Research on Appointment Travel Behavior Based on SEM-NL during Peak Travel Periods

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***Abstract*—With the increasingly severe problem of urban traffic congestion, scheduled travel, as a new means of traffic demand management, alleviates the supply-demand contradiction through the optimization of spatiotemporal resource allocation. This article takes Dalian as an example, focuses on the commuting behavior, and constructs a structural equation nested Logit (SEM-NL) integrated model that integrates psychological latent variables (policy acceptance, congestion aversion, technological operation convenience, system fairness perception, etc.) to analyze the impact mechanism of the combination selection of "departure time+travel mode". Based on 746 valid questionnaire data, the study found that psychological latent variables significantly affect policy acceptance, with perceived systemic fairness and congestion aversion having the most significant effects; The direct impact coefficient of policy acceptance on the intention to book travel is 0.875. Compared to traditional NL models, the SEM-NL model has improved prediction accuracy by 7.75% and NagelkerkeR^2 by 0.234, indicating that models considering psychological perception have stronger explanatory power. Research suggests that optimizing the flexibility mechanism of appointment time slots, enhancing information transparency, and implementing differentiated subsidy policies can effectively increase users' willingness to make appointments. This article provides theoretical support and practical path for promoting the appointment travel system in river valley cities..**

***Index Terms*—travel reservation, psychological latent variables, structural equation modeling, nested Logit model, traffic demand management, combined decision-making behavior .**

I. Introduction

With the extraordinary growth of motor vehicle ownership, the contradiction between urban transportation supply and demand is becoming increasingly prominent, and the difficulties faced by traffic congestion control are gradually increasing Traffic congestion seriously affects the daily lives of residents, not only causing serious economic losses to the city, but also exacerbating travel safety hazards and environmental pollution, limiting the stable development of the city The fundamental reason for traffic congestion is the mismatch between traffic supply and residents' travel demand, manifested in the lack of effective traffic management measures to regulate the growing travel demand With the rise of intelligent networking technology, conditions have been provided for the effective implementation of traffic flow guidance At the same time, with the popularity of mobile Internet, the way of reservation is gradually accepted by the public Introducing the concept of reservation into daily travel has become a new means of transportation demand management Booking travel is a response to changing travel demands, combined with the urban road traffic supply capacity, relying on the global optimal supply and demand matching algorithm, to provide travelers with comfortable and convenient travel services By booking trips, traffic managers can allocate the frequency and intensity of road traffic trips in a reasonable manner, achieve planned guidance for traffic participants' travel behavior, control road traffic flow within a reasonable range, ensure travel time or speed from departure to destination, thereby reducing local or peak traffic congestion and improving users' travel experience.

It is necessary for enterprises or transportation management departments to strengthen their understanding of residents' willingness to use scheduled travel, and analyze the main factors that affect residents' acceptance of scheduled travel. Akahane et al. [1] were the first to apply appointment based travel methods to road traffic management, exploring the possibility of using travel appointment systems to adjust driver departure times to alleviate holiday road traffic congestion Since then, more and more scholars have explored road reservation travel, and the concept of reservation travel has been applied to various transportation scenarios, such as highway sections, urban road sections, etc Implementing a reservation system on highways is relatively simple [2], as only entrance and exit controls need to be implemented for specific sections or lanes The complex road network structure and diverse traffic behaviors of urban roads make it more difficult to establish a reservation travel system for urban roads Menelaou et al. [3] designed a vehicle scheduling and route selection algorithm based on route reservation that can completely eliminate congestion In 2018, Shenzhen implemented appointment based travel management in the eastern scenic areas [4]. Based on the daily distribution characteristics of traffic flow, traffic flow was allocated to different time periods, effectively improving the efficiency and service level of scenic areas while keeping the total amount of travel roughly unchanged Guo Jifu et al. [5] conducted a reservation practice in the Huilongguan area of Beijing, and the results showed that reservation can reduce the time for each traveler to pass through congestion points and the average congestion time of the transportation system At present, many scholars have conducted theoretical modeling and effectiveness verification on scheduled travel, and simulation experiments have concluded that scheduled travel can effectively alleviate road congestion Compared with the first come, first served queuing system, the reservation system can significantly reduce waiting time [6] At present, theoretical research on urban road reservation travel is very limited and has not yet formed a complete

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system Previous research has mostly focused on designing vehicle scheduling algorithms and model construction for scheduled trips, with less attention paid to the study of residents' travel mode selection behavior under scheduled trips

This article takes Dalian City as an example to construct an indicator system for the influencing factors of commuting mode selection, which includes observable explicit variables and unobservable psychological perception latent variables. A SEM-NL model considering traveler acceptance is established, and the influencing factors and mechanisms of the combination decision selection of "departure time+travel mode" are analyzed based on questionnaire data. The research results will help urban traffic managers adopt more reasonable strategies to implement appointment travel policies, enhance commuters' willingness to use road appointment travel, alleviate road traffic congestion, and provide reference for other congested cities.

