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The Influence of Information Services on Public Transport Behavior of Urban and Rural Residents

Xuemei Zhou [1], Jiahui Liang [1], Xiangfeng Ji [2,*] and Caitlin D. Cottrill [3]

[1] College of Transportation Engineering, Key Laboratory of Road and Traffic Engineering of the State Ministry of Education, Shanghai Key Laboratory of Rail Infrastructure Durability and System Safety, Tongji University, 4800 Caoan Highway, Shanghai 201804, China; zhouxm@tongji.edu.cn (X.Z.); 1833334@tongji.edu.cn (J.L.)

[2] Department of Management Science and Engineering, School of Business, Qingdao University, 62 Keda Branch Road, Laoshan District, Qingdao 266000, China

[3] School of Geosciences, Department of Geography & Environment, St Mary's Building, Elphinstone Road, Aberdeen AB24 3UF, UK; c.cottrill@abdn.ac.uk

* Correspondence: jixiangfeng@qdu.edu.cn

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Abstract: Rural and urban areas are mainly connected by public transport in China. The characteristics of the trips of local residents in rural and urban areas are different; therefore, the demand for public transport information services is different. Based on the revealed data, a structural equation model is applied to examine the critical factors affecting the behavior of urban and rural residents in choosing public transport in the Beidaihe District, Qinhuangdao City, China. The effect of information service factors on public transport behavior of urban and rural residents is obtained. The influence level of public transport information service on public transport behavior of urban and rural residents before and during travel is discussed. This study provides valuable insights to improving public transport services between urban and rural areas of China, which can attract more residents to use public transport and promotes sustainable development between urban and rural areas.

Keywords: public transport information service; public transport behavior of urban and rural residents; structural equation model

1. Introduction

The concept of urban and rural public transport is defined in that public transport provides connections between the urban area (or the central town) and rural areas (or the villages), relying on urban roads and highways to: lay the fixed route and unify serial numbers, establish the fixed terminal on the way and the return terminal of the start and end points, adopt the vehicle style of the public transport and refer to the operation management style of the urban public transport. Urban and rural residents are defined with residents living in towns or cities often using urban and rural public transport differently from township residents and rural residents. The public transport behaviors of urban and rural residents refer to the public transport travel choice behaviors of urban and rural residents, including the choice of public transport travel mode, the choice (or adjustment) of bus travel route and the choice of bus travel time.

Passenger travel modes between urban and rural areas have gradually changed. With the accelerating urbanization process and the increase of urban-rural contact, the communication between rural and urban areas has increased substantially in recent years [1]. It is necessary to build a public transport system for urban and rural areas to meet the evolving needs of residents and promote urban and rural development. In the formation and development of urban and rural integration, the function of the traffic system is essential; it becomes an important prerequisite and foundation of the urban

and rural integration. As a high-quality and high efficiency transportation mode, public transport has become a kind of development trend of the traffic connection between urban and rural areas [2]. Some cities in China have developed rural public transport systems or extended the existing urban public transport systems to suburban and rural areas [3]. However, when planning or designing a public transport system to serve urban and rural residents, there lacks sufficient consideration of information services for urban and rural areas, so the service level of urban and rural public transport is still not able to meet the needs of urban and rural residents for public transport.

The service level of urban and rural areas is restricted by many factors, such as the attitude of service personnel, fares, punctuality, the completeness of public transport facilities, the stability of vehicle operation, the convenience of arriving at public transport stations, etc. [4]. However, the departure interval of public transport in urban and rural areas is larger than that in urban areas; thus, information services are more important [5]. Public transport information has effects on passengers' transport mode selection, travel route selection of public transport between urban and rural areas or travel time selection of public transport between urban and rural areas [6]. From the perspective of the whole process of travel and the information service system of urban and rural public transport, we divide the urban and rural public transport travel information needs into 'before travel', 'during travel' and 'personalized information' [7].

Before traveling, travelers who choose public transport tend to use tools such as online and paper-based maps and services to collect relevant travel information in advance, including travel expenses, time, sites and other information. During the trip, the traveler pays attention to information such as ride, transfer, level of crowdedness and vehicle operations through stop sign, video and audio. In addition to the information required before and during travel, some travelers also want to obtain weather, social services, facilities, news, entertainment and other information.

The rest of this paper is organized as follows. The next section presents related existing literature. The structural equation model (SEM) takes into account factors such as public transport information services of urban and rural areas, other urban and rural public transport service factors, and individual and family characteristics. Then, according to the model results, the influencing factors of various public transport information services on public transport travel choice behaviors of urban and rural residents is analyzed in depth. Finally, suggestions for improving public transport information services of urban and rural areas are put forward. The research results have made valuable contributions to providing some additional references about how to improve the rural public transport information service under the topic of urban-rural integration and better meeting rural-urban residents' travel demands and attracting travelers to public transport.

2. Literature Review

The travel demand of residents has gradually changed with the continuous development of urbanization and the gradual weakening of the urban-rural dual structure. Some areas with relatively developed economies have begun to implement urban public transport integration, and gradually realize the coordinated development of public transport between urban and rural areas in planning, operation and management, e.g., American "transit village" [8], French complete intercity transportation system [9] and the integration of the British transportation system strategy [10].

Transit integration planning of urban and rural areas in China is mainly divided into three aspects: the overall structure, the network planning and the hub site planning. From principle to framework and method, it has been relatively complete and mature in China [11–15]. In the study of public transport operation management of urban and rural areas, passenger flow organization has been carried out according to the source of passenger flow and the volume of passenger traffic [16–18]. However, the latest concepts have not been followed up, such as the construction of intelligent transportation systems and the construction of public transport information service systems.

