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Tourist travel behavior in rural areas considering bus route preferences

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Abstract: To explore the travel behavior mechanism of tourists and encourage the use of tourist buses, realizing the dynamic balance between travel demand and transportation supply in rural areas, the bus route preferences of tourists based on trip chains and travel mode choices were analyzed. A nested logit model with trip chain pattern as the top level, travel mode choice as the middle level, and bus route preference as the third level was estimated by using tourism travel survey data collected from 546 respondents in Lishui, Nanjing, in 2021. The results indicate that travel mode choice significantly affects tourists' choice of a complex chain with featured scenic spots; bus route preference has a marked impact on private cars. Further, the results clarify the influence of tourists' sociodemographic attributes, tourism travel characteristics, and bus travel intention on the three choice levels. Finally, policies for improving bus operation efficiency and service quality were proposed for rural areas similar to Lishui, Nanjing.

Key words: rural tourism; bus route preference; travel mode choice; trip chain; nested logit model

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In the past two years, COVID-19 has considerably impacted the tourism industry, inhibiting cross-border tourism flow. Thus, with the orderly implementation of prevention and control owing to COVID-19, domestic tourism is becoming predominant in the tourism industry. The number and income of domestic tourists are showing a trend of recovery. Rural tourism has become an important growth point of the domestic tourism market. The rich tourism resources in rural areas provide strong support for the development of rural tourism. However, some rural scenic spots are scattered and lack traffic links. The resulting imbalance between tourism travel demand and transportation system supply is particularly prominent during peak periods such as holidays. Considering the advantages of buses in alleviating traffic stress and environmental pollution[1], addressing the tourist bus service system in rural areas is important.

For this purpose, the travel behavior mechanism of rural tourists should be studied. The decision-making process of a tourism trip includes the choice of destination, travel mode and route, and other choices. Previous studies have focused on single-choice behavior and analyzed the impact of external factors such as tourists' sociodemographic attributes, road conditions, and traffic policies[2-3]. However, tourists' choice behaviors are interrelated and, in reality, interactive[4]. Therefore, some tourism travel studies have introduced the concept of the trip chain, which profoundly reflects the internal mechanism of different choice behaviors[5-6]. With the characteristics of time, space, and structure, a trip chain better expresses the travel needs of tourists. Analyzing the trip chain can provide operation and management policies to optimize the travel demand structure and encourage tourists to travel by bus.

This paper selects trip chain pattern and travel mode choice, two key elements that affect bus route choice in travel decision-making, to analyze their influencing factors and the interaction mechanism with bus route preference. The Lishui District of Nanjing, China, is selected as a case study in rural tourism. In 2020, Lishui attracted more than 5 million tourists and achieved a comprehensive income of over 1.4 billion yuan. Large-scale tourism has resulted in complex travel behavior and serious traffic congestion on holidays, increasing demand for tourist bus services. At present, the central urban area of Lishui is serviced by Rail Transit Line S7 and a dense bus network; however, a direct bus connection is lacking between the scenic spots in peripheral areas, and tourists need to go to the central urban area to transfer. In this context, exploring the increasingly complex behavior of choosing tourist buses and proposing bus service optimization strategies according to tourists' route preferences is essential.

Although some studies have proposed improvement measures for bus services, exploring the influencing factors of tourists' preferred public transport mode[7-8], they

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focus on urban tourism travel. Considering this limitation, this study aims to make two contributions to the existing literature. Methodologically, a three-level bus route preference nested logit (NL) model based on the trip chain and travel mode choice is proposed, allowing for the joint representation of the correlations between the three components. Empirically, the research scope of tourism travel is within the rural area. The study is of theoretical significance and practical value in promoting sustainable tourism development in similar counties.

1 Literature Review

With the structural optimization and upgrading of tourism, the focus of domestic tourism has changed from traditional sightseeing to holiday leisure. The travel behavior of tourists exhibits basic characteristics, including individual travel, high travel rates, and high mobility, which are different from those of urban residents. Meanwhile, seasonal changes in tourism travel demand are obvious, and the spatial distribution of tourists is concentrated geographically. To better grasp the characteristics and laws of tourism travel, numerous studies have focused on the travel behavior of tourists[9–12].

Traditionally, tourism travel behavior analysis is developed based on the "four-stage" method. As the individual complexity and randomness of tourism increase, researchers have introduced the disaggregated model that considers individual behavior to analyze the influencing factors and mechanisms of tourists' travel choices. Current studies on travel behavior analysis focus on travel patterns, destination choice, travel route choice, and travel mode choice[4, 13–14]. In particular, travel mode choice has received extensive attention due to its direct effect on other choice behaviors. Studies have shown that tourists' travel behavior is affected by external factors such as socio-economic attributes and traffic conditions as well as internal factors related to the travel decision-making process, and there is an interaction between these factors[15]. Constructing discrete choice models based on utility theory, such as the binary logit, multinomial logit (MNL), NL, mixed logit, and SEM (structural equation modeling)-logit models with different structures, can reveal the mechanism of prominent influencing factors on tourists' travel behavior[16–17].

To explore tourists' travel demand characteristics and mechanisms, some researchers consider the influence of trip chains in their modeling. Taking all travel and activities from the residence in one day as a whole, the travel behavior analysis method based on the trip chain discusses the influencing factors and interactive relationship between tourists' spatiotemporal characteristics and travel structure. Based on the Beijing tourist survey data, Yang et al.[5] compared the choice of travel mode and trip chain between holidays and weekdays. The results indicate that the trip chain is determined before selecting travel mode on weekdays, while the decision order is reversed on holidays. Hermawati[6] studied the trip chain of tourists in Bali and found that the increase in travel time and cost will affect the trip chain with fewer destinations. Qi et al.[17] used the NL model to explore the relationship between tourists' trip chains and travel mode choices. They pointed out that tourists prefer to determine trip chains before selecting a travel mode and can accept increased time and economic costs when choosing complex chains.