II. Research Overview and Indicator System Construction

The appointment travel strategy is based on the traffic management department's analysis and judgment of the urban road network traffic operation status, determining the extremely congested sections and time periods that require appointment travel Guided by historical travel demand and aiming for smooth passage, different capacity thresholds are set according to travel demand at different time periods Develop a reservation schedule for private car travelers, who can choose their route and departure time on the reservation platform The core idea is to transform the on-site congestion queue into a virtual online queue by planning the passage time of private cars on extremely congested road sections, promoting travelers to choose their travel mode and route reasonably [13] During the appointment period, all private cars that have not been booked are prohibited from driving on the roads where scheduled travel is implemented, except for buses and special vehicles The implementation steps for booking travel on extremely congested road sections are shown in Figure 1

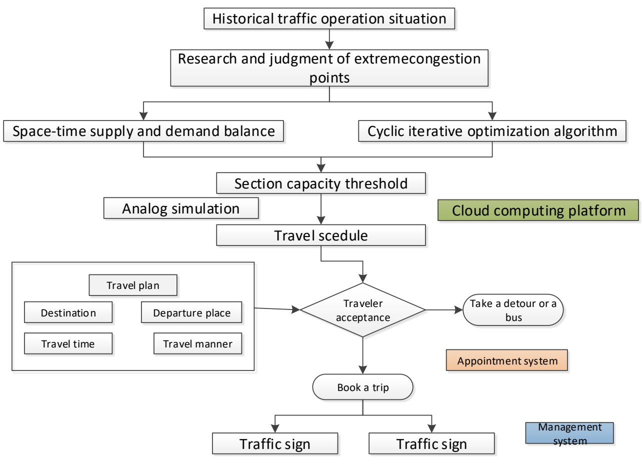

Figure 1 Travel reservation process

Due to many differences in traffic characteristics and backgrounds, it is not possible to fully refer to the indicator system of similar travel behavior research in the study of commuter appointment travel combination decision-making behavior. Therefore, this article combines the characteristics of road reservation travel and introduces seven psychological latent variables: "trust in institutional tools, perception of system fairness, congestion aversion, convenience of technical operations, perception of social norms, demand for travel flexibility, and policy acceptance". Based on the basic theory of structural equation modeling, the latent variables are explained and corresponding research hypotheses are proposed.

1) Travel reservation intention

Behavioral intention (BI) is the intensity of a user's subjective intention when using a new technology or performing a certain behavior, reflecting the impact of an individual's motivational intention on their behavior. The Theory of Planned Behavior (TPB) holds that behavioral intention is the most direct antecedent to actual behavior. In transportation research, behavioral intention is widely used to predict the probability of users adopting new travel modes. The stronger an individual's behavioral intention, the harder and more actively they will strive to achieve that behavior.

2) Policy acceptance

The policy acceptance is derived from the Technology Acceptance Model (TAM) and the Theory of Planned Behavior (TPB), emphasizing individuals' cognition and willingness to adopt new systems. In the field of traffic management, research has shown that policy acceptance directly affects users' response behavior to interventions such as congestion pricing and traffic restrictions. For example, the successful implementation of ERP systems in Singapore relies on public trust and acceptance of dynamic pricing mechanisms.

