Study on the choice of transportation mode in Zheng-Jiao Transportation Corridor

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Abstract. In order to study travelers' choice of different travel modes, quantitative analysis of travelers' travel behavior preferences can effectively choose the most effective way to travel. Based on the influencing factors of travel mode, the safety index, economic index, speediness index and convenience index of the choice of travel mode are proposed. According to the principle of utility maximization, the multiple Logit model is used to calculate the sharing rate of each travel mode in the transportation channel. Taking the transportation passage from Zhengzhou to Jiaozuo as an example, this paper makes an empirical analysis to study the traveler's choice of intercity bus and intercity railway.

1. Introduction
Transport corridor refers to a dense corridor in which passenger and cargo transport is undertaken jointly by multiple modes of transport in a narrow and narrow area. When a new mode of transportation, such as high-speed railway, appears in the transport corridor, the original transport structure and pattern in the corridor will be broken, and then the sharing rate of various travel modes will be changed. Therefore, it is of great significance to study the travelers' choice of travel modes in the transport corridor to optimize the transport organization.

Nowadays, scholars at home and abroad have carried out extensive research on travel decision-making behavior, for example, Li Dawei [1] proposed a travel decision-making method based on utility maximization and Monte Carlo method. Rasoul [2] considered the influence of traveler's subjective preference on travel decision-making behavior, and based on the principle of subjective preference, discussed the application of Regret Theory in travel decision-making. Vos [3] considered the impact of travelers' satisfaction on travel choice decision-making, and studied the choice behavior of residents in Ghent city during leisure travel from the perspective of maximum satisfaction and maximum utility of travel mode. Zhu Hongguo [4] selected the economy, safety and convenience of travel mode as the variables of mixed utility function, took the maximum utility of travel mode as the decision-making basis, and combined with nested logit model, analyzed the choice behavior of travelers in Guangzhou Shenzhen transportation corridor. Ye Yuling [5] considered the influence of travelers' psychological latent variables on travel choice behavior, and took the time sensitivity, reliability and safety of travel mode as the variables of utility function, and combined with multiple logit model, analyzed travelers' choice behavior. Wang Wenxian [6] applied the nested choice behavior model to analyze the railway passengers' choice behavior towards different passenger transport products of ordinary speed railway.
The choice of travel mode is a typical multi-attribute decision-making problem. The traveler makes the decision index according to the service attributes and technical characteristics of each travel mode, and chooses the optimal way to travel with the decision principles of utility maximization, regret minimization, prediction satisfaction and so on.

Although many literatures use a variety of theoretical models to analyze the travel mode of travelers, most of them focus on short distance travel in the city or long-distance travel across provinces. In the choice of short distance travel in the city, most of them focus on time or economic utility due to the influence of the traveler's subjective purpose or intention. On the other hand, because of the influence of many factors, the travel utility of cross-provincial long-distance travel is widely concerned, especially for long-distance travel, although there is a competitive relationship between various modes of transportation in the process of travel mode selection. However, the study of inter-provincial travel choice in short and medium routes is easy to be ignored. Taking Zhengzhou —— Jiaozuo passenger passage as an example, considering all factors, such as proximity time, transit time and transfer time, intercity bus and intercity railway have strong game relationship. Therefore, the travel choice of the two modes in this passage is more comparable and more realistic.

Based on this, this paper takes the transportation channel from Zhengzhou to Jiaozuo as an example, analyzes the travel mode selection of the close-distance transportation channel, and applies a number of logit models to construct the travel mode selection model of intercity bus and intercity railway. According to the real operation data of the road network, the model parameters are calibrated and the influencing factors of different travel modes are analyzed. Finally, the utility values of intercity bus and intercity railway are compared, so as to clarify the influence of each selection characteristic index on passenger travel behavior choice.

2. Analysis of Influencing Factors of Travellers in Transport Channel

In order to solve the choice of transportation mode from Zhengzhou to Jiaozuo, the influencing factors of the choice behavior of travelers in the transportation channel are analyzed. There are many factors that affect the travel decision of travelers. Travelers will consider the service attributes and technical characteristics of each travel mode. Usually, passengers often consider whether the choice of travel mode is safe, the length of travel time and the comfort of the ride. Pay special attention to the economic cost, ticket price and discount of the train. Therefore, this paper selects safety, economy, speed and convenience as the four indexes to analyze the advantages and disadvantages of each travel mode.