At present, research on the travel behavior of tourist bus users mainly involves factors affecting the choice of bus mode, preference to travel by bus and the development potential of the tourist bus. Then strategies to improve the tourist bus system and encourage the use of buses are put forward. Nutsugbodo et al.[8] examined the public transport preference of international tourists in Ghana and pointed out that affordability, accessibility, availability, safety, and comfort would affect tourists' choice of taking the bus. By constructing the mixed Logit model, Gutiérrez et al.[7] found that tourist age, social class, educational level, and point of departure have a great impact on the use of buses in tourist destinations. Based on the data provided by Google Maps Platform, Perea-Medina et al.[18] modeled and compared tourist buses with private cars, thus demonstrating the potential for regionalization of public transport. Tourist bus services can be improved from the aspects of convenience, information systems, network accessibility, and service frequency[19–20].

By studying the existing literature, two major research gaps have been found. First, although researchers have carried out numerous studies on tourist bus preference, they are normally devoted to the single stage of bus mode choice. Few consider the interaction of different choice stages from the perspective of the tourism travel decision-making process. Second, most of the relevant studies focus on the scope of the country, region, city, or within a scenic spot, while few researchers have considered rural tourism. Involving tourists' trip chain and travel mode choice in the modeling of bus route preference, this study attempts to reveal the mechanism of rural tourists' choice behavior to fill the above gaps effectively.

2 Data

2.1 Data source

From February to March 2021, a rural tourism and bus travel intention survey was conducted in Nanjing, China, to obtain tourists' sociodemographic attributes, rural travel behavior characteristics, and bus travel intentions. Although the development of tourism has been seriously affected by COVID-19 in the last three years, Nanjing is creating a secure environment for tourism through orderly epidemic prevention and control. In 2020, Nanjing achieved a total of 182.26 billion yuan as tourism revenue and received 97.04 million tourists. As an important rural tourism destination, Lishui is in south-central Nanjing, 45 km away from the main urban zone, with an administrative area of 1 067.26 km^2 and a population of 540 000. It is rich in natural resources and surrounded by a group of ecological rural landscape features in the peripheries (see Fig. 1). By innovating the supply of tourism products such as featured agriculture, tourism villages, and health industry, as well as improving tourism infrastructure, rural tourism has become a crucial growth point of Lishui's economy.

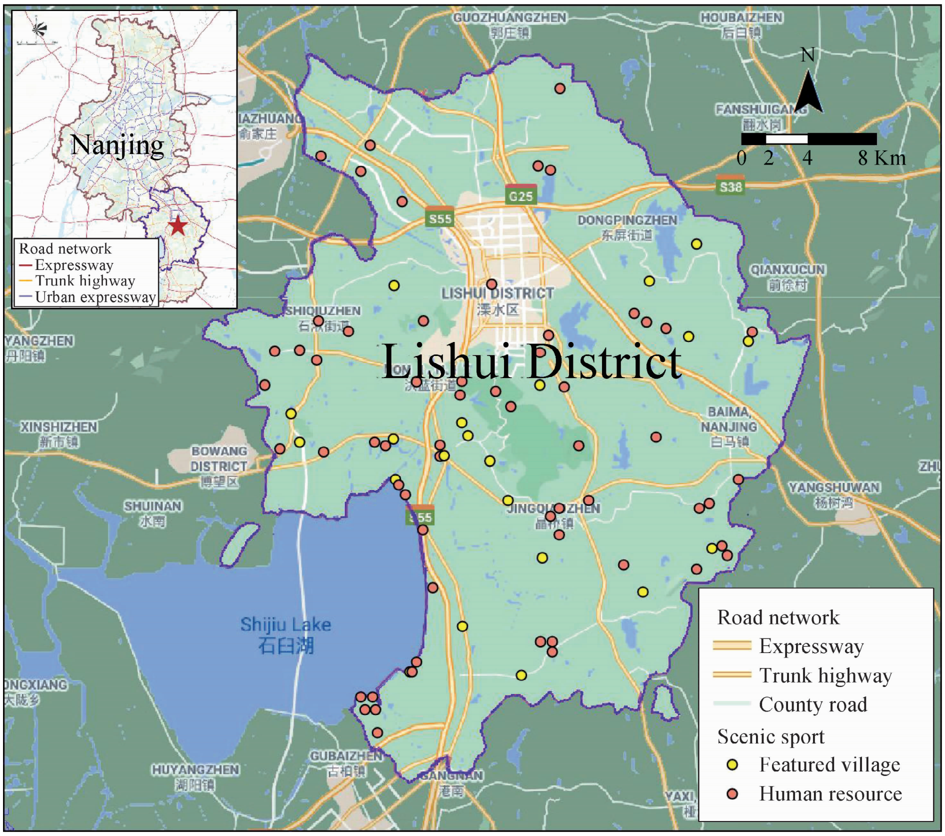

Fig. 1 Distribution of tourism resources in Lishui

Under the relatively comprehensive transportation system, the tourist buses in Lishui District are provided with good development conditions. Relying on aviation and high-speed rail, Lishui has formed a fast channel connecting the Yangtze River Delta region, expanding the radius of tourist sources. Moreover, the two metro lines connecting Nanjing's urban area can transport tourists rapidly to rail transit stations in the rural area, while 1 350 km of rural roads spreading to 186 rural scenic spots lay a foundation for the development of the tourist bus service. By the end of 2020, Lishui had opened 85 regular bus routes, including 26 urban routes (3 of which are tourist routes), 7 town routes, and 52 urban-rural routes (see Fig. 2). Among them, 3 routes connect high-speed rail stations, and 23 routes connect metro line S7 and S9 stations. The total mileage of bus routes reaches 1 095 km, with 8 urban-rural interchange hubs. In terms of operation, Lishui is equipped with 477 buses, with new and clean energy buses accounting for more than 78%. One-way bus fare is 2 yuan, and a preferential policy is implemented for bus and metro transfer. Overall, bus network density is large in urban areas and small in peripheral towns. The lack of direct connection routes between the scenic spots results in high transfer ratio and large nonlinear coefficient of bus route, indicating the low service quality of tourist buses in rural areas. Therefore, this study discusses tourists' travel behavior and bus travel intention in Lishui to improve their travel experience and bus service quality.