H1: Policy Acceptance (PA) has a positive impact on Reservation Intention (TRI)

3) Congestion aversion

The theoretical basis for congestion aversion comes from the Psychological Stress Theory and the Value of Time (VOT) theory. The former believes that anxiety and loss of control caused by congestion can lead to the accumulation of negative emotions, while the latter quantifies the monetary cost that users are willing to pay to avoid congestion. Research has shown that high congestion averse individuals are more inclined to choose high cost but reliable travel options (such as scheduled trips), with a time value typically 2-3 times that of low averse individuals

H2: Congestion aversion (CA) has a positive impact on policy acceptance (PA)

4) Technology operational convenience

The Technology Acceptance Model (TAM) and Task Technology Fit (TTF) theory suggest that the usability of technology systems enhances user adoption intention by reducing cognitive load. In intelligent transportation systems (ITS), operational convenience is reflected in user-friendly interfaces, clear information, and concise processes. For example, the "Suishenban" transportation module in Shanghai has reduced user steps from 5 to 2 through a one click appointment function, resulting in a 40% increase in usage rate.

H3: The convenience of technical operations (TOC) has a positive impact on policy acceptance (PA)

5) System fairness perception

The Equity Theory states that users' perception of fairness in resource allocation rules (such as quotas and priorities) significantly affects their willingness to cooperate. In Transportation Demand Management (TDM), fairness perception is considered a core element of the sustainability of reservation systems. For example, the Beijing entry permit reservation system balances rigid demand and fairness through a lottery mechanism, and relevant research has verified the positive effect of transparency rules on user participation.

H4: The perception of systemic fairness (SFP) has a positive impact on policy acceptance (PA)Trust in institutional tools

6) Trust in institutional tools

The trust in institutional tools originates from the Trust in Government theory in the field of public management, which emphasizes that the public's belief in the ability and integrity of policy implementing agencies directly affects their policy compliance. In transportation policy research, institutional trust is considered a key prerequisite for users to adopt new management tools such as appointment systems. For example, some scholars have pointed out that users' trust in the technical capabilities of traffic management departments (such as data security and system stability) and the fairness of rule enforcement significantly increases their willingness to accept dynamic congestion pricing policies. In addition, institutional trust indirectly enhances behavioral compliance by reducing perceived risks in policy implementation, such as information leakage and execution bias

H5: Trust in institutional tools (TIT) has a positive impact on policy acceptance (PA)

7) Perception of social norms

The perception of social norms is rooted in the concept of "subjective norm" in the Theory of Planned Behavior (TPB), which refers to the influence of an individual's perceived expectations of important others or group behavior on their decision-making. In the study of transportation behavior, social norms drive behavior imitation through a dual path of descriptive norms (actual behavior of others) and directive norms (recognized behavior of others). For example, when users perceive that the surrounding population generally uses carpooling services, their carpooling adoption probability increases by 23%, indicating the promoting effect of social norms on green travel behavior.

H6: The perception of social norms (PSN) has a positive impact on policy acceptance (PA)

The problem description of each latent variable corresponding to the observed variable is shown in the table 2.

Table 2 Explanation of latent variables and various observed variables

Latent Variable	Symbol	Problem description for measuring variables
Travel reservation intention (TRI)	TRI1	I think booking a trip can effectively alleviate traffic congestion during peak hours
	TRI2	I am willing to make advance reservations for travel time slots and routes in order to avoid congestion
	TRI3	I am willing to use this system even if I need to pay a reservation fee
	TRI4	If everyone around me is using the reservation system, I would be more willing to try it
Policy acceptance (PA)	PA1	I think booking a trip can effectively alleviate traffic congestion during peak hours
	PA2	I am willing to make advance reservations for travel time slots and routes in order to avoid congestion
	PA3	I am willing to use this system even if I need to pay a reservation fee
	PA4	If everyone around me is using the reservation system, I would be more willing to try it
Congestion aversion (CA)	CA1	The congestion during peak hours makes me feel anxious and irritable
	CA2	I would rather take a detour or depart early to avoid congested roads
	CA3	Even if payment is required, I am willing to make an appointment to ensure smooth travel
	CA4	I usually check navigation software in real-time to avoid congestion
	CA5	I think the time waste caused by congestion is more unacceptable than the economic cost
Technology operational convenience (TOC)	TOC1	I think the operation interface of the reservation system is simple and intuitive
	TOC2	I can easily complete operations such as booking, modifying, or canceling
	TOC3	The real-time information provided by the reservation platform is clear and easy to understand
	TOC4	The loading speed of mobile apps or websites will affect my willingness to use them
System fairness perception (SFP)	SFP1	I think the allocation rules for appointment time slots and road sections are transparent and fair
	SFP2	Users who frequently use roads should pay higher reservation fees
	SFP3	Randomly allocating remaining reservation slots is more fair than bidding
Trust in institutional tools(TIT)	TIT1	I believe the traffic management department can effectively manage the appointment system and prevent cheating
	TIT2	The fees charged by the appointment system should be clearly used to improve transportation facilities
	TIT3	The government should publicly disclose the

