Analysis of Residents ' Willingness to Transfer Travel Modes Based on Structural Equation Model

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Abstract. As a new type of bus service mode, the efficient operation of demand-responsive bus can not only improve the efficiency of urban traffic, but also meet the growing travel needs of citizens. Based on the survey of residents ' travel choice behavior and willingness in Jiaozuo City, this paper constructs a structural equation model, and collects 303 questionnaires online to study the decision-making factors of residents ' transfer to demand-responsive public transport. The study uses reliability, convenience, comfort, economy, perceived value and passenger intention as potential variables to establish a structural equation model and analyze the impact of each factor. The research shows that reliability, convenience, comfort, economy and perceived value all have a significant impact on passenger intention, among which reliability and perceived value have the greatest impact. Through the above conclusions, it lays a foundation for the later residents ' choice of travel mode transfer willingness and the feasibility study of urban operation demand response bus, so as to improve the urban travel structure, alleviate traffic congestion and improve residents ' travel satisfaction.

Keywords: Demand responsive transit, structural equation model, resident travel modes, passengers ' willingness to ride

1 INTRODUCTION

With the continuous advancement of urbanization, urban traffic congestion, energy consumption and environmental pollution have become increasingly prominent. In order to cope with these challenges, optimizing the public transport system has become an important way to improve urban traffic conditions. With the continuous expansion of the city, the traditional conventional bus system is difficult to meet the increasingly diverse travel needs of the public due to the problems of fixed lines, few shifts and limited coverage. Demand-Responsive Transit (DRT) emerges as a flexible and customized public transportation mode, which can adjust services according to actual needs and provide more efficient transportation solutions for urban residents. Therefore, it is of great significance to explore the willingness of urban residents to take demand-responsive buses and attract more residents to choose this mode of trav-

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el, which not only helps to alleviate urban road congestion, but also provides residents with more comfortable and convenient travel services.

With the popularity of demand-responsive public transport, domestic scholars have paid more and more attention to this field, and have carried out in-depth research work. Liu K et al.[1] proposed a shared bus service based on the problem of insufficient capacity and high cost of shared cars. Jin Wenzhou et al[2]. adopted the hybrid genetic ant colony algorithm HGACO, which can effectively solve the flexible scheduling problem of DRT. He Yunzhu et al[3.] studied the BPW-DRT model and its departure schedule and fare optimization in bus services. Xin et al[4]. established a multi-objective network optimization model for demand-responsive public transport with the goal of minimizing the cost of operating companies and reducing passenger travel time. Jiang Ruisen et al[5]. proposed a GA-LSTM hybrid prediction model and compared its prediction accuracy. Hu Kai et al[6.] established a scheduling optimization model based on the mixed operation of traditional fuel bus and electric bus.

In terms of residents ' travel mode choice, domestic and foreign scholars have also conducted in-depth research on this. Wan et al[7]. studied the passenger satisfaction of BRT by using the structural equation model, and found that the frequency of departure, the punctuality of vehicles and the speed of vehicles are all important factors affecting passenger satisfaction. Ettema et al[8].found that travel characteristics (mode, distance and time) have an important impact on commuting satisfaction among all determinants. Wen Huiying et al[9]. established an ordered multi-classification Logistic regression model based on the characteristics of passenger bus satisfaction to analyze the influence of bus travel time on multi-group passenger satisfaction. Yuan Zhibing et al[10.] based on the survey of passenger satisfaction with bus travel in Xi 'an, established a structural equation model to analyze the factors affecting passenger satisfaction with bus travel.

Through the above research on demand-responsive bus and residents ' travel mode choice at home and abroad, it is found that although the existing research has made some progress in the optimization of bus routes, most of the research still focuses on the optimization of fixed routes and the analysis of residents ' satisfaction with bus travel. There are relatively few studies on residents ' individual choice behavior preferences. Therefore, in order to further attract more residents to take demand-responsive buses, it is feasible to explore the transfer of residents ' demand-responsive bus travel modes. In this paper, the travel behavior of Jiaozuo residents is taken as the research object, and the structural equation is constructed to analyze the influence degree of each factor, so as to obtain the influencing factors of passengers ' choice of transfer intention, which lays a foundation for the later residents ' choice of transfer intention and the feasibility study of urban operation demand response bus, so as to improve the urban travel structure and improve the residents ' travel satisfaction.