2.2 Survey design

In the design of the survey, the key elements of the selected subject (including variables, their value range, and the relationship between them) was analyzed in advance to clarify the scope of the investigation. Based on the survey objectives, the questionnaire includes the following three sections.

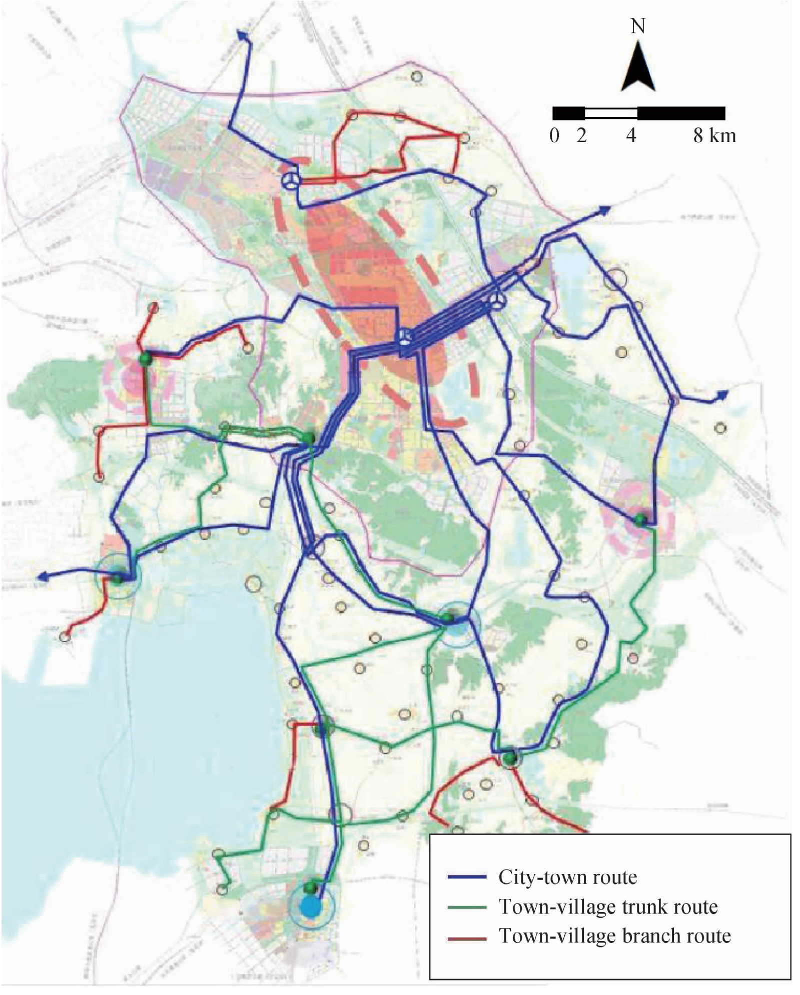

Fig. 2 Rural bus routes in Lishui

2.2.1 Survey on sociodemographic attributes of tourists

Sociodemographic attributes refer to the features and status data of the respondents, including gender, age, occupation, income, holding driving licenses, and car ownership. As basic data for studying tourism activities and travel choices, sociodemographic attributes are variables determined outside the travel decision and are not affected by causal systems.

2.2.2 Survey on tourism activity and travel characteristics

Tourism activity characteristics refer to the decision-making aspects of tourism, including tourist source (local and foreign), travel scale (number of tourists and children), travel days, tourist destination type, number of scenic spots, and weather.

Travel choice characteristics include the number of transfers, travel distance, external mode of arrival, travel mode choice in the tourism city, and travel cost. They are major components of tourist travel choice, and there is an interaction between these variables, providing important data support for the construction of the model.

2.2.3 Survey on tourists' intention to travel by bus

This section aims to grasp tourists' perception of bus service, acceptance of bus travel (travel time, waiting time, walking distance, the number of transfers, and transfer waiting time), demand for tourist bus services, and intention to travel by bus. The results of the stated preference (SP) survey can better guide tourist bus route planning and service improvement. Fig. 3 shows the design structure of the questionnaire.

The survey was conducted online and offline. Respondents were required to have visited Lishui in the past three months. Besides sociodemographic attributes, they had to recall the specific travel characteristics of their last trip. In total, 546 valid questionnaires were collected.

2.3 Data processing

The rural tourism survey data of Lishui was processed to extract trip chain information. This study defines a tourism trip chain as a sequence of one-day trips and activities that start and end at a tourist's residence. As residences may change, it is not mandatory to end at the starting point.

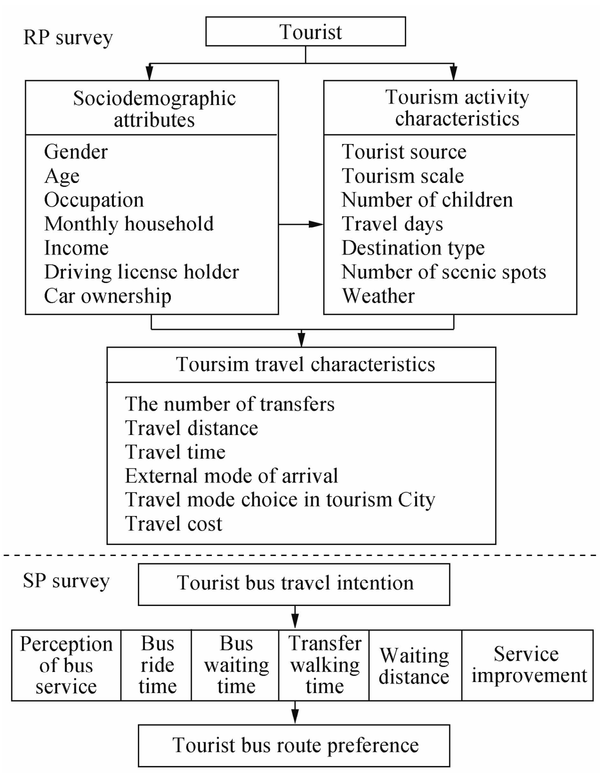

Fig. 3 Survey design structure

According to the number of scenic spots visited by a tourist in 1 d, trip chains can be classified into simple chains, which contain one tourism destination, and complex chains, which contain two or more tourism destinations. By defining rural tourism destinations as featured scenic spots and non-featured scenic spots, trip chains can be further divided into five subcategories. Specifically, the division of the rural scenic spots takes the geographical location and environmental characteristics of the rural area, as well as the survey results, into account. This study finally defines featured scenic spots as hydrogeological landscapes, beautiful villages, and farmhouse resorts, with the other types of scenic spots categorized as non-featured scenic spots. The five trip chains are described as follows, where H refers to home or hotel, F means featured rural scenic spot, and O represents non-featured one (see Fig. 4). HFH represents simple trip chain with only one featured scenic spot; HOH represents simple trip chain with only one non-featured scenic spot; HFFH represents complex trip chain containing two or more featured scenic spots; HFOH represents complex trip chain containing featured scenic spot(s) and non-featured spot(s); HOOH represents complex trip chain containing two or more non-featured scenic spots.