		operational data of the appointment system
	TIT4	The implementation effect of similar appointment policies in the past has given me confidence in the appointment system
Perception of social norms(PSN)	PSN1	If most people follow the appointment rules, I will also actively participate
	PSN2	My community or workplace encourages residents to use appointment based travel
	PSN3	Unannounced travel will be considered as a violation of public order
	PSN4	I will try the appointment system based on recommendations from family or colleagues
	PSN5	The positive promotion of the appointment system by the media will affect my willingness to use it

This article uses a nested Logit model to study the impact of scheduled travel on the joint selection of "departure time+travel mode" by commuters. There are two selection branches for the upper level address selection in the model: departure within one hour in advance and departure more than one hour in advance; The subset of lower level travel modes includes three alternative options: public transportation, road reservation travel, and detour travel, as shown in the figure 2

III. Research Method

The Nested Logit model is one of the discrete choice models that can be used to handle categorical dependent variables, and is very suitable for studying travel mode choice behavior. However, it cannot measure the influence of latent variables such as traveler perception and attitude on travel mode choice. Ignoring the influence of latent variables will result in insufficient explanatory power of the model. Structural equation modeling is a statistical method used to analyze the relationships between variables, which can simultaneously consider and handle multiple dependent variables, as well as estimate factor structure and relationships; However, using only structural equation modeling to simultaneously estimate the relationship between explicit and latent variables can make the established model overly complex in terms of dependent variable relationships. Therefore, based on the NL model, this article introduces the structural equation model (SEM) to characterize the impact of scheduled travel on commuters' travel behavior, and constructs a SEM-NL integrated model for scheduled travel combination decision-making considering psychological latent variables [7], as shown in Figure 3. Propose the following hypothesis: the decision-making process of travelers is rational and they will choose the mode of travel with the maximum utility function; The error term of the utility function follows the Gumbel distribution.

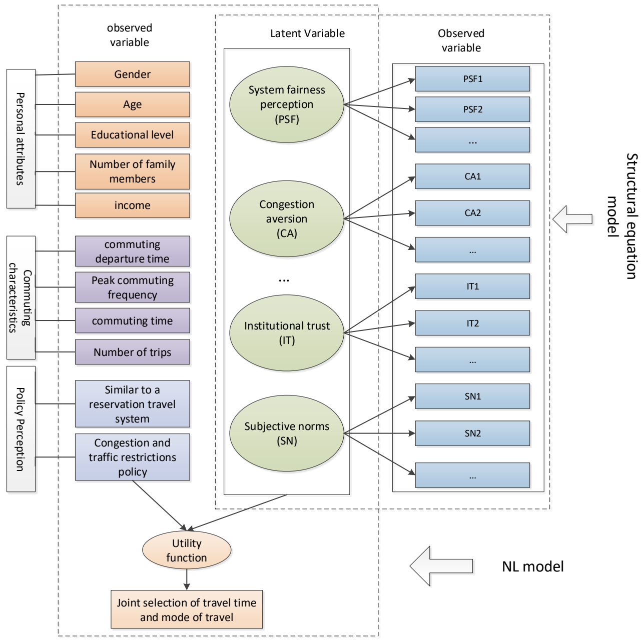

Figure 3 Theoretical Framework

Structural equation modeling mainly consists of measurement models and structural models: measurement models describe latent variables through corresponding observed variables, while structural models use exogenous latent variables to explain endogenous latent variables [8].

$$\eta_{ikn} = \sum_r \lambda_{ikn} x_{irn} + \zeta_{ikn} \quad (1)$$
$$y_{itn} = \sum_k \gamma_{ikt} \eta_{ikn} + \xi_{itn} \quad (2)$$

In the formula, i is the mode of travel and n is the number of travelers; λ_{ikn} and γ_{ikt} are the parameters to be estimated; η_{ikn} is an endogenous latent variable; x_{irn} is an exogenous latent variable; y_{itn} is the observed variable corresponding to the latent variable; r is the number of explicit variables, k is the number of latent variables, and t is the number of observed variables corresponding to latent variables; ζ_{ikn} and ξ_{itn} are the error vectors between latent variables and their corresponding observed variables.