2 SURVEY ON RESIDENTS' TRAVEL CHOICE BEHAVIOE AND WILLINGNESs

2.1 Questionnaire Design

This paper collects relevant data by combining the methods of Revealed Preference (RP) and Stated Preference (SP) to understand residents ' behaviors and preferences more comprehensively. The combination of these two methods can make up for the limitations of a single method, so as to obtain more accurate and abundant information. In the specific investigation process, it mainly focuses on three aspects : The first is the survey of residents ' personal characteristics, aiming to obtain the basic demographic information of the respondents, such as age, gender, education level, occupation and so on. Secondly, it is the survey of residents ' travel characteristics. This part involves the daily travel behavior of residents, including travel frequency, travel purpose, travel mode, travel time and waiting time. Through these data, we can understand the travel patterns of residents in detail and provide basic data support for subsequent analysis. Finally, the survey of residents ' choice preference is carried out. This part uses the Likert 5-level scale for questionnaire design, in which the questionnaire options from 1 to 5 indicate unwillingness to very willing. Through this scale design, we can quantitatively evaluate residents ' preference for reliability, convenience, comfort, safety and economy.

2.2 The Survey Data Analysis

Sample data analysis. This questionnaire adopts the method of network questionnaire at random places in Jiaozuo City, and conducts a survey on the travel choice behavior and willingness of residents in Jiaozuo City. A total of 303 questionnaires were obtained. The composition of residents ' personal characteristics samples and travel behavior characteristics samples are shown in Figure 1 and Figure 2.

According to Figure 1, it can be seen that the respondents are mainly young people and the elderly, and the income level is concentrated between 1500-6000 yuan. The vehicle ownership is 55.45 %, which reflects that the respondents have a large demand for public transportation.

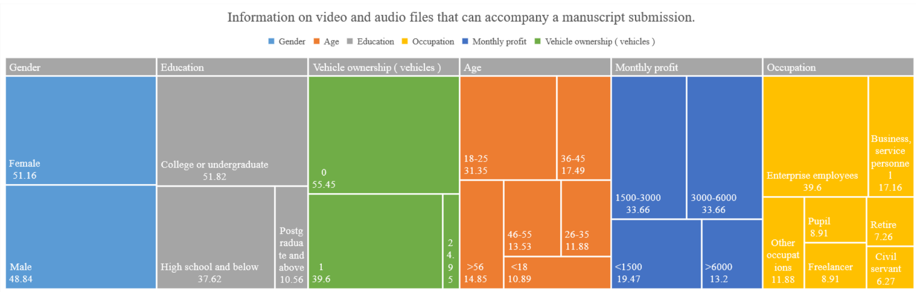

Fig. 1. Chart of personal characteristic sample composition of residents.

It can be seen from Figure 2 that the proportion of respondents waiting for more than 10 minutes is 44.22 %, which indicates that there is a certain efficiency problem in Jiaozuo 's public transportation system. In addition, a survey was conducted on whether respondents knew about demand-responsive public transport information, and 44.55 % of residents did not know about demand-responsive public transport, indicating that there is a need to strengthen publicity and education in promoting and popularizing demand-responsive public transport.

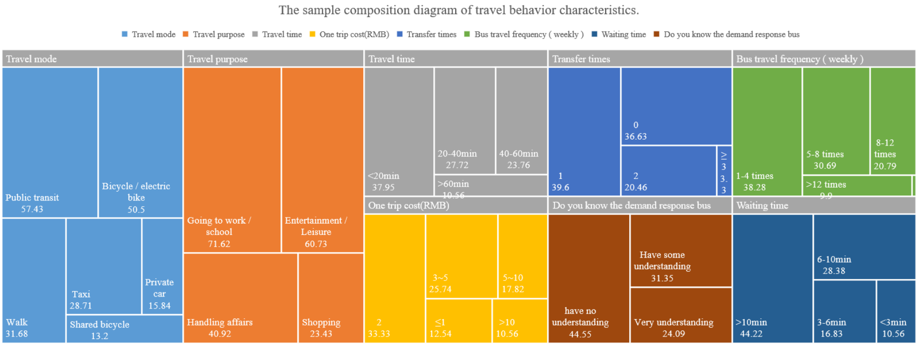

Fig. 2. The sample composition diagram of travel behavior characteristics.

Reliability and Validity Analysis. In this paper, SPSS software is used to test the reliability and validity of the questionnaire. The reliability test refers to the consistency and stability of the measurement tools. Through analysis, the Cronbach 's alpha values of each latent variable are all greater than 0.7, indicating that the questionnaire has good reliability. The validity test evaluates whether the measurement tool accurately measures the content of its expected measurement. The validity test is mainly carried out by evaluating the Kaiser-Meyer-Olkin (KMO) value and the Bartlett spherical test. In this study, the validity test results show that the KMO value is 0.844> 0.8, which is close to 1, indicating that the sample is very suitable for factor analysis. In addition, the approximate chi-square value of Bartlett 's sphericity test is 2166.265, the degree of freedom is 105, the significance level is 0.000< 0.1, and the significance level is 1 %. The test shows that the questionnaire has good validity and provides a solid foundation for subsequent data analysis.