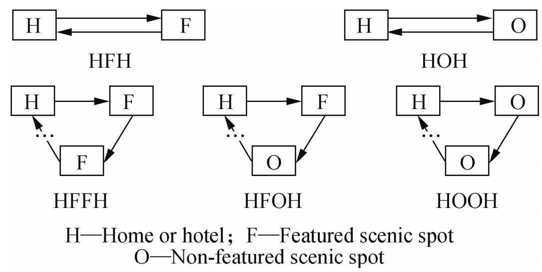

Fig. 4 Rural tourism trip chains

Due to the favorable socioeconomic conditions and transportation infrastructure, travel mode choices in Nanjing are flexible and diverse. Buses, the metro, taxis, and private cars are the major travel modes of rural tourism, chosen by 88.1% of the respondents. The remaining modes are then classified into the "Others" category. Since there may be multiple travel modes in a one-day trip, the dominant mode is determined for each chain according to the priority ordering scheme[21]. In the one-day trip chain, metro and bus have the highest priority, followed by taxis and private cars.

In the survey, the question of bus route choice was designed as semi-open. To reduce dimensions, this study used principal component analysis to extract common factors with a cumulative variance contribution rate greater than 60%. Tab. 1 shows the correlation between the observed variables and the principal components. According

Tab. 1 Principal component analysis results of tourist bus route preference

Item	Principal component 1# BSQ	Principal component 2# MEC	Principal component 3# MTC	Principal component 4# HTC
Comfortable seats	−0.563		0.236	
Beautiful surrounding scenery	−0.569			
Complete auxiliary facilities	−0.442			
Good carriage environment	−0.378			−0.215
Preferential transfer policy		−0.574		0.171
Low bus fare		0.535		
Park + ride facilities		0.464		
Short walking distance			0.610	
Short waiting time			0.588	
Short travel time			−0.566	
Fewer stops		−0.213	0.488	
High punctuality	0.226		0.426	
Fewer transfers		0.280		0.618
Short transfer and walking distance				0.319

Note: Factor loads less than 0.2 are represented by a space.

to the degree of correlation, the choice preference of rural bus routes can be summarized into four categories, namely, routes with the best service quality, routes with a minimum economic cost, routes with minimum time cost, and routes with the highest transfer convenience. In particular, the best service quality represents high comfort, safety, and beautiful surrounding scenery. For the convenience of expression, the four categories of tourist bus routes in the rural area are represented by BSQ, MEC, MTC, and HTC.

2.4 Descriptive analysis

After data processing, the characteristics of representative variables in rural tourism travel are analyzed in this sub-section. Tab. 2 reports the cross percentages of trip chain and travel mode choices in rural tourism. Complex chains account for 73.7% of the sample, while featured scenic spots are the major destinations. The travel mode choice in rural tourism reveals different characteristics from that of city tourism. While metro is the main travel mode for urban tourists, cars are favored by the majority of rural tourists, especially private cars (47.5%). In contrast, fewer tourists choose public transport, with only 9.1% of respondents traveling by bus. The reason for this difference may be the poor availability of bus services to scenic spots.

Tab. 2 Statistics of trip chain and travel mode choice %

Travel mode	Trip chain					Total
	HFH	HOH	HFFH	HFOH	HOOH	
Bus	0.4	0.4	3.1	5.0	0.2	9.1
Metro	1.2	1.5	1.5	8.1	0.8	13.1
Taxi	3.1	1.9	2.7	9.2	1.2	18.1
Private car	10.8	2.7	15.8	17.4	0.8	47.5
Others	3.5	0.8	2.3	5.4	0.2	12.2
Total	19.0	7.3	25.4	45.1	3.2	100.0

In terms of bus route preference, most tourists choose MTC and HTC, accounting for 39.9% and 36.5%, respectively. When traveling by bus, tourists tend to choose bus routes with less time cost, fewer transfers, and higher service quality, whereas economic cost, walking distance, and safety are not given high priority among the considerations for tourist bus route choice.

As shown in Fig. 5(a), tourists who travel in different trip chains have different preferences for bus routes. Two simple chain patterns, HFH and HOH, are usually associated with less time cost. Tourists traveling in HFFH or HFOH regard time cost and the number of transfers as equally important. Of tourists who choose HOOH, 50.1% give the highest priority to the number of transfers, while factors such as economic cost and service quality only account for 5.8%. With the increasing complexity of the trip chain, the importance of the number of transfers in tourist bus route choice increases, which is consistent with the actual situation.