The research on the influencing factors of public transport travel in urban and rural areas is mainly focused on the traditional public transport service factors (which can be roughly divided into

dimensions such as comfort, convenience, safety, reliability, and completeness of facilities), mainly from personal and family characteristics. The public transport service factors are studied in two aspects. Among the personal and family environmental factors, the travel destination [19], occupation, and family annual income [20,21] have a significant influence on public transport travel behaviors of urban and rural residents, along with travel time and travel expenses, public transport service factors [22,23], walking distance [24], comfort level [19], etc. The insufficiency of the current research is the lack of study on the impact of information service factors on public transport behavior of urban and rural residents.

The influence of information services on public transport behavior is roughly divided into three aspects. The first is the influence of information services on the choice of departure time, the choice of travel route and the choice of travel mode [25–29]. The research shows that the information service has a positive influence on these public transport travel behaviors. The second is the influence of information services on the objective effects of travel behavior [30–34]. These studies show that information services can attract travelers, reduce travel time, and improve public transport service levels; The third is the influence of information services on public transport time and psychological activities at public transport stations [35,36]. Research shows that information services can reduce the average waiting time, and reduce the fatigue and anxiety when waiting for the bus. However, these studies pay more attention to the influence of information services on urban public transport travel behavior of urban residents, but less on the influence of information services on public transport travel behavior of urban and rural residents.

Other types of public transport service factors, such as comfort, safety, convenience, economy, reliability, etc., have an influence on public transport travel behavior, especially on travel choices. Among them, the public transport service with convenience, comfort and reliability dimensions has a greater influence on the choice of public transport mode [37–39].

The study of travel behavior mainly adopts the non-aggregate method. There are three main methods: the first one is the Logit model and its improved model, such as the Nested Logit model [40,41], the Mixed Logit model [42] and the Probit model [43] et al.; the second is to establish a research model based on prospect theory [44,45]—an important assumption of the theory is that the decision maker is completely rational; the third is the structural equation model, from the overall structural model and the local measurement model Composition [46,47].

The structural equation model includes the measurement model and the structural model, and the structural model can reflect the complex influence relationship between variables, which is in line with the needs of this paper. The Logit model can only reflect the independent variables and dependent variables, but cannot reflect the relationship between the independent variables. In addition, structural equation modeling can study non-observable variables (latent variables). For example, researchers use structural equation models to study the relationship between residents' personal attributes and travel mode choices [47]. The structural equation model is also used to analyze the relationship between travel behavior and socioeconomic factors and built environment [48,49], which is well suited to study the effects of various factors on travel behavior. The Logit model can only evaluate and analyze the variables that can be directly observed, and it does not meet the requirements of this paper. Therefore, this paper intends to use the structural equation model to establish a model of urban and rural public transport travel behavior.

3. Data and Methods

3.1. Data Collection

To investigate the influence of information services on public transport behaviors of urban and rural residents, this study collected data from a survey of urban and rural residents in Beidaihe New District of Qinhuangdao City. The data analyzed in this paper are collected from a questionnaire survey, which is designed for people living or working in Beidaihe New District of Qinhuangdao City. Beidaihe

New District of Qinhuangdao City is located in the northeast of Hebei Province and the west side of Qinhuangdao City Coastal Area. Beidaihe New District has 9 townships (6 towns and 3 villages) and 2 forest farms, including 1 nature reserve and 2 tourist resorts. The public transport of urban and rural areas relies on rural roads and some cities and towns are routed with uniform numbers and fixed stops. By 2016, there were four public transport lines in the district, all of which operate across the district, 22, 801, 802 and 803. These lines are connected to urban and rural areas. The total length of the public transport lines is 81.2 km, the average length is 20.3 km, the longest line is 42 km, and the shortest is 19.8 km. A map in Appendix A shows the area of the study and the bus system. In addition, according to the results of the residents' travel survey of the "Qinhuangdao Comprehensive Transportation Plan (2014–2020)", the current rate of public transport travel in the Beidaihe New District is about 9.4%, and the share of public transport trips in the motorized mode is about 12.4%. It should be pointed out that the areas selected in earlier similar research are mainly urban suburbs, towns [50] or industrial development areas transformed by towns [5], and the areas selected in this study include the above categories. The common characteristics of the region have more significant personality characteristics, such as the tourism-oriented population in the region, and the equivalent population of the tourism and holiday industry (the average annual tourist population is equivalent to the population of the annual resident population for social service facilities and infrastructure needs). The scale is larger than the resident population, and due to the influence of the geographical climate, the passenger flow has a strong seasonality, and the gap between the peak and slack season is large. Due to the large number of non-local tourists in Beidaihe New Area, the demand for information services is large, and the improvement of public transport information services between urban and rural areas will improve the tourism service quality of the area to a certain extent and increase the attractiveness to non-local tourists.

The survey yields data from July 2016. Stated preference (SP) surveys are important tools, which help forecast decisions, suggesting to respondents' questions about their possible choices in hypothetical situations given a specific set of conditions. Stated preference methods are widely used in travel behavior research [51–53]. Therefore, the SP methods were adopted in the questionnaire. The survey was conducted by issuing a paper questionnaire and the questionnaire was designed according to the needs of the study. The survey was distributed to all people through the community and the unit, and the survey technique is sent to the individual face to face. The questionnaire is divided into three parts: the first part is the personal attribute information part, which mainly collects the basic characteristics of the respondent, such as gender, age, annual income, etc.; the second part is the investigation of the residents' travel situation, and investigates the residents' travel time throughout the working day; the third part is a survey of the subscales, surveying the passengers' satisfaction and expectation of urban and rural public transport information services and other urban and rural public transport services. The specific questionnaire is shown in Appendix B. In this survey, 1500 questionnaires were distributed and 500 valid questionnaires were collected as sample data. Table 1 is a descriptive statistic of the main features of the sample.