According to the theory of random utility, considering the influence of latent variables, the utility function of the NL model is improved as shown in equation (3)

$$U_{in} = V_{in} + \varepsilon_{in} = \sum_l a_{il} s_{iln} + \sum_q b_{iq} h_{iqn} + \sum_f c_{if} w_{ifn} + \sum_g d_{ig} m_{ign} + \varepsilon_{in} \quad (3)$$

In the formula, V_{in} is the fixed term of the utility function for choice of traveler n of method i; l, q, f and g represent the personal attributes, travel characteristics, built environment, and number of latent variables of the traveler, respectively; The observation variables corresponding to personal attributes, travel characteristic attributes, built environment, and latent variables are s_{iln}, h_{iqn}, w_{ifn} and m_{ign}, respectively; a_{il}, b_{iq}, c_{if}, d_{ig} are the parameters to be estimated; ε_{in} is the random error term.

According to the maximum utility theory, when $U_{in} > U_{jn}$ and $i \neq j$ are satisfied, the traveler chooses the i-th travel option. Therefore, in the SEM-NL integrated model, the probability P_{in} of traveler n choosing the i-th travel option is

$$P_{in} = P\{U_{in} > U_{jn}, i \neq j\}$$

(4)

Assuming that the random error term ε_{in} in the utility function follows a Gumbel distribution, the probability P_{in} for traveler n to choose the i travel option is:

$$P_{in} = \frac{\exp(V_{in})}{\sum \exp(V_{in})} \tag{5}$$

IV. Case Analysis

A. Data Acquisition

Commuter travel data is obtained through a questionnaire survey. Design a questionnaire from three aspects based on the established indicator system, including personal information statistics, measurement of psychological latent variables related to travel habits, and selection of combined decision-making scenarios. The observation variables corresponding to latent variables are quantitatively evaluated using the Likert 5-point scale method for the items in Table 1. Questionnaires were distributed in Dalian, a typical congested city during peak hours, and 746 valid questionnaires were ultimately collected. The description and statistics of the personal socio-economic attributes of the respondents are shown in Table 4. The questionnaire survey data sample includes travelers of different social attribute categories, ensuring the comprehensiveness and representativeness of the sample.

B. SEM coefficient calibration

The indicator testing of the structural equation model is shown in Table 5. The reliability and validity of the indicators were tested using SPSS software, and the Cronbach's alpha values for all dimensions were>0.7. The KMO (Kaiser Meyer Olkin) value was 0.886>0.7, and the Bartlett sphericity test value was<0.001, indicating reliable data quality [9]. Due to the lack of standardized measurement indicators for the perception attributes of scheduled travel, factor analysis was conducted on the selected indicators. The higher the cumulative variance value of the indicators, the stronger the correlation between the relevant indicators of the variable [10]. The average variance extracted (AVE) reflects the explanatory power of observed indicators on latent variables. The combined reliability CR values of each latent variable are all greater than 0.7, and the AVE values are all greater than 0.4, indicating that the theoretical framework measurement indicators proposed in Table 5 have good reliability and validity [11].

Table 4 Variable Definition

Variable	Category	Percentage %
Sex	Male	44.57
	Female	55.43
Age	[18,40)	57.24
	[40,60)	37.11
	[60,+∞)	5.65
Career	High degree of freedom	29.36
	Low degree of freedom	70.64
Monthly income	[0,5k)	33.37
	[5k,10k)	49.69
	[10k,15k)	13.47
	[15k,+∞)	3.47
Private car	Have	66.78
	Not have	33.22
Travel purpose	Flexible travel	65.90
	Rigid travel	34.10
Commuting period	Low peak period	42.61
	Peak period	57.39
Commute Distance	[0，7.7km)	65.83
	[7.7km，+∞)	34.17
transfer time	0	71.66
	1	26.11
	>1	2.23
Distance between work and residence	[0，7.7km)	56.53
	[7.7km，+∞)	43.47
Distance from starting and ending points to the station	[0，1km)	76.12
	[1km，+∞)	23.88
Available parking spaces at the destination	Have	80.25
	Not have	19.75