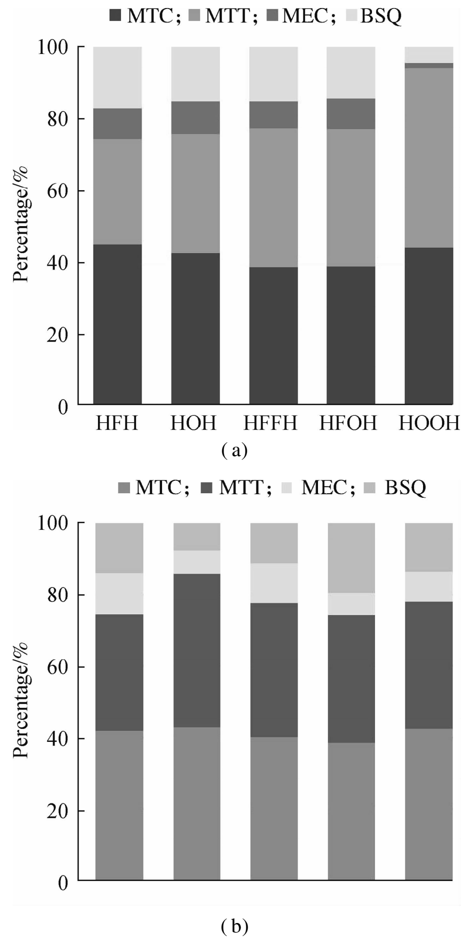

Fig. 5 Percentage stacking histograms of tourist bus route preference. (a) Percentage of tourist bus route preference under different trip chains; (b) Percentage of tourist bus route preference under different travel modes

Fig. 5(b) shows that tourists' bus route preference is closely related to the travel mode they choose. Some tourists prefer to choose bus routes with the advantages of the chosen travel modes. Because taxis and private cars can reach tourist destinations conveniently, over 35% of tourists who travel using these modes have higher requirements for accessibility of tourist buses and have a strong intention to choose bus routes with fewer transfers. Tourists traveling by private car attach importance to the travel experience; hence, 19% of them are likely to choose bus routes with high service quality. Other tourists prefer bus routes that alleviate the shortcomings of their chosen modes to a certain extent. Considering that metro stations are distant from some scenic spots and require bus routes to connect, tourists traveling by metro tend to choose bus routes with minimal transfers. In addition, 10.1% of tourists who take taxis expect bus routes to have the least economic cost, which may be because taxi travel increases tourism expenses.

As the sequence of tourists arriving at featured or non-featured scenic spots and the number of the types of scenic spots are important attributes for HFOH trip chains, regression analysis was conducted to reveal their impact on travel mode choice and bus route preference. The results show no significant correlation between the attributes of different scenic spot types and the focus of this study. Therefore, tourism trip chains are classified into five categories according to the number and types of scenic spots.

The statistical description of explanatory variables is shown in Tab. 3. Rural tourism is more attractive to young people aged 18-30, and most respondents have driving licenses and cars. More than 70% of the tourists travel in groups of 2-4 without children, and their travel distance is mainly 5-30 km. Although most tourists visit multiple scenic spots in a day, the utilization of cars reduces the number of transfers effectively. Statistics show that 37% of the respondents do not experience transfers, and over 80% of the tourists transfer less than three times. For bus travel intention, more than half of the respondents can accept a single 1-h bus ride. The average longest acceptable waiting time for transfer is slightly less than that of ordinary waiting, but they are both concentrated in the 5-10 min range. Moreover, an increase in walking distance decreases tourists' willingness to choose buses. When walking distance exceeds 1 km, about 70% of the respondents will turn to other travel modes.

Tab. 3 Description of explanatory variables

Category	Variable name	Variable content	Percent/%
Sociodemographic attributes	Tourist source	Local	49.1
		Foreign	50.9
	Gender	Male	48.2
		Female	51.8
	Age	≤18	1.8
		18-30	69.8
		30-50	25.5
		>50	2.9
	Monthly household income/yuan	≤5 000	8.5
		5 000-10 000	31.4
		10 000-30 000	51.4
		>30 000	8.7
	Driving license holder	Yes	76.7
		No	23.3
	Car ownership	Yes	75.5
		No	24.5
Rural tourism travel characteristics	Tourism scale/person	1	17.6
		2-4	72.3
		≥5	10.1
	Number of children	0	75.2
		1	17.9
		≥2	6.9
	Travel days	1	35.8
		2	32.3
		3	21.4
		≥4	10.5
	Number of transfers	0	37.0
		1	24.4
		2	20.8
		≥3	17.8
	Travel distance/km	≤5	11.4
		5-10	30.2
		10-30	30.0
		30-50	15.5
		>50	12.9
Bus travel intention	Maximum acceptable bus ride time/min	≤30	32.9
		30-60	58.8
		>60	8.3
	Maximum acceptable transfer waiting time/min	≤5	14.7
		5-10	58.2
		10-15	23.5
		>15	3.6
	Route choice preference	Minimum time cost	32.6
		Minimum transfers	35.0
		Minimum economic cost	11.5
		Best service quality	20.9
	Maximum acceptable bus waiting time/min	≤5	7.9
		5-10	42.6
		10-15	32.0
		15-20	11.4
		>20	6.1
	Maximum acceptable walking distance/m	≤500	17.3
		500-1 000	51.7
		1 000-1 500	17.6
		1 500-2 000	7.6
		>2 000	5.8

3 Methodology

3.1 Model structure

This study utilized the NL model to explore the relationship between trip chain, travel mode choice, and bus route preferences in rural tourism. The NL model is a common method used to study travel behavior, analyzing the interaction mechanism between different decision-making stages effectively. Essentially, the NL model is an MNL model with a nested structure. Considering the correlation between choice branches, each level of the NL model is composed of relevant branches. Based on random utility theory and the conditional choice assumption, the upper level constrains the lower level, and the lower level influences the upper level in the form of logsum variables. Completed by the upper and lower variables, the calibration process of the NL model starts from the bottom level, whereas the model prediction is conducted from top to bottom. To overcome the independence from irrelevant alternation property, the NL model considers the alternative correlation. Although revealed preference (RP) and stated preference (SP) survey data were collected, the study design ensures that the same respondent does not have repeated choices. Thus, emphasizing individual heterogeneity is unnecessary in the model. Compared with the mixed logit model with respect to heterogeneity, the NL model is more consistent with the data in this study.