Table 1. A summary statistics table for users' socioeconomics of the sample.

Main Feature	Classification	Percentage (%)
Gender	male	41
	female	59
Age	<20	10
	20–29	37
	30–39	26
	40–49	18
	50–59	3
	≥60	6

Table 1. *Cont.*

Main Feature	Classification	Percentage (%)
Registered residence	Local registered residence	95
	Non-local registered residence	5
Career	Office staff	48
	Self-employed	8
	Worker	15
	Business service staff	6
	Farmer	8
	Student	6
	Unemployed	4
	Others	5
Educational background	High school, technical secondary school and below	25
	Junior college	37
	Undergraduate	34
	Postgraduate and above	4
Monthly personal income	<1000	5
	1000–2000	18
	2000–3000	17
	3000–4000	42
	4000–5000	12
	≥5000	6
Annual household income	<20,000	4
	20,000–50,000	30
	50,0000–80,000	33
	80,000–100,000	21
	100,000–150,000	8
	≥150,000	4
Car ownership	Yes	44
	No	56

3.2. Methodology

3.2.1. Theory of SEM

Structural Equation Modeling (SEM) is an analysis method based on covariance matrix between variables. It has been widely used in sociology, psychology and education since the 1970s. Since the 1980s, structural equation models have been gradually introduced into the study of transportation problems.

As a multivariate statistical method, the structural equation model integrates factor analysis and path analysis, and can process a large number of variables (including directly observable observation variables and non-observable latent variables), and achieve an estimate of the relationship between variables.

Compared with the conventional factor analysis method, the structural equation model has the following advantages:

1. Multiple endogenous variables (dependent variables) can be processed simultaneously;
2. The model can contain variables that cannot be directly measured (latent variables, such as the subjective attitude of the individual), can characterize the relationship between latent variables, and can assess the reliability and validity of the variables;
3. The structural relationship between various variables can be designed and the fitting level of the model can be estimated;
4. In addition to analyzing the direct effects between variables (the direct effect of exogenous variables on endogenous variables), the indirect effects of independent variables on dependent variables can also be obtained (exogenous variables affect endogenous variables through one or more mediator variables) or a total effect (the sum of the two) that enables a more accurate analysis of the relationship between variables.

Due to the above advantages, in the related research of residents' travel, the structural equation model can analyze various factors that affect residents' travel behavior and willingness to travel (including factors that cannot be directly observed, such as satisfaction with vehicle services). In addition, the model can identify the complex interrelationships between factors and factors and travel choices, and get realistic results to provide a reliable basis for better improving the relevant vehicle service level and achieving the goal of adjusting the structure of residents' travel modes.

3.2.2. Conceptual Structure

SEM contains measurements (Equations (1) and (2)) and structural equations (Equation (3)) for observed and latent variables, given by

$$x = \Lambda_x \xi + \zeta \quad (1)$$

$$y = \Lambda_y \eta + \varepsilon \quad (2)$$

$$\eta = B\eta + \Gamma\xi + \zeta \quad (3)$$

where x = vector of observed exogenous variables; y = vector of observed endogenous variables; Λx and Λy = loading matrix; ξ = vector of latent endogenous variables; ζ = vector of errors; η = vector of latent endogenous variables; ε = vector of errors; B = coefficient of latent endogenous variables; and Γ = coefficient of latent exogenous variables.

3.2.3. Key Variables

Variables used in the analysis include personal and family characteristics, information service factors before and during travel, other public transport service factors, public transport travel willingness and public transport travel choice behavior of urban and rural residents (Table 2). It also gives a corresponding code for each latent variable and measured variable in the scale.

Table 2. Variables for the SEM.

Variable Attribute	Variable Categories	Variable Names (Encoding)
Exogenous variable	Personal and family characteristics (UV1)	Gender (A1)
		Age (A2)
		Monthly personal income (A3)
		Occupation (A4)
		Driving license (A5)
		Car ownership (A6)
		Annual household income (A7)
Endogenous variable	Information service factors before travel (UV2)	Bus fare information (B1)
		Bus route and transfer information (B2)
		Time information to arrive at the destination (B3)
		Bus route schedule information (B4)
		Distance information from the departure point or destination to the bus stop (B5)
		Time information for the departure point or destination to walk to the bus stop (B6)
	Information service factors during travel (UV3)	Next bus location information (C1)
		Site next bus arrival time information (C2)
		Next stop arrival time information (C3)
		Next bus congestion status information (C4)
		Next seat free seat information (C5)
		Bus route and station information on the stop sign (C6)

Table 2. *Cont.*

Variable Attribute	Variable Categories	Variable Names (Encoding)
Endogenous variable	Other public transport service factors (UV4)	Air conditioning service in the bus (D1)
		Credit card machine service in the bus (D2)
		The smoothness of bus operation (D3)
		Service attitude of the passengers (D4)
		Convenience of taking the bus to the city (E1)
		Convenience of taking the bus to the adjacent town (E2)
		The convenience of transferring to other buses at the site (E3)
		The punctuality of the bus to the station by timetable (F1)
		The completeness of the site facilities (such as seats, canopies, etc.) (F2)
	Public transport travel willingness of urban and rural residents (UV5)	If the car is not crowded, it will be more willing to use (G1)
		If you know the next bus arrival time at the site, you will be more willing to use (G2)
		If the bus is more punctual, it will be more willing to use (G3)
		If the bus fare is reduced, it will be more willing to use (G4)
		If there is a bus stop near the home, you will be more willing to use (G5)
		If the number of bus shifts increases, it will be more willing to use (G6)
		If you are convenient to transfer to other buses at the site, you will be more willing to use (G7)
	Public transport travel choice behavior of urban and rural residents (UV6)	I will use the route query information to select the travel route (H1)
		I will use the timetable and each bus arrival time to adjust the departure time (H2)
		I will use the line and transfer query information to adjust the travel route in the middle (H3)
		I will not take the bus because the stop sign has no route and site information (H4)
		I will give up the bus because the station does not have the next bus arrival time information (H5)