Table 5 Reliability and validity testing

Latent Variable	Cronbach's alpha	AVE	C.R.	KMO	Bartlett Test	Cumulative total variance explanation rate
SFP	0.767	0.536	0.772	0.886	0.000	71.37%
CA	0.821	0.509	0.833			
TIT	0.782	0.567	0.795			
PSN	0.765	0.516	0.795			
TOC	0.870	0.581	0.872			
PA	0.772	0.535	0.763			
TRI	0.853					

SEM was fitted using Amos software and the model was tested for fit. The standard residual root mean square (SRMR) was 0.024, the goodness of fit index (GFI) was 0.923, the comparative fit index (CFI) was 0.975, the standard fit index (NFI) was 0.941, the Tucker Lewis index (TLI) was 0.963, the chi square degree of freedom ratio (CMIN/DF) was 1.675, and the root mean square error (RMSEA) of approximation was 0.048, indicating that the overall fit of the model is good and can be used for subsequent analysis [12]. According to Table 6, the perceived fairness (0.346), congestion aversion (0.447), trust in institutional tools (0.313), perceived social norms (0.584), and operational convenience (0.534) of commuters who use scheduled travel have a significant impact on the acceptance of road scheduled travel policies. Policy acceptance (0.568) has a significant impact on the intention of scheduled travel.

Table 6 Path coefficient

Route	Coefficient	Approximate standard	Critical ratio	P

		deviation		
SFP->PA	0.346	0.03	5.92	***
CA-> PA	0.447	0.04	7.32	***
TIT-> PA	0.313	0.03	5.95	***
PSN-> PA	0.584	0.03	8.55	***
TOC-> PA	0.534	0.02	9.36	***
PA->TRI	0.568	0.02	8.46	***

C. Research on Decision making Behavior of Combination Travel

Incorporate the psychological latent variable adaptation values calibrated in the structural equation model, along with the traveler's personal basic information, commuting characteristics, travel behavior background, policy and facility perception, into the SEM-NL model to analyze the impact of various attributes on combination decision-making. Based on questionnaire data, establish NL models that do not consider commuters' psychological perception of booking travel and SEM logit models that consider psychological latent variables. Conduct significance level analysis and utility function parameter calibration of variables using SPSS software.

The parameter estimation results are shown in Table 7. The significant value of the likelihood ratio test for the SEM-NL integrated model is 0.000<0.05, and the value of the Hosmer Lemeshau H-L test is greater than 0.05. The goodness of fit of the model is 0.801, and the prediction accuracy is 92.11%, indicating a good fit of the model [13]. Compared with the NL model that does not consider travel perception, the negative double logarithmic likelihood function value -2LL (β) decreased by 264.425, the goodness of fit Nagelkerke R2 increased by 0.234, and the prediction accuracy increased by 7.75%. This indicates that the SEM Logit integrated model that considers psychological latent variables is more explanatory and predictive than the NL model that does not consider psychological latent variables for commuters to book travel.

Table 7 Model parameter calibration

Variable	NL model			SEM-NL model		
	coefficient	significance	Advantage ratio	coefficient	significance	Advantage ratio
constant	-4.350	0.001	0.013	-1.516	0.000	0.000
sex	0.020	0.062	1.020	0.009	0.520	1.009
age	-0.015	0.036	0.986	-0.022	0.030	0.979
career	1.064	0.000	2.898	0.816	0.000	2.261
monthly income	-0.419	0.000	0.658	-0.752	0.000	0.472
Private car ownership	0.234	0.000	1.263	0.337	0.000	1.400
educational background	0.101	0.020	1.106	0.267	0.000	1.307
Main commuting methods	0.134	0.000	1.143	0.158	0.000	1.171
One way commuting distance	0.149	0.000	1.161	0.084	0.003	1.088
One way commuting time	-0.077	0.110	0.926	-0.198	0.004	0.820
Is the commuting time fixed	0.087	0.000	1.090	0.132	0.000	1.142
Have you ever used a similar appointment travel system	-0.249	0.000	0.779	-0.132	0.001	0.877
Do you hold a valid driving license	0.588	0.001	1.801	0.487	0.046	1.628
Does the employer provide flexible working hours	-0.037	0.000	0.964	-0.031	0.000	0.969
Booking travel intention	——	——	——	0.132	0.001	1.141
Policy acceptance	——	——	——	1.482	0.000	4.402
System fairness perception	——	——	——	1.613	0.000	5.018
Flexible travel needs	——	——	——	1.060	0.001	2.887
Congestion aversion	——	——	——	2.058	0.000	7.826

The model results show that age, occupation, income, and the presence or absence of a private car all significantly affect the choice of rail transit travel.