3 RESIDENTS TRAVEL CHOICE MODEL

3.1 Model Selection

The model used in this study is the structural equation model (SEM). The model is a multivariate statistical method based on factor analysis and path analysis. It can not only analyze the internal relationship between variables, but also allow the model variables to be latent variables that can not be directly observed. Quantitative analysis makes up for the shortcomings of traditional analysis methods. Therefore, in recent years, structural equation models have become very popular in research and have been widely used. SEM combines the advantages of regression analysis, path analysis and factor analysis, verifies the hypothesis through model fitting test, and provides intuitive visual results to help fully and accurately understand and explain the key factors and paths that affect residents ' travel choice behavior. According to the different relationships described, the structural equation model can be divided into measurement model and structural model.The measurement model is mainly to describe how the latent variable is measured by observing the variable. The expression of the measurement model is:

$$X = \Lambda_x \xi + \delta \tag{1}$$

$$Y = \Lambda_y \eta + \varepsilon \tag{2}$$

The structural model mainly describes the relationship between potential variables. The structural model expression is:

$$\eta = B\eta + \Gamma\xi + \zeta \tag{3}$$

Among them, ξ is the exogenous latent variable, η is the endogenous latent variable, X is the vector composed of exogenous indicators, Y is the vector composed of endogenous indicators, δ is the measurement error of exogenous latent variables, ε is the measurement error of endogenous latent variables, Λ_x is the factor loading matrix of X on ξ, Λ_y is the factor loading matrix of Y on η, B is the relationship matrix between endogenous latent variables, Γ is the influence matrix of exogenous latent variables on endogenous latent variables, and ζ is the residual term.

3.2 Model Construction

Based on the existing research and the questionnaire data analysis results of the previous survey, this paper sets the relevant structural variables, including reliability, convenience, comfort, safety, economy, perceived value, passenger satisfaction and passenger willingness to ride. The passenger willingness to ride is the final target variable of the model, and the specific model variables are described as shown in the table 1.

Table 1. Model variable description table.

Latent variable	Name of observation variable	Symbols
	The departure time is accurate	X_1
Reliability	The arrival time is close to the expected value	X_2
	The waiting time is shorter	X_3
	The site location is reasonable	X_4
Convenience	There is no need to transfer	X_5
	Bus operation information is transparent and	X_6

	easy to obtain	
	Smooth driving	X_7
Comfort	Provide one person one, no standing	X_8
	The temperature in the car is suitable and clean	X_9
	There are various forms of ticket purchase	X_{10}
Economy	Mobile payment or small program payment has a discount	X_{11}
	The walking distance after the station is shorter	X_{12}
Perceived value	Ticket price concessions under certain service quality	X_{13}
Passenger willingness	Passenger satisfaction with demand-responsive buses	X_{14}
	Willing to shift from the current mode of travel to demand-responsive transit	X_{15}

3.3 Model Calibration

When evaluating the fitting degree of the model, *AMOS* is used for testing. The higher the fitting degree is, the stronger the consistency is. The comprehensive use of the fitting index can effectively evaluate the goodness of fit of the model, so as to ensure the reliability and validity of the research conclusions. The specific evaluation indicators and standards are shown in Table 2.

Table 2. Evaluation criteria of structural model.

Evaluating indicator	CMIN/DF	GFI	CFI	NFI	RMSEA
Evaluation criterion	<3.000	>0.900	>0.900	>0.900	<0.080

In this study, *Amos* software was used to construct the structural equation model framework as shown in Figure 3.

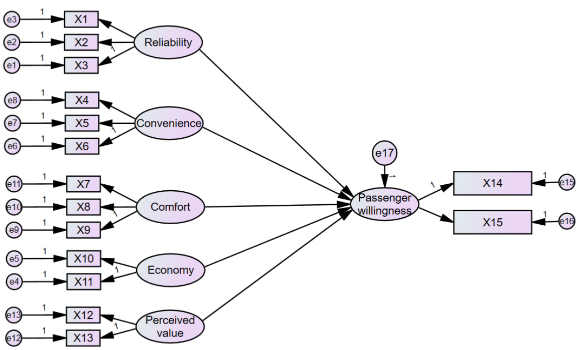

Fig. 3. Frame diagram of structural equation model.