The survey results demonstrate that when making travel decisions, tourists are used to determining trip chain patterns first, including the number and type of scenic spots they plan to visit. According to the given set of scenic spots they plan to visit, tourists will choose the dominant mode that meets their requirements from the available travel modes and supplement it with other connection modes. Specifically, only dominant travel modes are considered in this study. After deciding the destinations and travel mode, tourists will consider comprehensive utility and choose the appropriate travel route from the set of all possible routes. As tourists using different travel modes will show different preferences for bus routes, conducting relevant research is beneficial to improve the operation and service of the tourist bus system. Therefore, this study proposes a nesting structure with trip chain pattern as the top level, travel mode choice as the middle level, and bus route preference as the third level. Accordingly, the model choice set consists of three subsets. First is trip chain subset C, including HFH, HOH, HFFH, HFOH, and HOOH. Alternatives in the travel mode subset M are bus, metro, taxi, and private cars. For the bus route preference subset R, there are MTC, HTC, MEC, and BSQ.

3.2 Utility function

The utility obtained by tourist n selecting alternative i from choice set J is defined as U_{ni}. Under random utility theory, the condition for tourist n to choose alternative i from J is $U_{ni} > U_{nj}$, $i \neq j, j \in J$, indicating that each tourist will adopt the most effective alternative from the choice set[22].

Utility U_{ni} is often divided into a systematic component and a random component. Assuming a linear relationship between the two components, U_{ni} can be described as

$$U_{ni} = V_{ni} + \varepsilon_{ni} \tag{1}$$

where V_{ni} and ε_{ni} respectively denote the systematic component and random component in the utility function of alternative i for tourist n.

The systemic utility function has many expressions. This study applied the most commonly used linear relationship to represent the utility function V_{ni}, namely

$$V_{ni} = \alpha_i + \sum_{l=1}^{L} \beta_{il} x_{nil} \tag{2}$$

where α_i is the constant term for alternative i; x_{nil} represents the l-th variable of alternative i for tourist n; and β_{il} refers to an unknown parameter. According to Tab. 3, the systematic utility function for each alternative is a linear combination of sociodemographic attributes, tourism travel characteristics, and bus travel intention.

3.3 Choice probability

According to the complexity of decision-making, the NL model divides the travel behavior decision-making alternatives into multiple nests. The lower nests are constrained by the conditional probability of the upper, and one variable of the upper level is the logsum of the lower. Assume that ε_{ni} follows a type Ⅰ extreme value (or Gumbel) distribution. Based on the generalized extra value (GEV) theory, the joint probability of rural tourist's individual choice can be expressed as

$$P_n = P_n(c) P_n(m \mid c) P_n(r \mid m) \tag{3}$$

where $P_n(c)$ is the marginal probability of trip chain c; $P_n(m \mid c)$ expresses the conditional probability of travel mode m being chosen under the given trip chain c; and $P_n(r \mid m)$ is the conditional probability of bus route preference r being chosen under the given travel mode m. The marginal and conditional probabilities are represented as

$$P_n(r \mid m) = \frac{\exp\left(\frac{V_{nr}}{\mu_m}\right)}{\sum_{i=1}^{R} \exp\left(\frac{V_{ni}}{\mu_m}\right)} \tag{4}$$

$$P_n(m \mid c) = \frac{\exp\left(\frac{V_{nm} + \mu_m L_m}{\mu_c}\right)}{\sum_{i=1}^{M} \exp\left(\frac{V_{nj} + \mu_j L_j}{\mu_c}\right)} \tag{5}$$

$$P_n(c) = \frac{\exp(V_{nc} + \mu_c L_c)}{\sum_{i=1}^{C} \exp(V_{nk} + \mu_k L_k)} \tag{6}$$

where V_{nr}, V_{nm}, V_{nc} respectively show the systematic components of bus route preference r, travel mode choice m, and trip chain c; μ_m and μ_c are the scale parameters associated with the nests of travel mode m and trip chain c. Located in the interval $(0, 1)$, μ reflects the degree of independence among random components of utility for different alternatives in a nest. Larger μ implies greater influence and weaker substitution between each level of the model[11]. Corresponding to scale parameters, L_m and L_c represent logsum variables (or inclusive values) related to the nests of travel mode m and trip chain c, which can be specified as

$$L_m = \ln\left(\sum_{i=1}^{R} \exp\left(\frac{V_{ni}}{\mu_m}\right)\right) \tag{7}$$

$$L_c = \ln\left(\sum_{j=1}^{M} \exp\left(\frac{V_{nj} + \mu_j L_j}{\mu_c}\right)\right) \tag{8}$$

This study uses the maximum likelihood method to estimate the scale parameters and coefficients in the systematic utility function V_{ni}. For parameter estimation results, the discrete choice model usually employs a likelihood ratio test to verify whether the influence of independent variables on dependent ones is significant. Another commonly used indicator is the goodness of fit ratio ρ^2, which can reflect the fitting effect of the model on the original data. ρ^2 is equal to the ratio of the sum of regression squares in the total sum of squares, that is, the percentage of variability of the dependent variable that can be explained by the regression equation. The value of ρ^2 is between 0 and 1. The closer the value is to 1, the higher the accuracy of the model.

4 Results and Discussion

Tabs. 4 to 6 respectively display the estimation results of the three-level NL model. Most explanatory variables are significant at the level of 95% or higher. In terms of model accuracy, the initial log likelihood is −2 040.203, and the converged log likelihood is −1 603.133, indicating that the impact of selected variables on the travel behavior choice of rural tourists is significant. As the goodness of fit ratio ρ^2 is 0.705, the proposed model can be considered to have a good fitting effect on the original data.

4.1 Scale parameters

In Tab. 4 and Tab. 5, the scale parameters of logsum variables are distributed between 0 and 1 and are most significant at the level of 95% and 99%. This indicates that the proposed NL model has a reasonable structure. Generally, a larger scale parameter suggests a greater impact of alternatives at the lower level than on the upper and weaker substitution between the lower level alternatives.

Tab. 4 Model estimation results of trip chain choice level

Category	Variable	HFH	HOH	HFFH	HFOH
	Constant	5.76*	3.571	3.601	5.296
Sociodemographic attributes	Age	2.953*	2.569**	3.147***	2.577**
Rural tourism travel characteristics	Tourism scale	−2.188*	−1.581	−1.772	−2.401**
	Travel days	−1.812***	−1.182**	−1.406***	−1.005**
	Arrival mode	1.182*	0.802	1.483**	1.349**
	Number of transfers	−1.294**	−0.872	−1.283**	−0.982*
Scale parameters μ	Logsum	0.521**	0.262*	0.791***	0.818***

Notes: 1) In the calibration results of model parameters, HOOH is taken as base alternative of the trip chain choice level. 2) *** significance at 99% level; ** significance at 95% level; * significance at 90% level.