Objective traffic environment and subjective travel experience perception factors have differentiated impacts on road reservation travel choices. Among them, the matching degree of transportation supply and demand has a significant positive effect on the willingness to book travel. The demand for cross group commuting during peak hours in cities is highly concentrated, and the carrying capacity of narrow road networks is limited, which can easily lead to sustained congestion at key nodes. The appointment mechanism can alleviate the supply-demand contradiction by optimizing the allocation of spatiotemporal resources. Therefore, travelers are more inclined to adopt the appointment travel mode. The rationality of the reservation policy design directly affects user acceptance. If the reservation time slot is divided too roughly or the penalty for breach of contract is too strict, it may lead to misallocation of reservation resources and user psychological resistance, which may actually reduce the efficiency of system operation. Compared to plain cities, alternative routes between river valley clusters are scarce and have a high detour coefficient, resulting in higher travel uncertainty for travelers. Therefore, refined appointment time slots and flexible fault-tolerant mechanisms are more critical.

There is a significant positive correlation between travelers' trust in the reservation system and their willingness to use it. The improvement of information transparency perception will promote the choice of booking travel behavior. When users can obtain real-time information on the remaining capacity of reserved lanes, dynamic rate changes, and abnormal event warnings, the completeness of their travel decisions is significantly enhanced, which helps to form stable reservation preferences. At the same time, differences in time value perception lead to behavioral differentiation, and business travelers have higher requirements for on-time travel and are willing to pay a premium to obtain deterministic travel guarantees; The flexible travel group is more sensitive to rates and tends to choose booking during off peak discount periods. It is worth noting that unreserved channels in bottleneck sections such as urban river bridges often face systematic delay risks, which in turn reinforces users' path dependence on reserved channels. Therefore, building an elastic reservation mechanism that dynamically matches supply and demand, synchronously improving information transparency and user trust, is the key path to increasing the proportion of urban road reservation travel.

The utility function of the decision-making model for booking travel combinations during peak travel periods is shown in equation (6)

$$\ln\left(\frac{P_i}{1-P_i}\right) = -13.516\text{q} - 0.022\text{age} + 0.816\text{occ} - 0.752\text{inc} + 0.132\text{ord} + 0.337\text{car} + 0.276\text{aim} + 0.158\text{dep} + 0.084\text{dis} - 0.198\text{tra} - 0.132\text{sta} + 0.487\text{npl} - 0.031\text{lum} + 0.132\text{sec} + 1.482\text{con} + 1.613\text{eco} + 1.060\text{com} + 2.058\text{spa} \tag{6}$$

V. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

This article constructs a SEM Logit model that considers the spatial perception of commuters in river valley cities, clarifies the factors that affect the choice of commuting booking modes, and draws the following conclusions.

1) Compared to the NL model that does not consider travel perception, the SEM-NL integrated model that considers psychological latent variables has improved to varying degrees in terms of explanatory and predictive power of data, and the model results are more convincing.

2) The spatial perception of rail transit travel has a significant positive impact on the intention of rail transit travel. The stronger the spatial perception of travelers towards valley type cities, the higher their willingness to choose rail transit travel. There are significant impacts on the spatial perception of rail transit travel for travelers in river valley cities in five aspects.

3) The SEM Logit model results show that long commuting distances, peak travel periods, no available parking spaces at the destination, and previous use of similar reservation scenarios all promote travelers to choose road reservation travel.

B. Recommendations

Accelerate the construction of road reservation travel facilities and promote the proportion of commuters' road reservation travel during peak travel periods. Reasonably plan the allocation of road capacity for congested sections and reduce congestion waiting on the road. At the same time, the service level of road reservation travel can be improved by starting from the observed variables corresponding to latent variables. For example, carbon credits can be given to users who choose public transportation reservation, which can be exchanged for subway tickets, shared bicycle riding coupons, etc., to enhance the external positive effects of environmental behavior. Alternatively, big data can be used to identify users who commute long distances (>20 kilometers) or frequently congested road sections, and reservation fee subsidies can be issued (such as a 50% discount on the first three reservations per month), reducing the risk of policy exclusion. By promoting the advantages of road reservation travel compared to regular detours, such as pushing personalized reservation plans based on user historical travel data, we can attract commuters during peak hours on the road.

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