The personal and family characteristics of the traveler are exogenous variables, which are not caused by any other variables in the model. The exogenous personal and family characteristics used in the model include gender (male = 1), age, monthly personal income, driving license (yes = 1), car ownership and annual household income.

The endogenous variables of the model are information service factors before and during travel, other public transport service factors, public transport travel willingness and public transport travel choice behavior of urban and rural residents. The public transport service factors in the exogenous variable are determined by establishing the SERVQUAL scale and model [6,54], which is measured by the perceived score and the expected score difference in the questionnaire. Public transport travel willingness and public transport travel choice behavior of urban and rural residents are obtained by 2–6 observed variables. A five-grade scale is applied, in which 1 point indicates incompatible and 5 points indicates the respondent is very consistent with the attribute.

To illustrate whether measurement indicators of the latent variables in the model have good internal consistency, Cronbach's Alpha coefficient method is adopted to analyze the reliability, with results shown in Table 3. It is shown from Table 3 that Cronbach's Alpha coefficients of all the latent variables are greater than 0.8, which shows that the questionnaire has a good reliability. The last column in Table 3 can be interpreted as the change of Cronbach's Alpha coefficients with the removal of corresponding measure items. By the column data, with the corresponding item removed from the questionnaire, the internal consistency of the latent variables declines, indicating the reasonability of the designed questionnaire.

Table 3. Cronbach's Alpha Coefficients within the Latent Variables.

Latent Variable	Cronbach's Alpha Coefficient	Observed Indicator (Coding)	Cronbach's Alpha Coefficient with the Item Taken Out
Information service before travel	0.874	Bus fare information (B1)	0.857
		Bus route and transfer information (B2)	0.861
		Time information to arrive at the destination (B3)	0.866
		Bus route schedule information (B4)	0.873
		Distance information from the departure point or destination to the bus stop (B5)	0.856
		Time information for the departure point or destination to the bus stop (B6)	0.859
Information service during travel	0.867	Next bus location information (C1)	0.864
		Next bus arrival time information on the site (C2)	0.857
		Next stop arrival time information (C3)	0.852
		Next bus congestion status information (C4)	0.851
		Next seat free seat information (C5)	0.854
		Bus route and station information on the stop sign (C6)	0.850
Other public transport services	0.859	Air conditioning service in the bus (D1)	0.846
		Credit card machine service in the bus (D2)	0.849
		The smoothness of bus operation (D3)	0.850
		Service attitude of the passengers (D4)	0.848
		Convenience of taking the bus to the city (E1)	0.850
		The convenience of taking the bus to the adjacent town (E2)	0.850
		The convenience of transferring to other buses at the site (E3)	0.852
		The punctuality of the bus to the station by timetable (F1)	0.855
		The completeness of ordinary facilities (such as seats, canopies, etc.) (F2)	0.856
public transport travel willingness of urban and rural residents	0.861	If the car is not crowded, it will be more willing to use (G1)	0.850
		If you know the next bus arrival time at the site, you will be more willing to use (G2)	0.853
		If the bus is more punctual, it will be more willing to use (G3)	0.850
		If the bus fare is lowered, it will be more willing to use (G4)	0.845
		If there is a bus stop near the home, you will be more willing to use (G5)	0.851
		If the number of bus shifts increases, it will be more willing to use (G6)	0.850
		If you are convenient to transfer to other buses at the site, you will be more willing to use (G7)	0.855
public transport travel choice behavior of urban and rural residents	0.857	I will use the route query information to select the travel route (H1)	0.850
		I will use the timetable and each bus arrival time to adjust the departure time (H2)	0.850
		I will use the line and transfer query information to adjust the travel route in the middle (H3)	0.851
		I will not take the bus because the stop sign has no route and site information (H4)	0.850
		I will give up the bus because the station does not have the next bus arrival time information (H5)	0.850

3.2.4. Model Hypothesis

This paper studies the impact of personal and family characteristics, travel information services and other information services on public transport travel willingness and travel choice behavior of urban and rural residents. This leads to the following hypotheses.

H 1: Personal and family characteristics affect public transport travel willingness of urban and rural residents;

H 2: Personal and family characteristics affect the level of demand for information services before travel;

H 3: Personal and family characteristics affect the level of demand for information services during travel;

H 4: Personal and family characteristics affect the demand for other public transport services;

H 5: Information service factors before travel affect public transport travel willingness of urban and rural residents;

H 6: Information service factors before travel affect public transport travel choice behavior of urban and rural residents;

H 7: Information service factors during travel affect public transport travel willingness of urban and rural residents;

H 8: Information service factors during travel affect public transport travel choice behavior of urban and rural residents;

H 9: Other public transport services affect public transport travel willingness of urban and rural residents;

H 10: Other public transport services affect public transport travel choice behavior of urban and rural residents;

H 11: Public transport travel willingness affect public transport travel choice behavior of urban and rural residents.