Safety indicators. Taking the probability of accidents in a certain mode of transportation as a measure factor, the incidence of accidents in previous years can be queried through the network for the determined transportation channels.

Economic indicators. The economic cost of each travel mode can be obtained through the ticket office or the ticket purchase website, and the information of ticket price, discount and so on can also be obtained from the determined transportation channel.

Rapid indicators. The waiting time and in-car time of a certain travel mode are measured by the traveler's choice. For the definite transportation passage, the frequency and travel time of each travel mode can be obtained from the ticket office or the ticket purchase website.

Accessibility indicators. The ticket purchasing channel, arrival time, entry and exit time and waiting time of a certain travel mode are taken as the measurement factors.

According to the principle of choice of travel behavior index, combined with the research object and method, this paper intends to discuss the main factors affecting the choice of traffic mode, as follows.

2.1. Characteristics of travel agents

The study found that women usually travel more frequently than men for shopping, family care and other reasons, the distance and duration of single trip is shorter than that of men, and gender and age also have a significant impact on travel mode choice behavior. Some domestic scholars have also found that demographic characteristics, including gender and age, have an impact on the choice of intercity
travel mode, and believe that demographic characteristics affect the choice of various modes of transportation, including general speed trains, high-speed trains, high-speed trains and long-distance buses. However, most travelers are difficult to provide personal real information considering factors such as personal privacy security. The characteristics of travel subject include sex, age, education, income and so on. For us to compare intercity bus and intercity high-speed rail travel mode choice to provide a reference basis.

2.2. Travel characteristics
In order to achieve a specific purpose of life, travelers choose behavior by using different urban public transport modes to achieve this purpose. At present, with the rapid development of the city, the diversified public transport travel mode not only greatly satisfies but also indirectly stimulates the diversified travel demand of travelers. According to the analysis of traveler's travel behavior, the behavior of traveler's travel mainly has the derivative demand based on the purpose of travel, and the diversity demand caused by the individual differentiation of travelers. Pay attention to the specific needs of time and space elements. Residents guide different travel choices according to different travel needs.

Purpose of travel. Whether the purpose of travel has an impact on the choice of transportation mode is controversial. Zhang Rui [7] analysis in Beijing-Shanghai high-speed railway and civil aviation passenger travel choice points out that travel purpose has no significant impact on travel mode choice. Tian Sheng [8] took travel purpose and travel time as input variables and established a travel mode selection model based on deep neural network to realize effective prediction of passenger travel mode selection. Luan Xin [9] analysis that travel purpose has a significant impact on the choice of travel mode. We believe that the purpose of travel may affect the choice between high-speed rail and ordinary railway, but because the ticket data cannot obtain the information of travel purpose, we integrate the "Baidu index" data. The search index of business, leisure, home and other key words closely related to travel is taken as the agent variable of travel purpose, and the relationship between travel purpose and travel mode selection is revealed from the perspective of group, so as to test the choice of intercity railway and intercity bus.

Distance from travel.
Travel time limits.
Availability of various modes of transport.
Road congestion.
Accident rate.
Travel preferences.

Based on the above factors, residents will choose the mode of transportation to meet their travel needs to realize their travel needs, which can be called the decision-making process of travel choice. Therefore, according to the characteristics of travelers' travel behavior and the travel mode that the city can provide, and make full use of the decision psychology of travelers' travel, it provides a certain theoretical basis for travelers to choose the most suitable travel mode.

2.3. Characteristics of transport facilities

2.3.1. measurable factors
Travel time various ways of in-car time, waiting time, walking time, etc. The length of travel time determines the choice of travel mode. If the journey is within a few hundred meters, people usually walk, use bicycles a little farther, and choose cars or public transport. If the car user does not need to wait for the car, the walking time is short, but if the traffic jam occurs, the time in the car will be greatly extended. Such as the use of subway and other high-speed trains, walking time is longer, but fast. Usually, in cities with more developed high-speed railways, people prefer high-speed railways when they go to the center of the city because of road traffic jams and lack of parking lots. And go to the countryside, people mainly choose cars. Buses are rarely used because of fewer trains and traffic jams.