Tab. 5 Model estimation results of travel mode choice level

Category	Variable	Bus	Metro	Taxi	Private car
	Constant	−1.076	−2.584	−1.002	8.072***
Sociodemographic attributes	Car ownership	0.18	0.315	−0.542	−2.219***
	Tourist source	−1.257	0.005	1.104	−2.583***
Rural tourism travel characteristics	Travel days	−0.354	−0.482*	0.193	−0.363
	Arrival mode	0.015	−0.436*	−0.204	0.412*
	Number of transfers	1.635***	1.761***	1.018***	−0.74***
	Travel distance	−0.377	−0.365	−0.179	0.850***
	Number of children	−0.959*	−1.318**	−0.975***	−0.292
Scale parameters μ	Logsum	0.398*	0.653***	0.430**	0.926***

Notes: 1) In the calibration results of model parameters, others are taken as base alternatives of the travel mode choice level. 2) *** significance at 99% level; ** significance at 95% level; * significance at 90% level.

For logsum variables at the first level, the estimated scale parameters of HFOH and HFFH are the largest, illustrating that travel mode alternatives are significant under the condition of complex chains. In addition, changes in the utility of a travel mode under these trip chain nests may dramatically influence the probability of the trip chain being chosen. Furthermore, Tab. 4 shows that tourists prefer to select complex trip chains with featured scenic spots in rural travel. This may be attributed to the poor public transport accessibility of scenic spots and sound road infrastructure in the rural area of Nanjing. In multi-destination travel, tourists have higher requirements for transfers between travel modes and are more willing to travel by car. Finally, the scale parameter of trip chain HOH is 0.262, ranging from 0 and 1 at the 90% level. In this case, the increase in car travel utility will result in the transfer of tourists to buses.

Bus route preference can indirectly reflect the travel mode choice tendency of tourists. Tab. 5 shows that the estimated scale parameter for private cars is the largest, indicating a significant impact of bus route choice on private cars. Moreover, tourists traveling by private car tend to choose the same type of bus route. When the utility of a bus route changes, great changes occur in travel mode choice. As a less-used travel mode for rural tourism in Nanjing, bus travel is not significantly affected by route choice preference, and there is strong substitutability between different routes.

4.2 Influencing factors

4.2.1 Trip chain choice

Results show that the trip chain choice of rural tourists is positively affected by age and arrival mode, whereas tourism scale, travel days, and the number of transfers have negative coefficients. At the level of 95% or higher, age and travel days are significant for each alternative. Older tourists with fewer transfers are more likely to travel in HFH and HFFH. For trip chains containing featured scenic spots, fewer trips and transfers will significantly increase the probability of choice. Besides, tourists who reach the rural area by car, public transport, or long-distance bus are more inclined to visit featured scenic spots. This is because most of these tourists live nearby or travel in groups and are familiar with rural tourism resources. On comparing the constant terms, when other variables are the same, tourists are more likely to travel in HFH and HFOH.

As the trip chain type with the largest proportion in county tourism, HFOH is composed of featured and non-featured scenic spots, having some similarities with other travel chains of the single scenic spot type in the variable mechanism. For instance, the probability of HOH and HFOH being chosen is similar for tourists of the same age, with other variables unchanged, suggesting that whether or not to visit the featured scenic spots has little impact on tourists' travel plans with respect to non-featured scenic spots. When adopting the same external travel mode to arrive at the tourist city, the probability of choosing HFFH and HFOH would increase. This may be because the daily itinerary of non-local tourists would be more compact. They fully intend to visit local featured scenic spots, accompanied by certain leisure and entertainment activities. As HFOH has similar characteristics to other trip chains, optimization measures for one of them may have the same effect on the choice probability of the other.

4.2.2 Travel mode choice

As shown in Tab. 5, the impact of travel days and arrival mode on the choice of the metro is negative and significant at the level of 90%, indicating that the metro is more suitable for foreign tourists who have fewer travel days and reach the rural area by high-speed rail and plane. The number of transfers have a significant impact and positive coefficients on all alternatives of travel modes except that of a private car. It can be inferred that when tourists choose public transport or taxis, they experience more transfers. Travel distance is only positive for private cars and significant at the level of 99%. In other words, the preferred mode for long-distance rural tourism travel is self-driving. The choice probabilities of the other three modes are significantly negatively affected by the number of children traveling together. With other variables unchanged, the probability of selecting the metro decreases by 0.27 times for each unit increase in the number of children. As taking children on public transport or by taxi is inconvenient, parents prefer to drive their children to rural areas. Among all travel mode choice alternatives, the private car has the largest and most significant constant term. When the influencing factors remain the same, the probability of rural tourists traveling by private car is much higher than other travel modes. To encourage more tourists to choose buses in rural areas, bus route preference and its influencing factors are discussed in the following section.

4.2.3 Bus route preference

In terms of sociodemographic attributes, foreign tourists are likely to choose any type of bus route (see Tab. 6). Women prefer routes with minimum transfers. As family income increases, tourists pay less attention to time and economic costs, with bus service quality becoming the focus. When rural tourists pursue efficiency in tourism, they usually do not bring children with them. Tourists selecting routes with minimum transfers can accept a longer bus waiting time, but their tolerance of transfer waiting time is poor. If choosing a route with a minimum economic cost, the tourist may allow more time cost, transfer waiting time, and walking distance. Keeping other explanatory variables the same, a route with the minimum

Tab. 6 Model estimation results of bus route preference level

		MTC	HTC	MEC
	Constant	1.885	−2.073*	−6.053***
Sociodemographic attributes	Tourist source	0.867**	0.659*	1.657***
	Gender	−0.508	0.563*	0.004
	Household income	−0.391**	−0.084	−0.504**
Rural tourism travel characteristics	Number of children	−1.052***	0.044	−0.201
Bus travel intention	Maximum acceptable bus ride time	0.367	−0.013	1.152**
	Maximum acceptable bus waiting time	0.025	0.405**	0.344
	Maximum acceptable transfer waiting time	0.006	−1.229***	1.075**
	Maximum acceptable walking distance	−0.063	0.002	0.536**

Notes: 1) In the calibration results of model parameters, BSQ is taken as base alternatives of the bus route preference level. 2) *** Significance at 99% level; ** significance at 95% level; * significance at 90% level.

time cost has the largest constant term and is most likely to be chosen.

