Research on the Evaluation of Urban Conventional Bus Service Quality and Route Optimization----Taking Jiaozuo City as an Example

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Abstract. Conventional bus system mainly based on public steam (electric) vehicles is the main body of urban public transport passenger transport, its good service quality, reasonable line layout, higher level of operation has a greater impact on the residents travelling, and at the same time related to the public transport enterprises can be healthy development, but also on the society of low-carbon, green development has far-reaching significance . In this paper, we firstly use surveys and questionnaires to obtain and analyse the data resources of Jiaozuo City's public transport development overview, residents' willingness to travel, and public transport lines and stations; secondly, according to the content method of service quality evaluation, we select 11 indicators to establish a service quality evaluation index system from three perspectives of line network planning, operation level, and user service, and we use the hierarchical analysis method to determine the weights of the indicators, and conduct a comprehensive analysis of the service quality of the public transport in Jiaozuo City; finally, we combine the commonly used bus optimization methods, base on the 'four-phase' method of bus passenger flow distribution, select some of the problematic routes in Jiaozuo to put forward optimization and adjustment plans, and briefly summarize and analyse the optimization and adjustment plans. The study shows that the level of bus service quality in Jiaozuo City is general, and there is still a need and necessity for further improvement. Based on this, we propose the optimization plan of adding lines to the east section of Fengshou Road, splitting and adjusting the 30 bus lines and extending the starting and ending points, aiming to better improve the level of bus service in Jiaozuo City, and promote the development of public transport.

Keywords: Urban public transport, indicator selection, service quality evaluation, route optimization

1 INTRODUCTION

With the number of motor vehicles increasing year by year, the city road load is getting bigger and bigger, in order to ease the urban traffic problems, the Ministry of Transport

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put forward the "public transport priority" development strategy[1]; in recent years, Baoding and other cities have issued notices that: the current bus passenger flow continues to decline, the operating income is difficult to maintain daily expenses! China's urban statistical yearbook data show that from 2011 to 2015, the total number of cities in China's annual operation of public buses and trams and the total number of passengers have shown growth, while the annual per capita number of rides and single-vehicle daily capacity has continued to decline, which indicates that the growth rate of the willingness of city dwellers to choose public transport is lower than the growth rate of the scale of the urban public transport, and the situation has further worsened the trend. In order to solve the problem of urban traffic congestion, to increase the attractiveness of public transport and to promote the long-term development of low-carbon cities, relevant scholars have carried out in-depth studies: Klier J M et al.[2] used the binomial logit model to plan the urban and rural bus routes in Preston, Germany, with the ultimate goal of improving the satisfaction of bus passengers and enhancing the enthusiasm of local residents to travel by public transport. Sushreeta M et al.[3] focused on the bus service in Oviedo (Spain), assessing their satisfaction with the service and the factors affecting their valuation based on a survey of passengers. In China, from the perspective of bus passengers, Huang Ting[4] proposed three evaluation indexes of bus stations, bus lines and bus systems and established a more humanized comprehensive evaluation system of service quality based on the research on bus effectiveness, travel time and cost, comfort and convenience, safety and risk comfort and convenience. Qian Xiaoxian[5] applied the customer satisfaction theory in management to the establishment of a conventional public transport service quality evaluation model, and established a conventional public transport service quality index evaluation system based on passenger satisfaction,starting from the characteristics of the constituent elements of public transport service quality. In terms of bus network optimization, Seda Y et al.[6] designed bus routes with short distance service mode by taking the common short-distance service mode as a bus route design strategy to effectively cope with limited transport capacity and considering various objectives of operators and passengers. Wang F et al.[7] took a typical shared bus route in LG City as an example, carried out operational route planning on the Visual C platform, and planned bus routes according to road conditions and passenger travel needs. Wu Hongbo[8] took the urban area of Hanzhong City, Shaanxi Province as an example, based on the POI(Point of Interest) data, resident bus travel data, bus network information and community demographic data obtained by online map API interface, combined with the Floyd-Warshall algorithm and multi-objective planning model, the route length, line density, non-linear coefficient, station density, average station distance, station coverage rate and other indicators were selected to adjust and optimize the bus network nodes and routes in Hanzhong city by GIS path analysis.Hu Shenghua[9] proposed that the public transport system should be divided into three interconnected levels for planning based on the different functional positioning of public transport lines, and studied the optimization objectives and constraints of public transport at different levels, established the corresponding optimization model, and adjusted the existing public transport network combined with the generated ideal public transport network to obtain the optimal public transport network.