Related currency costs.
whether there are parking lots and parking fees. In the big cities of Japan, there are few parking lots in the center of the city and the fees are very high, so the people who choose public transportation to the center of the city are the most. In the countryside, there are free parking lots in large shopping malls, where people mostly use cars to go.

2.3.2. difficult factors to measure
Comfort and convenience in foreign countries, the competition between public transport and cars is very fierce, so the operators of public transport work hard in comfort and convenience, such as setting up air conditioning equipment in the car, automatic ticket checking and so on. People's choices are influenced to some extent by such factors.

Reliability and punctuality subway and so on because not affected by traffic jam, it can run completely according to the timetable, reliability and timing are better, people prefer to ride. Because of the influence of traffic jam, public transport is not very punctual, which to a large extent affects people's choice of it.

Protection and safety many people pay great attention to the safety of transportation. Although riding a scooter is fast and convenient, many people do not want or dare not use it because there is no protection, it is greatly affected by the climate and the safety is relatively poor.

3. Questionnaire Design and Model Development
Using the S P (Stated Preference) method to investigate the data, this paper designs a S P scenario example, each situation contains two travel modes of intercity bus and intercity railway. The cost, walking time and in-car time of these two travel modes are different. The respondents were asked to choose the most suitable travel mode and use orthogonal design to design the questionnaire. Among them, the safety index, economic index, rapidity index and convenience index of intercity bus and intercity railway are set up 5 grades. The scores corresponding to each grade from high to low are +5, +3, 0, -3, -5.

According to the above analysis, this paper studies the choice of two kinds of motorized travel modes: intercity bus and intercity railway. A number of logit models are used to construct the travel mode selection model of intercity bus and intercity railway.

According to the stochastic utility theory, assuming that the travel mode selection set faced by passenger n is C, the calculation formula of the utility function \( U_{in} \) for passenger n to choose the ith travel mode is as follows:

\[
U_{in} = V_{in} + \xi_{in}
\]

Type: \( U_{in} \) is the utility of passenger n choosing the ith mode of travel, \( V_{in} \) is the observed utility value of passenger n choosing the ith mode of travel, and \( \xi_{in} \) is the error term of passenger n choosing the ith mode of travel, assuming that the error term is independent and follows the Gumbel distribution.

It is generally assumed that \( V_{in} \) is a linear function of service level variable of the ith travel mode and individual characteristic variable \( X_{kin} \) of passenger n, and the calculation formula is as follows:

\[
V_{in} = \sum_k \beta_{ki} X_{kin}
\]

Type: \( \beta_{ki} \) is the parameter to be estimated about the specific preferences of individual n, and \( X_{kin} \) is the kth attribute that affects passenger n's choice of the ith travel mode.

On the basis of the principle of maximum utility, the probability of passenger n choosing the i mode of travel can be expressed as:

\[
P_{in} = \Pr [U_{in} > U_{jn}, \forall j \neq i \in C] = \frac{\exp(V_{in})}{\sum_j \exp(V_{jn})}
\]

Type: \( P_{in} \) is the probability for passenger n to choose train i. \( U_{in} \) is the utility for passenger n to choose the ith travel mode, and \( U_{jn} \) is the probability for passenger n to choose the jth travel mode.
4. csae analysis

The transportation channel from Zhengzhou to Jiaozuo is taken as an example. At present, the stable travel mode in Zhengzhou to Jiaozuo transportation channel is intercity public transport and intercity railway. In order to study the travel choice behavior of travelers, the author takes the direct passenger flow from Zhengzhou to Jiaozuo as the research object, and does not consider the exchange passenger flow between the transportation channels. The GDP and resident population of Zhengzhou in 2019 were 115.89 billion yuan and 10.12 million respectively, and the GDP and resident population of Jiaozuo was 234.28 billion yuan and 3.5601 million respectively. The actual intercity bus and intercity railway from Zhengzhou to Jiaozuo are divided into 27.59 and 72.41 respectively.

