transportation Accessibility Connotation

In the field of transportation, accessibility was initially defined as the magnitude of opportunities for nodes in a transportation network to interact with each other, and later transportation accessibility was defined as the ease of transportation from one city to another, representing the combined external accessibility of a region or city [5,6].

At present, people's transportation modes mainly include air, rail and road. Due to the limited spatial distance of major cities in Yangtze River Delta, the analysis of traffic accessibility and equilibrium level in this paper focuses on two modes of transportation: railroad (mainly considering high-speed rail) and highway.

2.2 Evaluation method of traffic accessibility

The weighted time cost method is a method of measuring intercity connectivity using weighted average travel time as an evaluation indicator [7], and the weighted average travel time of the evaluation indicator is calculated by the formula:

$$A_i = \frac{\sum_{j=1}^{n}\left(T_{ij} * M_j\right)}{\sum_{j=1}^{n} M_j} \tag{1}$$

Of which, the weighted average travel time A_i denotes the accessibility level of city i and a smaller value of A_i indicates a higher accessibility level of city i and vice versa. T_{ij} is the shortest travel time required for city i to reach city j; $M_j = \sqrt{G_j * P_J}$ is the amount of socio-economic factors of a city j within the study area, reflecting the high or low economic capacity of the city itself and its small ability to attract radiation, n is the total number of nodes within the study area except city i , G_j denotes the gross product of city j, and P_j denotes the population of city j.

In addition, the coefficient of variation is generally used to reflect the degree of regional differences and can be used to reflect the degree of concentration and dispersion of traffic accessibility among regional cities. Therefore, the equilibrium level of traffic accessibility can be measured by the coefficient of variation of traffic accessibility CV [8], which is calculated as:

$$CV = \frac{\sigma^A}{\sum A_i P_i / \sum P_i} \tag{2}$$

where σ^A is the standard deviation of the traffic accessibility index A_i and P_i is the population of city i.

3. Traffic profile and index statistics of major cities in Yangtze River Delta

3.1 Traffic Overview of Major Cities in Yangtze River Delta

The Yangtze River Delta region is now building the Yangtze River Delta on rail, speeding up the construction of a modern rail transportation system integrating high-speed railroads, general speed railroads, intercity railroads, suburban railroads and urban railways, and building a high-quality rapid rail transportation network. With the goal of urban commuting in the metropolitan area, the construction of intercity railroad network is accelerated, and the extension of municipal railroads to the surrounding small and medium-sized cities is promoted [9]. At the same time, we will improve the accessibility of inter-provincial highways, accelerate the construction of inter-provincial highways [10], and implement the improvement and expansion of trunk highways of national and provincial roads with serious congestion during peak hours to form a convenient and accessible highway network [11].

3.2 Data Sources and Indicator Statistics

Using the weighted average travel time to evaluate the accessibility of transportation, the specific data needed include the high-speed rail travel time between major cities in the Yangtze River Delta as shown in Table 1, the road travel time as shown in Table 2, and the gross product and urban population of each city as shown in Table 3. Among them, the road travel time data source is Gaode Map [12] to select the driving mode, and the high-speed rail travel time data is mainly from the website of China Railway 12306. If there are multiple trips between two cities and the running time is not the same, the shortest trip will prevail.

Table 1 Railroad traffic travel time in major cities of the Yangtze River Delta

Unit: minutes

City	Shanghai	Nanjing	Suzhou	Hangzhou	Ningbo	Hefei
Shanghai	—	59	23	45	94	111
Nanjing	59	—	44	62	135	48
Suzhou	23	44	—	78	132	110
Hangzhou	45	62	78	—	45	113
Ningbo	94	135	132	45	—	195
Hefei	111	48	110	113	195	—

Table 2 Road traffic travel time in major cities in the Yangtze River Delta

Unit: minutes

City	Shanghai	Nanjing	Suzhou	Hangzhou	Ningbo	Hefei
Shanghai	—	258	78	131	161	301
Nanjing	258	—	144	190	283	130
Suzhou	78	144	—	118	158	246
Hangzhou	131	190	118	—	110	291
Ningbo	161	283	158	110	—	384
Hefei	301	130	246	291	384	—

Table 3 Statistical Scale of GDP and Population Statistics of Major Cities in Yangtze River Delta in 2020

City	Shanghai	Nanjing	Suzhou	Hangzhou	Ningbo	Hefei
Total production value (billion yuan)	38700.58	14817.95	20170.45	16106.00	12409.00	10045.72
Population (10,000 people)	2487.09	931.97	1274.96	1196.50	942.00	936.99

4. Traffic accessibility analysis and equilibrium level analysis

4.1 Traffic accessibility analysis

Based on the model established above and the statistical data, the weighted average travel time between the major regions of the Yangtze River Delta can be calculated, as shown in Table 4 below.