Figure 1 shows the research model used to posit and test all hypotheses in this study.

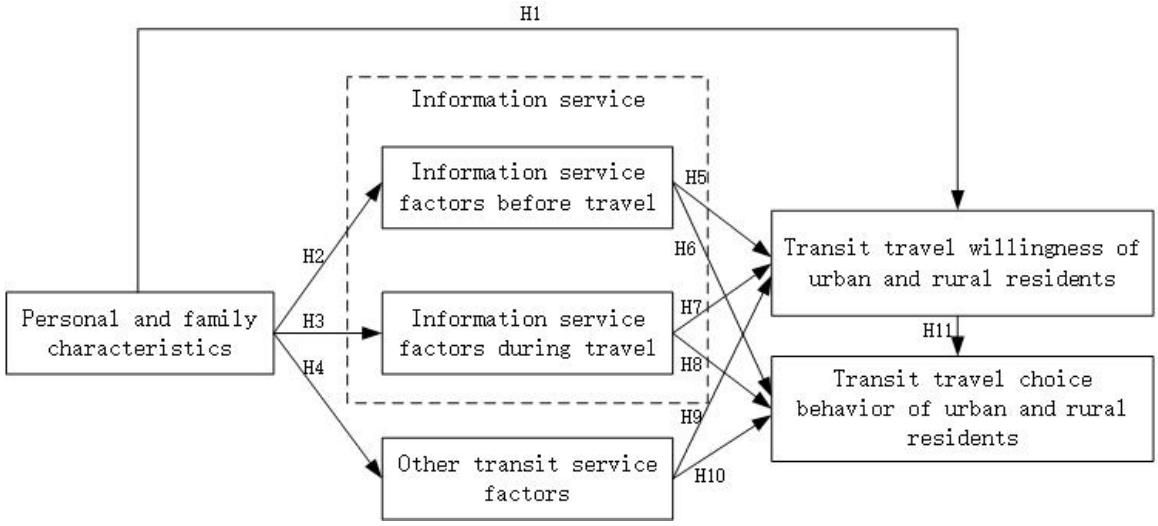


Figure 1. Preliminary hypothesis relationship between latent variables in the model.

3.3. Estimation Results

3.3.1. Model Fitness Indices

The fit of the initial model is not good enough (Table 4), and some of the fitting indicators cannot meet the evaluation criteria. For Table 4, it should be noted that: *** means $p < 0.01$. Some of the theoretical hypotheses in the model failed the test (with a confidence level of 0.05) and could not be

established. The influence of UV1 on UV2, UV3, UV4 and UV5 was not significant at 95% confidence level ($p > 0.05$). The theoretical model assumes that 1, 2, 3, and 4 are not valid. In addition, the effect of UV2 on UV5, UV3 on UV5 and UV6, UV4 on UV5 and UV6 is not significant at 95% confidence ($p > 0.05$), so the theoretical model assumes 5, 7, 8, 9, 10 Not established. The model is modified by deleting the inconspicuous causal relationship in the initial model.

Table 4. Initial model coefficient estimate.

Relationship between Variables			Estimate	S.E.	C.R.	P
UV4	<—	UV1	0.348	0.237	1.472	0.141
UV2	<—	UV1	0.775	0.463	1.673	0.094
UV3	<—	UV1	0.227	0.189	1.206	0.228
UV5	<—	UV4	0.233	0.197	1.184	0.236
UV5	<—	UV1	0.179	0.214	0.837	0.403
UV5	<—	UV2	0.160	0.063	2.527	0.012
UV5	<—	UV3	0.506	0.588	0.862	0.389
UV6	<—	UV4	0.543	0.364	1.489	0.136
UV6	<—	UV5	0.537	0.250	2.146	0.032
UV6	<—	UV3	1.284	1.161	1.106	0.269
A1	<—	UV1	1.000			
A2	<—	UV1	−0.717	0.523	−1.370	0.171
A3	<—	UV1	−3.448	0.800	−4.311	***
A4	<—	UV1	2.561	1.102	2.324	0.020
A5	<—	UV1	0.668	0.224	2.983	0.003
A6	<—	UV1	−0.520	0.200	−2.607	0.009
A7	<—	UV1	−2.571	0.659	−3.904	***
C6	<—	UV3	1.000			
C5	<—	UV3	4.954	3.922	1.263	0.207
C4	<—	UV3	4.524	3.665	1.234	0.217
C3	<—	UV3	4.491	3.576	1.256	0.209
C2	<—	UV3	9.041	7.045	1.283	0.199
C1	<—	UV3	7.631	5.944	1.284	0.199
B6	<—	UV2	1.000			
B5	<—	UV2	0.913	0.153	5.961	***
B4	<—	UV2	0.268	0.153	1.755	0.079
B3	<—	UV2	0.600	0.148	4.041	***
B2	<—	UV2	0.676	0.135	5.002	***
B1	<—	UV2	0.262	0.158	1.656	0.098
D4	<—	UV4	1.000			
D3	<—	UV4	1.649	0.907	1.818	0.069
D2	<—	UV4	1.381	0.827	1.670	0.095
D1	<—	UV4	0.951	0.594	1.602	0.109
G1	<—	UV5	1.000			
G2	<—	UV5	1.587	0.410	3.872	***
G3	<—	UV5	1.443	0.380	3.801	***
G4	<—	UV5	1.526	0.462	3.304	***
G5	<—	UV5	1.688	0.438	3.851	***
G6	<—	UV5	1.742	0.445	3.915	***
G7	<—	UV5	1.721	0.468	3.675	***
H1	<—	UV6	1.000			
H2	<—	UV6	0.943	0.264	3.577	***
H4	<—	UV6	1.085	0.316	3.432	***
H5	<—	UV6	0.941	0.328	2.870	0.004
E1	<—	UV4	1.570	0.850	1.848	0.065
F2	<—	UV4	0.756	0.519	1.457	0.145
F1	<—	UV4	1.817	0.981	1.852	0.064
E3	<—	UV4	2.160	1.132	1.908	0.056
E2	<—	UV4	2.978	1.512	1.970	0.049
H3	<—	UV6	1.200	0.370	3.242	0.001

The modified model shows an acceptable goodness of fit (Table 5). The ratio between chi-square and degree of freedom is 2.346, which is an indicator of relatively good fit. Additionally, the fitness index (GFI and AGFI) and the root mean square error of approximation (RMSEA) indicate that the model is acceptable.