Through the discussion of the above research, it is found that most scholars have different perspectives on the evaluation of service quality, and the service quality evaluation indexes of the research are not comprehensive enough, if the systematic evaluation is carried out through multiple levels, it will be more comprehensive, systematic and accurate evaluation of the quality of public transport services. In the study of bus network optimization, most scholars optimization objectives are generally the shortest passenger travel time or the maximum number of direct passengers, etc., and design a certain algorithm for the optimal solution, the computation process has some difficulty. In this paper, based on the discussion and study of the current state of the research mentioned above, and taking into account the actual situation, using the overall service quality score and meeting other constraints, we take Jiaozuo City as an example to carry out evaluation and analysis and route optimization and adjustment suggestions.

2 ANALYSIS OF THE CURRENT SITUATION OF PUBLIC TRANSPORT DEVELOPMENT IN JIAOZUO CITY AND THE QUESTIONNAIRE SURVEY

2.1 Current Situation of Public Transport Development in Jiaozuo City

Jiaozuo city currently has a total of 41 bus lines, 839 buses, and there are direct access to the Yuntai Mountain tourism line, the urban area set up more than 40 kilometers of bus lanes; in the construction of intelligent public transport, Jiaozuo City bus intelligent scheduling platform is fully functional, part of the bus corridor electronic bus stops to achieve full coverage; Jiaozuo Bus Group also initially explore tourism bus, custom bus and other operating modes, as of November 2023, has been planned out of Jiaozuo fourth middle schools, vocational and technical schools and other 21 schools a total of 55 student Customised lines.

2.2 Questionnaire Survey and Analysis of Travelling in Jiaozuo City

This paper adopts online questionnaire survey and offline actual questioning form to investigate the travelling situation of Jiaozuo City residents, and collects a total of 213 questionnaires and 34 enquiry materials, after invalid questionnaires are eliminated and enquiry materials are processed, and combined with the related satisfaction credibility and validity analyses, the specific results of the survey are as follows: Most of the residents of Jiaozuo City still have a high level of enthusiasm for public transport, 57.32% of the residents travelling are willing to choose public transport; Jiaozuo City residents travelling time is generally around 8:00 am and 18:00 pm, with a slight uptick around 12:00 pm; most of the residents of Jiaozuo City travelling by public transport are for recreation and entertainment, going out to shop, and about 1/3 of the people travelling are for their daily work, visiting friends and relatives; their overall satisfaction with public transport is good, with more than half of the residents scoring more than 3 points for Jiaozuo public transport satisfaction (0-5 points means very dissatis-

fied - very satisfied). But when analyzed angle by angle, some of the people are dissatisfied with the direction of the bus line, waiting time, and the condition of the line network, and on the Jiaozuo bus development proposals, many people hope that the direction of bus routes can be adjusted, the location of stops can be reasonably set, the operating environment of buses can be improved, and there are high expectations for the development of public transport.

2.3 Jiaozuo City Bus Line Network Analysis

By using ArcGIS Pro software, creating the service area function, and importing the bus routes and station information, we plotted the 300m and 500m station coverage maps, and processed and summarised the data such as line lengths and non-linear coefficients.For Jiaozuo's bus operation situation, we used field surveys to carry out, and collected data such as passenger load factor and travelling speed of some bus routes, part of the data such as Table 1.