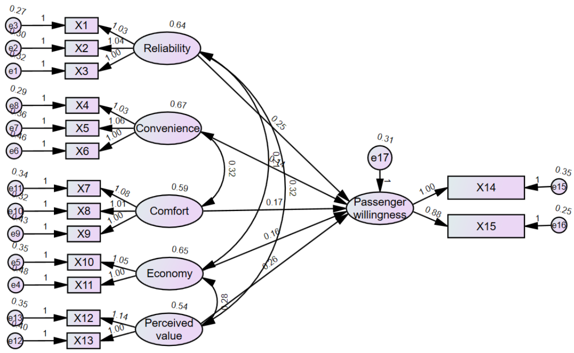

Fig. 4. The modified structural equation model frame diagram.

4 STRUCTURAL EQUATION MODELING ANALYSIS

4.1 Model Calculation

Based on the questionnaire data, this paper constructs a structural equation model. Before the structural equation verification, it is necessary to verify the fitting index of each variable. *AMOS* software is used to test the relevant factor analysis index system. The fitting results of the structural equation model are shown in Table 3.

Table 3. Structural model fitting results.

Evaluating indicator	CMIN/DF	GFI	CFI	NFI	RMSEA
Evaluation criterion	<3.000	>0.900	>0.900	>0.900	<0.080
Model result	4.779	0.816	0.847	0.849	0.112

The evaluation results of the structural equation model in this study showed that the chi-square degree of freedom ratio (CMIN / DF) was greater than 3, the goodness of fit index (GFI), the normalized fit index (NFI), and the value-added fit index (IFI) were all lower than 0.90, and the root mean square error of approximation (RMSEA) was higher than 0.08.These values did not meet the evaluation criteria, indicating that the model 's goodness of fit was poor, especially the values of CMIN / DF and RMSEA were significantly higher, indicating that the overall fitting effect of the model was poor and needed to be adjusted and improved.

4.2 Adjustment of Model

In order to improve the fitting degree of the structural equation model, this study uses the Modification Indices (MI) in AMOS software. On the basis of theoretical support, the error correlation between some variables is increased, and the paths with higher MI values are viewed. By increasing the path between the following latent variables, such as convenience and perceived value, multiple latent variables interact with each other, as shown in Figure 4. The results showed that the fitting index was significantly improved (CMIN/DF=2.086, GFI = 0.917, CFI = 0.928, IFI = 0.907), and the fitting degree of the final model reached a satisfactory level, indicating that the improved path relationship can more accurately reflect the real relationship between variables. The increased cross paths and higher path coefficients indicate that the modified model is more accurate and effective in fitting data, which can better explain passenger intentions and provide more reliable predictions.

4.3 Analysis of Effect

The results of the modified structural equation model show that reliability, convenience, comfort, economy and perceived value all have a positive impact on passenger intentions, as shown in Figure 4. Among them, reliability (0.272) and perceived value (0.261) have a strong influence, while convenience (0.160) has a relatively weak influence. Comfort (0.184) and economy (0.178) also have a significant positive impact on passenger intention. In order to improve passenger intentions, it is recommended to improve the convenience and reliability of services, increase operating frequency and coverage, optimize scheduling, ensure punctuality, reasonably price and provide preferential policies, improve in-vehicle facilities to enhance comfort, strengthen brand building and publicity, and enhance passengers ' overall perceived value of bus services, thereby increasing the deviation of passenger travel modes from demand-responsive buses.

5 CONCLUSION

This study takes Jiaozuo residents as an example, based on the structural equation model to study the influencing factors of residents ' travel choice behavior and willingness, and to explore the reliability, convenience, comfort, economy and perceived value of demand response bus. The influence of the transfer of passengers ' willingness to take, and finally get the following conclusions.

(1) The path coefficients between the potential variables in this study have reached a significant level, indicating that there is a significant positive impact between the potential variables. These significant path relationships verify the theoretical model assumed in this paper.

(2) This study further explores the positive correlation between influencing factors and passenger intentions. The results show that the reliability, convenience, comfort, economy and perceived value of demand-responsive buses have significant positive effects on passenger intentions. Among them, the path coefficient of reliability and perceived value to passenger intention is the largest, indicating that reliability and perceived value have the strongest positive effect on passenger intention. Improving this influencing factor can effectively enhance passenger intention, thus improving the deviation degree of passenger travel mode to demand-responsive bus.

Future research can consider expanding the scope and number of samples to improve the universality of research results, and introduce more potential variables and influencing factors, so as to consider the complexity and diversity of passenger intention more comprehensively. Through these in-depth studies, we can improve the transfer of residents ' travel modes to demand-responsive public transport, thereby reducing the use of private cars, alleviating urban traffic congestion, reducing environmental pollution, and improving the overall efficiency and sustainability of urban public transport systems.

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