Table 5. Modified model Fitness Indices.

Adaptation Index	Numerical Value	Standard
Chi-square/df	2.346	[1,3]
Goodness-of-fit indexGFI)	0.906	>0.9
Adjusted goodness-of-fit index (AGFI)	0.912	>0.9
Root mean square error of approximation (RMSEA)	0.064	<0.08

3.3.2. Effects of Variables

1. Personal and family characteristics of the traveler

The observation variable "family annual income" (A7) is retained in the modified model. Additionally, the direct influence of "family annual income" on public transport travel choice behaviors is presented in Table 6. It can be seen that the influence of family annual income on the choice of several public transport travel choices of urban and rural residents from high to low is: "adjustment of bus travel route", "choice of bus travel mode", "choice of bus travel route" and "choice of bus travel time".

Table 6. Effect between personal and family characteristics and public transport travel choice behavior.

The Relation	Choice of Bus Travel Route	Choice of Bus Travel Time	Adjustment of Bus Travel Route	Choice of Bus Travel Mode
Annual household income	−0.07200	−0.07056	−0.09432	−0.07848

2. Information service factors before travel

Table 7 reports the effects of the four information services before travel on the four public transport choice behaviors. According to the level of the influence effect, define the Level (I–V) of the influence relationship and fill in Table 7. Level I is the largest impact value, and the degree of influence is the highest. By analogy, the influence value of Level V is the smallest, that is, the degree of influence is the lowest.

Table 7. Effect between four kinds of information services before travel and four public transport travel choice behaviors.

The Relation	Choice of Bus Travel Route	Choice of Bus Travel Time	Adjustment of Bus Travel Route	Choice of Bus Travel Mode
Bus route and transfer information	0.152064(III)	0.149023(IV)	0.199204(I)	0.165750(II)
Time information to reach the destination	0.121968(V)	0.119529(V)	0.159778(III)	0.132945(IV)
Distance information from the departure point or destination to the bus stop	0.156816(III)	0.153680(III)	0.205429(I)	0.170930(II)
Time information for the starting point or destination to walk to the bus stop	0.158400(III)	0.155232(III)	0.207504(I)	0.172656(II)

3. Information service factors during travel

Table 8 reports the effects of the four information services during travel on the four public transport choice behaviors, and also defines the Level (I–V) of the influence relationship according to the level of the influence effect value and fills in Table 8.

Table 8. Effect between four kinds of information services and the four public transport travel behaviors.

The Relation	Choice of Bus Travel Route	Choice of Bus Travel Time	Adjustment of Bus Travel Route	Choice of Bus Travel Mode
Next stop arrival time information on the bus	0.10800(III)	0.10584(III)	0.14148(I)	0.11772(II)
Next bus congestion status information	0.07920(V)	0.07603(V)	0.10375(III)	0.08633(IV)
Next seat free seat information	0.07920(V)	0.07603(V)	0.10375(III)	0.08633(IV)
Bus route and site information on the stop sign	0.07920(V)	0.07603(V)	0.10375(III)	0.08633(IV)

Figure 2 compares the effect of information service factors before travel and information service factors during travel on public transport travel choice behavior. It can be seen that the influence of information service factors before travel on public transport travel choice behavior of urban and rural residents is generally higher than that of information service factors during travel. The "time information of the starting point or destination walking to the public transport stop" has the greatest impact on urban and rural public transport travel choice behavior.

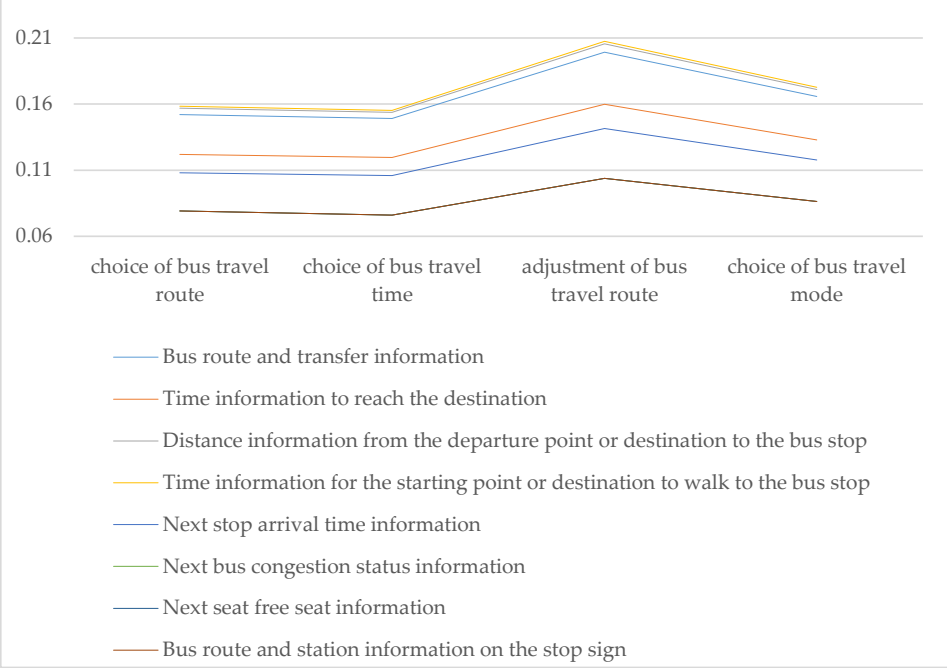


Figure 2. The effect of information on public transport travel behavior.