Table 1. Data of some bus routes in Jiaozuo urban area.

Bus name	Departure point	Final stop on rail or bus line	Line length/ Km	Straight-line distance in space/Km	Non-linear coefficient
Route 1	Zhongzhan Central Station Bus Terminal	Hongxin District	15.04	7.44	2.02
Route 7	Wanfang Aluminium Plant	Shenzhou Road Bus Terminal	26.01	12.83	2.02
Route 20	Shenzhou Road Bus Terminal	Zhanqian Road Bus Terminal	14.36	5.72	2.50
Route42 Dashahe Special Line	Shenzhou Road Bus Terminal	Shizhuang	7.11	3.70	1.92

Through the investigation of Jiaozuo bus line data, it is analysed that most of the lines between urban and rural areas in Jiaozuo City are long, with high non-linear coefficients, which to a certain extent will result in the wastage of residents' travelling time. And through the investigation of Jiaozuo bus operation speed and departure interval, it is found that the departure interval of some lines is long, and the operation speed can not reach the people's demand.

3 EVALUATION STUDY ON THE QUALITY OF CONVENTIONAL PUBLIC TRANSPORT SERVICES

3.1 Jiaozuo City Bus Service Quality Evaluation Indicators and Their Weights Determination

This paper refers to the "Bus City Assessment and Evaluation Indicator System"[10], "Evaluation Indicator System for the Development Level of Urban Public Transportation", and the U.S. TCQSM Bus Service Quality Evaluation Indicator System, and

according to the actual situation of Jiaozuo City, establish the hierarchical structure of the Figure 1, adopts the expert questionnaire survey method, and selects five experts for the comparative scoring of the indicator elements.

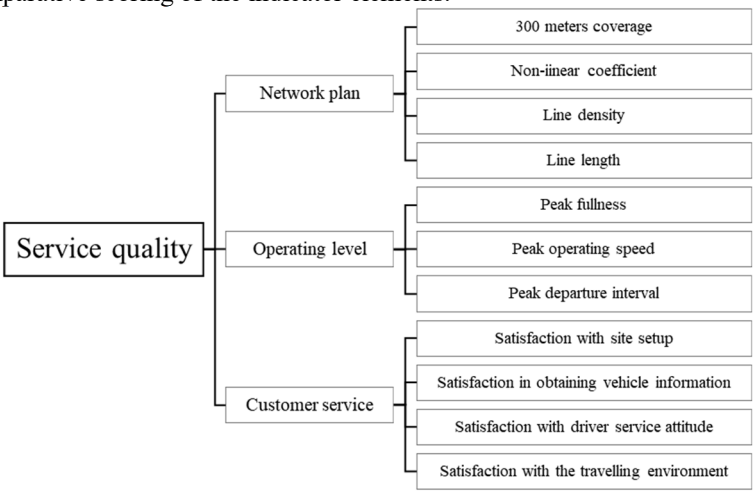

Fig. 1. Service quality evaluation hierarchy.

Through the results of expert survey correspondence and matrix element calculation method, the data are processed using SPSSAU software and consistency test is conducted to get the final weights of the corresponding indicator layers.Specific calculations are shown in the Table 2、Table 3

Table 2. Criterion level judgment matrix.

Criterion layer	Network plan	Operating level	Customer service
Network plan	1	2.05	1.64
Operating level	0.49	1	1.74
Customer service	0.61	0.57	1

Table 3. Criterion layer weight analysis results.

Criterion layer	Eigenvector	Weights	Maximum eigenvalue	CI
Network plan	1.417	47.238%		
Operating level	0.906	30.203%	3.067	0.034
Customer service	0.677	22.559%		

Using the same method as above, the indicator layer is calculated, and the consistency test is carried out separately, and the final weight of the indicator layer is obtained as Table 4.