Table 4 Weighted average travel time between major cities in the Yangtze River Delta

City	Shanghai	Nanjing	Suzhou	Hangzhou	Ningbo	Hefei	Average
Railroad A_i	60.79	65.34	62.30	62.51	110.88	113.15	79.16
Highway A_i	173.07	212.04	127.57	153.82	195.48	275.46	189.57

The smaller the accessibility value, the higher the accessibility level, and conversely, the larger the accessibility value, the lower the accessibility. From the table, we can conclude that Ningbo and Hefei have lower accessibility and Shanghai has the highest accessibility in terms of rail transportation. The accessibility of Ningbo and Hefei is low because they are located far away from other cities. Shanghai's accessibility is high because of its many railway lines such as Shanghai-Nanjing and Ning-Hang. Using the same comparison method to compare road accessibility, it can be concluded that Nanjing, Ningbo and Hefei are below average, mainly due to their distance from other cities, while Suzhou has the highest accessibility.

4.2 Analysis of traffic accessibility balance level

According to the formula of variation coefficient of traffic accessibility, the coefficient of variation of traffic accessibility is further calculated, and the coefficient of variation of high-speed rail accessibility $CV_{railway}$=0.31, and the coefficient of variation of road accessibility $CV_{highway}$ =0.26. Since the larger coefficient of variation indicates the greater dispersion of data, the higher the degree of unbalance of traffic accessibility and the lower the level of balance; conversely, the smaller coefficient of variation indicates the higher the level of balance of traffic accessibility. indicates that the equilibrium level of traffic accessibility is higher.

It can be seen that the unbalanced degree of road accessibility among cities in the Yangtze River Delta is higher than that of rail accessibility; the balanced level of rail accessibility among major cities in the Yangtze River Delta is lower than the balanced level of road accessibility. The unbalanced level of road accessibility is higher than that of railroads, which is mainly due to the unbalanced layout of railroad lines, while the highways are relatively balanced and comprehensive in their coverage among cities. In addition, although the amount of socio-economic factors is the weight for calculating accessibility, its influence on traffic accessibility is not obvious. The unevenness of traffic accessibility will further promote the aggregation of economic factors, making them converge to the cities with high traffic accessibility.

5. Conclusion

After analysis, the road accessibility between cities in the Yangtze River Delta is more balanced compared to the railroad, so the Yangtze River Delta regional planning needs to pay more attention to the comprehensiveness of the railroad laying coverage. Looking back to 2021, the Yangtze River Delta region, a number of rail transit into use, so that people in the Yangtze River Delta region often see the "so-and-so order of different railroads or high-speed rail history" such expressions, once became a network of hot topics, greatly improving the convenience of travel for the people of Yanbian City. This also proves from the side that the Yangtze River Delta railroad construction has entered a new stage of "completing the short board and writing gaps", gradually completing and vigorously cultivating the development of the Yangtze River Delta metropolitan area, creating a 1-hour commuting circle in the Yangtze River Delta, promoting the mutual flow of people between different cities, and ultimately promoting urban economic development. Looking ahead to 2022, the railroad development plan of the Yangtze River Delta region, through Jiangsu, Zhejiang, Shanghai, Anhui, a number of municipal railway tracks (Jiaxing to Fengnan line, Nanjing to Maanshan suburban railroad, Nanjing to Chuhe municipal (suburban) railroad, Nanjing to Yizheng line (including Yangzhou extension), Hangzhou-Germany intercity, Shanghai municipal line two Hong Kong express line (Nanhui branch), Xiasha to Chang'an municipal railroad, Shanghai demonstration area line, Jiashan to Xitang line, Hefei Xinqiao Airport S1 line, Ningbo to Xiangshan city area (suburban) railroad, Huangshan city area tourism T1 line phase I, etc.) are also all included in the plan. The overall railroad construction investment in the Yangtze River Delta remains high and continues to play a key role in effective investment, supporting major strategies for regional economic development, making up for the shortcomings of the regional railroad sector, guaranteeing stable employment of the labor force, playing a key role in the construction of the railroad between the cities "six guarantees", and escorting the economic development of the Yangtze River Delta region.

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