4. Other public transport service factors

The observation variable "The convenience of taking the bus to the city" is retained in the modified model. The effect of "The convenience of taking the bus to the city" on public transport travel choice behaviors is presented in Table 9. According to the results, the influence of other public transport service factors on the four urban and rural public transport travel choice behaviors of urban and rural residents from high to low are: "adjustment of bus travel route", "choice of travel mode", "choice of bus travel route", and "choice of bus travel time".

Table 9. Effect between the convenience of taking the public transport to the city and various public transport travel choice behaviors.

The Relation	Choice of Bus Travel Route	Choice of Bus Travel Time	Adjustment of Bus Travel Route	Choice of Bus Travel Mode
Convenience of taking the bus to the city	0.1800	0.1728	0.2358	0.1962

4. Suggestions

- In the public transport information service of urban and rural areas, the information service before travel has a greater influence on the public transport travel choice behavior of urban and rural residents than information service during travel. Therefore, improving the information service level before travel is the key to improving the public transport information service level of urban and rural areas.
- "Time information of the starting point or destination walking to the bus stop", "distance information of the starting point or destination walking to the bus stop" and "bus line and transfer information" have a relatively important influence on the public transport travel choice behaviors of urban and rural residents. Therefore, effective and convenient provision of static information services such as bus stops, bus routes and corresponding transfers should be the focus of public transport information service construction before travel of urban and rural areas.
- The "incoming station arrival time information" and "next bus congestion status information" also have a relatively important influence on public transport travel choices of urban and rural residents, especially "the next station arrival time information". Therefore, providing information such as the arrival time of the next station on the train and the information of the congestion status of the next bus with dynamic characteristics should be the focus of the construction of public transport information services of urban and rural areas.
- Before the trip, the static public transport information service is recommended to be released via the Internet or mobile app. The bus terminal and some large-scale stop stations are recommended to post a complete bus route map and timetable information map, and the bus map should indicate the public transport information that can be transferred. For dynamic public transport information during travel, if economic conditions permit, it is recommended to build an intelligent docking station for distribution (via electronic display), such as publishing the next bus arrival time, the next bus congestion situation and other information. Otherwise, it can be temporarily released through the mobile app.

5. Conclusions

This paper presents an empirical study to analyze the factors affecting the choice of travel modes for urban and rural residents. Data in this paper were obtained by a well-planned questionnaire survey. Personal attributes, information service factors (including information service factors before travel and information service factors during travel) and other public transport service factors are considered, which can be regarded as an innovative point in this paper.

The results show that the influence of information service factors before travel on public transport travel choice behavior of urban and rural residents is higher than that of information service factors during travel. The public transport travel choice behaviors of urban and rural residents are divided into four types, namely, "choice of bus travel route", "choice of bus travel time", "adjustment of bus travel route" and "choice of bus travel mode", which is used to discuss the information service factors before during travel. The influence of information service factors before and during travel on these four types are discussed, respectively. The results show that among the information service factors before travel studied, the "time information for the starting point or destination to walk to the bus stop" has the greatest impact on the overall choice behaviors of urban and rural residents, and among

the information service factors during travel studied, "next stop arrival time information on the bus" has the greatest impact on the overall choice behaviors of urban and rural residents.

Due to the limited data sources, the research results in this paper still have certain limitations. Future research needs to select more typical rural areas of different types and sizes. Although this paper considers other public transport service factors other than information service factors as the influencing factors of public transport choice behavior, and also makes a certain degree of subdivision of information services (for example, divided into two categories before and during travel), there are still some shortcomings in the comprehensiveness of the model and the depth of research. In future research, more influencing factors can be considered (such as the cost of obtaining information, the cheapness of obtaining information, land use, economic geographic location, etc.) and a more detailed division of information services.

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Appendix A



Figure A1. The studied area and bus system of Beidaihe New District.

Appendix B

Questionnaire survey of residents' public transportation in Beidaihe New District, Qinhuangdao City

Investigator: _____ Date: _____ Location of investigation: _____

Hello! The Beidaihe New District of Qinhuangdao City is conducting a survey on residents' public transport trips to provide basic information for public transport planning in the district. Your answers will only be used for statistical analysis, not personal privacy, and will not be used for other purposes. Thank you for your cooperation.

Part 1: Basic information

Please mark √ before the option that matches your situation, or fill in the corresponding content on the horizontal line.