By referring to the bus priority policies of other cities and combining with the research of other scholars, based on the opinions of relevant experts and the current situation of public transport in Jiaozuo City, the grading standards are determined, and the service quality evaluation grade is now classified into five levels V={Good, Better, Medium, Worse, Poor}, and the evaluation score is calculated by using the following method.

Calculation of evaluation values for each criterion layer

$$Q_j = \sum_{n=1}^{m} a_i \times P_i \tag{1}$$

In the formula: Q_j is the evaluated value of the j criterion layer ;
a_i is the dimensionless value of the i indicator ;
P_i is the relative weight of the i indicator at this criterion layer

(2) Calculation of the comprehensive assessment value of the public transport system

$$Q = \sum_{j=1}^{m} Q_j \times P_j \tag{2}$$

In the formula: Q_j is the combined assessed value of the public transport system
P_j is the relative weight of the criterion layer in this evaluation system

3.2 Evaluation and Analysis of Bus Service Quality in Jiaozuo City

Based on Table 4, the evaluation score of bus service quality in Jiaozuo City is 75.17, and the overall score is between 70-80, which belongs to the general grade. Under the three perspectives of online network planning, operation level and user service, the operation level score is the lowest.

Table 4. Summary of Service Quality Evaluation

Normative layer	Weights	Indicator layer	Weights	Status quo	Dimensionless score	Criterion layer score	Overall score for quality of service
Network plan	47.24 %	300 metres coverage (%)	39.69 %	63	75.33	73.32	75.17
		Non-linear coefficient	19.85 %	1.46	73.00		
		Line density (km)	28.91 %	1.82	71.00		
		Line length (km)	11.55 %	18.55	72.75		
Operating level	30.20 %	Peak fullness (%)	25.07 %	63.7	50.00	68.27	
		Peak operating speed (km/h)	30.98 %	23.8	74.50		
		Peak departure interval (min)	43.96 %	10.3	74.30		
Customer	22.56 %	Satisfaction with site setup	15.44 %	3.59	85.90	88.32	

service	Satisfaction in obtaining vehicle information	20.11 %	3.22	82.20	
	Satisfaction with driver service attitude	25.70 %	4.28	92.80	
	Satisfaction with the travelling environment	38.76 %	3.95	89.50	

According to the data in the table, it is easy to know that the peak fullness score is the lowest, which directly affects the score of operation level and ultimately affects the overall evaluation results, and the reasons for this may be as follows: the route layout is unreasonable, and the duplication coefficient of vehicles on some roads is relatively high, such as Yingbin Road, People's Road, and Zhanqian Road. At the same time, according to the data in the table, it is easy to know that the density of Jiaozuo bus line network is low and covers less area, which in turn cannot meet the travelling demand in some areas. We can extend some of the lines, increase line coverage area, improve the overall quality of service. The data in the table line length, non-linear coefficient, peak operating speed and other scores are also relatively low, by improving the line network conditions, to a certain extent, to play a positive role in the evaluation of these indicators, and thus improve the overall quality of service.

4 CONVENTIONAL BUS LINE NETWORK ADJUSTMENT AND OPTIMIZATION THEORY AND METHOD INVESTIGATION

According to the analysis of bus service quality in Jiaozuo City and the conventional bus optimization method, using the current situation data of Jiaozuo bus, taking the traffic flow distribution results as the basis, through the comparison between the current bus network and the travel flow distribution results, and combining with the road conditions and other constraints, to carry out the optimization of the line reset or new set up.

This paper mainly takes the line planning in the service quality evaluation index as the optimization objective, integrates the operation level and user service and other objectives, and determines the optimization plan of the bus line network by using the method of proving excellence, aiming to improve the overall evaluation score of the urban bus service quality.

The specific optimization steps are as follows:

(1) The urban area was divided into traffic districts, and the TransCAD software and the "four-phase" method were used to assign bus passenger flows to the road network.

(2) Conduct constraint analyses for routes with high traffic distribution flows to find out whether route modifications or new installations are possible.