According to Multinomial Logit Mode, the utility functions of intercity bus and intercity railway are as follows:

\[ V_{1n} = \beta_1 X_{11n} + \beta_2 X_{21n} + \beta_3 X_{31n} + \beta_4 X_{41n} \]
\[ V_{2n} = \beta_1 X_{12n} + \beta_2 X_{22n} + \beta_3 X_{32n} + \beta_4 X_{42n} + \gamma \]  

(4)

Type: \( V_{1n} \) is the intercity bus utility function, \( V_{2n} \) is the intercity railway utility function, \( X_{ijn} \) is the data of each index, and \( \gamma \) is the error term.

Parameter calibration was carried out by using the constructed Multinomial Logit Mode.

\[ P_{1n} = \frac{\exp(V_{1n})}{\exp(V_{1n}) + \exp(V_{2n})} \]

(5)

Constructing linear regression equations.

\[ \ln \frac{P_{2n}}{P_{1n}} = \ln \frac{\exp(V_{2n})}{\exp(V_{1n})} = V_{2n} - V_{1n} \]

(6)

The linear regression equation can be obtained from (4)(5)(6) as follows.

\[ \ln \frac{P_{2n}}{P_{1n}} = \beta_1 (X_{12n} - X_{11n}) + \beta_2 (X_{22n} - X_{21n}) + \beta_3 (X_{32n} - X_{31n}) + \beta_4 (X_{42n} - X_{41n}) + \gamma \]  

(7)

According to the linear regression equation, the data of safety index, economy index, rapidity index and convenience index obtained by questionnaire survey of intercity bus and intercity railway are input, and then the model parameters are calculated by using linear regression analysis with the help of Python program language. The calculation results are shown in the table below:

| Serial number | Parameter value | Corresponding indicators |
|---------------|-----------------|--------------------------|
| 1             | \( \beta_1 \)   | 0.02192311               |
| 2             | \( \beta_2 \)   | -0.0003846               |
| 3             | \( \beta_3 \)   | -0.02192309              |
| 4             | \( \beta_4 \)   | 0.00038463               |
| 5             | \( \gamma \)    | 1.60104382               |

The utility values of intercity bus and intercity railway are calculated by (4), and the utility values of these two travel modes are compared.

Intercity bus :1.34808007
Intercity rail :2.31297135
According to the calculated utility values of intercity bus and intercity railway, passengers in the transportation corridor from Zhengzhou to Jiaozuo are more inclined to choose intercity railway. According to the analysis of indicators of speedability and convenience, the frequency of intercity railway is more than that of intercity bus, and the waiting time is less.

5. Concluding remarks
The diversified travel mode can meet the different needs of travelers, and it is of great significance to study the mode selection behavior of travelers in the transportation channel to optimize the passenger transport structure in the channel.

Firstly, this paper selects the transportation channel from Zhengzhou to Jiaozuo, divides the research object according to the travel survey data of Zhengzhou and Jiaozuo, summarizes the multiple variables that affect the travel behavior of passengers in Zhengzhou to Jiaozuo transportation channel, considers the influencing factors of passenger travel behavior selection in Zhengzhou to Jiaozuo transportation channel from four aspects: safety index, economy index, rapidity index and convenience index, then constructs a multi-item logit model based on utility maximization theory, and calibrates the model parameters by linear regression method. Get Zhengzhou to Jiaozuo channel passenger travel behavior choice specific law. The example analysis shows that the safety index and convenience index have a significant impact on the choice of passenger travel mode. The passenger travel in Zhengzhou to Jiaozuo transportation channel is more inclined to choose intercity railway. Combined with the calibration results of the parameters in this paper, the corresponding tendentiousness management measures and encouraging guidance policies can be taken.

Zhengzhou to Jiaozuo transport channels to encourage passengers to choose intercity railway travel. On the one hand, according to the travel demand, we should constantly improve the intercity railway network, optimize the road network design, and strengthen the management of intercity railway to ensure the smooth operation of intercity railway. In the rush hour, the departure interval is shortened and the number of intercity railway shifts is increased in order to better meet the travel needs of passengers. On the other hand, reasonable adjustment of fares, regular preferential discounts, considering the early peak before and after the late peak can travel at a more favorable price, so as to guide passengers to choose intercity railway travel through price advantages.

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