4.3 Policy implications

Tab. 2 shows that the bus is not widely used in rural tourism travel; tourists choosing the bus are generally limited to HFOH. In contrast, self-driving is popular among rural tourists and corresponds to diversified trip chain choices. This difference may be for two reasons. First, the increase in driving licenses and car ownership has created ideal conditions for self-driving. For long-distance travel in rural areas, tourists usually prefer fewer transfers and simpler trip chains. Therefore, the car is a better choice than the bus. Second, rural scenic spots are geographically scattered and have poor bus accessibility, especially featured ones such as farmhouse resorts. This makes it less possible for tourists to travel by bus when the trip chain is determined. Based on the model results and questionnaire, this study proposes the following measures to improve private car travel management, bus operation efficiency, and service quality in rural tourism.

For large cities with rapid social and economic development similar to Nanjing, an important issue of rural tourism is traffic congestion and environmental pollution caused by large-scale car travel on holidays. To manage private car travel, traffic control by time and section should be first implemented in rural areas with high traffic pressure. When roads around the scenic spot are saturated, tourists should be transferred to roads with lower traffic volumes or park their cars at a distance. The second measure is to encourage local tourists to visit the rural area during non-holidays. Model results indicate that tourists from the city are more likely to travel by car. To alleviate traffic congestion on holidays, preferential policies for tickets and transportation can be provided during off-peak periods. A parking charge policy is another important means of controlling car travel. By increasing parking charges around scenic spots, some tourists will be guided to park farther away, and the turnover rate of the scenic spot parking lot will be reduced. Last but not least, it is necessary to advocate for self-driving tourists to travel by bus. One effective way is the preferential policy of parking before taking the bus. The results show that 90% of self-driving tourists are willing to park and transfer to a bus if they obtain free parking or a preferential ticket price. Attracting more self-driving tourists to choose buses is a challenge for bus services; therefore, further improvement in bus operation efficiency and service quality is required.

According to Tab. 5, tourists from other cities or with economic constraints are likely to travel by bus. Compared with the number of transfers and travel costs, women pay more attention to travel time and service quality. Moreover, tourists with children are most sensitive to travel time and cost. For the above special groups, personalized bus policies need to be formulated. Therefore, this study proposes bus operation requirements based on public acceptability. First, the single bus ride time should not exceed 60 min, and the departure frequency should be controlled within 15 min, with an optimal frequency of 5-10 min. In terms of accessibility, it is recommended to control the walking distance to within 1 500 m, set popular scenic spots in the same bus route, and improve transfer convenience between different travel modes. Furthermore, respondents put forward the following suggestions to improve the rural tourist bus service.

When designing the interiors of the bus, the number of seats should be increased to ensure one for each passenger. Seat comfort, compartment environment, and auxiliary facilities should also be improved. The setting of the tourist bus route is required to minimize the number of stops and beautify the surrounding scenery. In addition, the bus information system should be developed to provide tourists with real-time and reliable travel information.

This study is an initial step in analyzing the rural tourism trip chain, travel mode choice, and bus route preferences of tourist behavior in rural areas. The following aspects need to be further studied. First, the consideration of travel modes is not comprehensive. With the continuous development of transportation systems, the metro and online ride-hailing play increasingly important roles in county tourism. Furthermore, the connection between modes within and outside the county impacts tourists' travel behavior. The above-mentioned modes can be taken as future research directions. Second, this study regarded trip chain choice as the first level and travel mode choice as the second. It was not considered whether the model effect would be better after structural priorities. In future research, NL models with different structures can be compared to explore the logical sequence of travel decisions. Thirdly, tourists' trip chains were simplified to static in this study. However, tourists will adjust their travel plans dynamically according to weather factors (such as rainfall), traffic conditions, and mood. These factors may influence tourists' bus route choice preference. Therefore, the dynamic impact of environmental and psychological factors on rural tourism travel behavior needs to be studied in the future.

5 Conclusions

1) Travel mode choice significantly affects tourists' choice of complex chains containing featured scenic spots, while bus route preference has a marked impact on private car use.

2) The choice probability of all trip chains can be improved with the increase in age and the decrease in travel days. Smaller-scale trips and fewer transfers will make

rural tourists more likely to choose trip chains containing featured scenic spots.

3) Self-driving is the preferred mode for tourism travel with longer distances and fewer transfers. When selecting buses, tourists have more transfers and fewer children traveling with them.

4) A longer bus waiting time is acceptable for tourists sensitive to the number of transfers; however, they are less tolerant of transfer waiting time. If economic cost is emphasized, tourists tolerate more bus travel time, transfer waiting time, and walking distance.

5) Policy implications from the perspective of private car travel management, bus operational efficiency, and service quality were proposed for counties like Lishui, Nanjing.

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考虑公交线路偏好的乡村游客出行行为

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摘要:为了探索游客出行行为机理并鼓励旅游公交的使用,实现乡村地区旅游需求与交通供给的动态平衡,基于出行链和出行方式选择分析了乡村游客的公交线路偏好. 利用 2021 年于南京溧水采集的 546 份乡村旅游调查数据,标定了以出行链模式为上层、旅游方式选择为中层、公交路线偏好为下层的 nested logit 模型. 研究结果表明:出行方式选择会显著影响游客对包含特色乡村旅游景点的复杂出行链的选择,选择私家车的游客对公交路线偏好的反馈较为明显;阐述了游客的社会人口属性、旅游出行特征和公交出行意愿对模型 3 个选择层次的影响. 最后,针对类似于南京溧水的地区提出了提高乡村旅游公交运营效率和服务质量的政策建议.

关键词:乡村旅游;公交线路偏好;出行方式选择;出行链;nested logit 模型
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