(3) Analyse the current traffic network, consider the number of bus routes on the optimization target road, station conditions and other conditions, and determine the specific optimization routes.

(4) Conduct line optimization scheme determination according to the above analysis, and conduct post-optimization line analysis and inspection and evaluation to determine the final optimization scheme.

5 JIAOZUO CITY BUS ROUTE OPTIMIZATION AND ADJUSTMENT EXAMPLES OF THE USE OF

5.1 Traffic Subdivision

According to the Jiaozuo City Territorial Spatial Master Plan (2021-2035), the central urban area is divided into three types of sub-districts, and in combination with the specific conditions , the traffic sub-districts are divided by actual communities (villages) in the urban area.

5.2 Bus Patronage Forecasts and Allocation

For Jiaozuo city passenger flow prediction, due to the difficulty of data OD investigation and the huge amount of data, this paper adopts the OD matrix back propagation form to carry out, based on the seventh census data and combined with the key traffic district OD data for correction. We divide the collated data into travel modes according to the proportion of Jiaozuo bus trips, and get the OD bus passenger flow in traffic districts, and allocate them on this basis.The specific passenger flow distribution results are shown in the Figure 2.

5.3 Optimised Routes Examples of Adjustments

Additional Route Determination. According to the Google map satellite display, the current situation of the line network structure (Figure 3), bus flow distribution map, it is Zhouzhuang Town to Shanyang Road has passenger demand, but the current lack of bus routes, and around the nearby new construction of a number of residential neighbourhoods, the comprehensive consideration of the eastern section of Fengshou Road, Longyuan Lake Road online only 12 buses, the actual need to set up a bus line. Proposed lines start and end respectively for Shenzhou Road bus yard and Zhouzhuang Town, can meet the Fengshou Road, a number of villages, Jiaozuo University, Jiaozuo City, Taiji Centre, such as the north gate travel needs, for the Xiuwu West Station transit Jiaozuo City Passenger Terminal also provides line support, indirectly strengthening the urban area and Xiuwu County, while the new road can be strengthened in the town of Zhouzhuang and the southern part of the demonstration area links to facilitate the travel of Zhouzhuang Town workers along the line of companies, and Make the west gate of Henan University of Technology and the south gate to establish a bus line, convenient for students to go out. It can also extend the end of 16 road and 36 road, which is more convenient for transfer and build a more perfect bus network.The results are shown in the Figure 4.

Fig. 2. Bus passenger flow allocation .

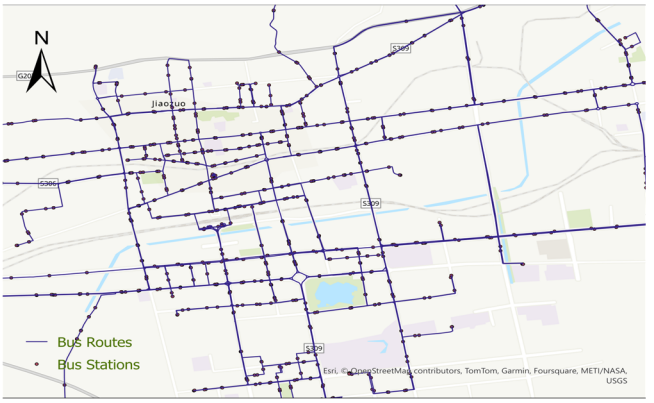

Fig. 3. Jiaozuo City bus lines .

Extension of Bus Routes. According to the Google map satellite display, the current situation of the line network structure (Figure 3), bus traffic distribution map, the following figure shows the area (Zhongnan Road and Film and Television Road, Zhongyuan Road) traffic demand is large but the bus network density is insufficient, and in the leaping into the road on the only bus line 1, the current 30 bus line non-linear coefficient of 2.23, the line length of 17.7Km, may be a large increase in passengers travelling to spend additional time, to be proposed to optimize and adjust this bus route. For the original 30 bus starting point for the line split, and were extended to the end point, the extension of its extension line together with the extension of the point to the realm of the Oriental Classic, the end point is set for the Jiaozuo City Tourist Passenger Terminal; another line starting point for the Jiaozuo City Railway Station, part of the line along the original 30 road, the end point is extended to the Central Station District, Wang Fengxiang Committee.The results are shown in the Figure 5.