1. Your gender: □ male □ female
2. You are _____ years old
3. Your registered residence type: □ local registered residence □ non-local registered residence
4. Family members: _____ people
5. Your address: _____ (street, township) ___ community (or village name, business name) or the closest intersection to _____ road and _____ road
6. Your job: □ office staff □ self-employed □ worker □ business service staff □ farmer □ student □ retiree □ unemployed □ others
7. Your educational background: □ high school, technical secondary school and below □ junior college □ undergraduate □ postgraduate and above
8. Your monthly personal income:

□ <1000 □ 1001–2000 □ 2001–3000 □ 3001–4000 □4001–5000 □ ≥5000

9. Do you have a driver's license? □ yes □ no
10. Family transportation:

□ no transportation □ __ bicycle □ __ electric bicycle □ __ motorcycle □ __ car

11. Annual household income:

□ <20,000 □ 20,000–50,000 □ 50,000–80,000 □ 80,000–100,000 □ 100,000–150,000 □ ≥150,000

12. Which of the following bus information do you find more useful? (Multiple choice)

□ bus route and site information □ bus schedule □ next bus location information □ next bus arrival time □ bus travel time □ bus exchange □ bus congestion □ ticket information □ others

13. Which publishing method do you like to get public transportation information (multiple choices are available)

□ Internet □ Bus information inquiry machine □ hub or first and last station electronic display □ electronic station □ bus display □ others

Part 2: Survey of public transport services and travel behavior

1. Among the following six factors, you think that the order of importance is from high to low: ___>___>___>___>___>___

① Public transport comfort level ② Public transport convenience level ③ Public transport facilities completeness ④ Public transport reliability ⑤ Information service level before travel ⑥ Information service level in travel

2. Public transport service satisfaction and expectations

- If you frequently take the public transport, please fill in this section, where the box with "-" is not required.
- Please refer to the following five levels to score the actual satisfaction and expectations for the daily public transport service indicators listed in the table below.
- Satisfaction level division: 5 points means "very satisfied"; 4 points means "satisfactory"; 3 points means "general satisfaction"; 2 points means "unsatisfactory"; 1 point means "very dissatisfied".

- Expectation level division: 5 points means "very expected"; 4 points means "comparative expectations"; 3 points means "general expectations"; 2 points means "not expected"; 1 point means "very undesired".
- The last column of indicators is sorted by importance, using sequence numbers, arranged from high to low.

Index	Serial Number	Specific Indicators	Satisfaction					Expectation					Order Importance Ranking
1	1	Bus fare information (B1)	5	4	3	2	1	5	4	3	2	1	___>___>___>___>___>___
	2	Bus route and transfer information (B2)	5	4	3	2	1	5	4	3	2	1	
	3	Time information to reach the destination (B3)	5	4	3	2	1	5	4	3	2	1	
	4	Bus route schedule information (B4)	5	4	3	2	1	5	4	3	2	1	
	5	Distance information from the departure point or destination to the bus stop (B5)	5	4	3	2	1	5	4	3	2	1	
	6	Time information for the starting point or destination to walk to the bus stop (B6)	5	4	3	2	1	5	4	3	2	1	
2	1	Next bus location information (C1)	5	4	3	2	1	5	4	3	2	1	___>___>___>___>___>___
	2	Site next bus arrival time information (C2)	5	4	3	2	1	5	4	3	2	1	
	3	Next stop arrival time information on the bus (C3)	5	4	3	2	1	5	4	3	2	1	
	4	Next bus congestion status information (C4)	5	4	3	2	1	5	4	3	2	1	
	5	Next bus free seat information (C5)	5	4	3	2	1	5	4	3	2	1	
	6	Bus route and site information on the stop sign (C6)	5	4	3	2	1	5	4	3	2	1	
3	1	Air conditioning service in the bus (D1)	5	4	3	2	1	5	4	3	2	1	___>___>___>___
	2	Credit card machine service in the bus (D2)	5	4	3	2	1	5	4	3	2	1	
	3	The smoothness of bus operation (D3)	5	4	3	2	1	5	4	3	2	1	
	4	Service attitude of the staff (D4)	5	4	3	2	1	5	4	3	2	1	
4	1	The convenience of taking the bus to the city (E1)	5	4	3	2	1	5	4	3	2	1	___>___>___
	2	The convenience of taking the bus to the adjacent town (E2)	5	4	3	2	1	5	4	3	2	1	
	3	The convenience of transferring to other buses at the site (E3)	5	4	3	2	1	5	4	3	2	1	
5	1	Bus on time by schedule (F1)	5	4	3	2	1	5	4	3	2	1	-
6	1	The completeness of the site facilities (such as seats, canopies, etc.) (F2)	-	-	-	-	-	5	4	3	2	1	-

3. The willingness of public travel and the behavior of travel

■ Compliance level: 5 points means "very consistent"; 4 points means "comparable"; 3 points means "general match"; 2 points means "non-conformity"; 1 point means "very non-conformity".

Index	Serial Number	Specific Indicators	Compliance				
7	1	If the car is not crowded, it will be more willing to use (G1)	5	4	3	2	1
	2	If you know the next bus arrival time at the site, you will be more willing to use it (G2)	5	4	3	2	1
	3	If the bus is more punctual, it will be more willing to use (G3)	5	4	3	2	1
	4	If the bus fare is lowered, it will be more willing to use (G4)	5	4	3	2	1
	5	If you have a bus stop near your home, you will be more willing to use it (G5)	5	4	3	2	1
	6	If the number of bus shifts increases, it will be more willing to use (G6)	5	4	3	2	1
	7	If you are convenient to transfer to other buses at the site, you will be more willing to use (G7)	5	4	3	2	1
8	1	I will use the route query information to select the travel route (H1)	5	4	3	2	1
	2	I will use the timetable and each bus arrival time to adjust the departure time (H2)	5	4	3	2	1
	3	I will use the line and transfer query information to adjust the travel route in the middle (H3)	5	4	3	2	1
	4	I will not take the bus because the stop sign has no route and site information (H4)	5	4	3	2	1
	5	I will give up the bus because the station does not have the next bus arrival time information (H5)	5	4	3	2	1

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