Fig. 4. Additional Routes .

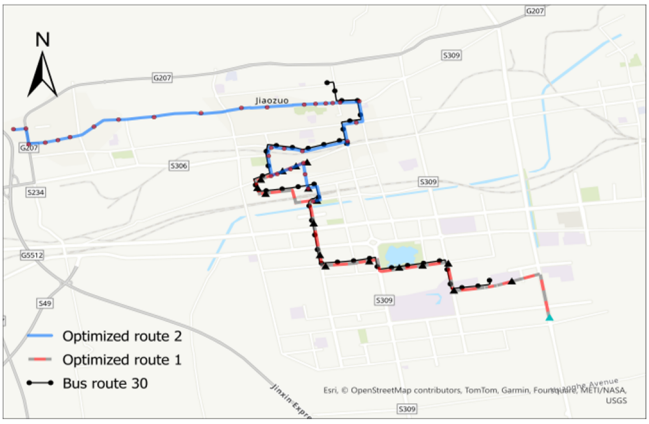

Fig. 5. Proposed Route Extensions .

5.4 Evaluation of the Line Network after Optimization and Adjustment of the Line Network

Through the above, we chose two routes for optimization and adjustment, and we carried out line splitting and end-point extension design for Jiaozuo Route 30, and proposed to set up an additional bus route on Fengshou Road to meet the travel needs of Zhouzhuang Town and other residents. Through the optimization example of the line, the line network planning part of the service quality has been improved, and its evaluation indexes: 300m coverage, non-linear coefficient, and line length all have a certain positive effect, and its line network planning score can be further improved. For the operation level and service quality, after the line optimization results, the line is straighter and smoother, the operation speed can be improved accordingly, the peak load factor can be further improved due to the adjustment of the line, and the overall operation level is on the rise. As for service quality, the optimization of the line will

also have a certain impact on the location of stations, while other indicators need to be maintained. After the above, the optimized line network will be more responsive to the needs and the service quality will be further improved.

6 CONCLUSION

This study starts from the overall goal of service quality, selects 3 angles of line network planning, operation level, user service, 11 specific indicators such as 300m coverage, non-linear coefficient, etc., and successfully builds up Jiaozuo bus service quality evaluation system, and carries out an overall evaluation, which results in the overall score of Jiaozuo bus evaluation of 75.17 points; and then, through the study of optimization methods and example analysis, it simplifies the optimization methods "one by one" by applying them to meet the travel demand and improve the evaluation indicator results, combined with the results of passenger flow distribution. Then, through the research and example analysis of optimization method, based on the results of meeting the travel demand and improving the evaluation indexes, combined with the results of passenger flow distribution, the optimization method is simplified by "setting up one by one", and the optimization plan of adding lines to the east section of Fengshou Road, splitting and adjusting the 30th bus line and extending the start and end points is proposed, and the rationality and feasibility of the evaluation of the quality of the city's regular bus services and the optimization study of the lines are proved. It also confirms the rationality and practicability of urban regular bus service quality evaluation and route optimization research.

Future research can consider the positioning of different cities, according to local conditions to establish a realistic evaluation system indicators, while combining the difficulty of obtaining actual data to ensure the reasonableness and feasibility of the evaluation system; for the study of optimization methods need to be considered systematically, and the use of data showing the difference between the optimization before and after the optimization of the effect of the optimization of the more obvious description. Through in-depth research, we will better promote the healthy and sustainable development of public transport, so that people will be willing to travel by public transport.

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