Contents List available at VOLKSON PRESS

Multidisciplinary Inclusive Education, Management and Legal Services (MIEMLS)

Journal Homepage: <https://topicsonsocialdevelop.com>

DOI: 10.26480/ismiemls.01.2018.04.06

ISBN : 978-1-948012-13-3

TRAVEL MODE CHOICE OF LONG-DISTANCE PASSENGERS

Xiangyu Jin¹, Chao Wang^{2*}, Wenli Hu³

¹Institute of logistics management and engineering, Zhuhai College of Jilin University, Zhuhai, China

²Department of Library, Zhuhai College of Jilin University, Zhuhai, China

³College of accounting and finance, Guangdong Polytechnic of Science and Technology, Zhuhai, China

*Corresponding Author Email: yhxy_2006@126.com

This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

ARTICLE DETAILS

Article History:

Received 26 June 2018

Accepted 2 July 2018

Available online 1 August 2018

ABSTRACT

This article analyzes the travel mode choice of long distance passengers. Several typical factors influencing the behavior of travel mode choice are put forward, such as generalized time cost, general transportation cost, security, success rate for buying tickets etc. Grouped income level of travelers is introduced into the developed logit model based on theory of utility maximization. Through an empirical investigation, we explore the reasonable strategies for different transportation modes.

KEYWORDS

Travel mode choice, division model, logit model, theory of utility.

1. INTRODUCTION

Owing to the first high-speed railway operated in 2008, competition between civil aviation and high-speed railways become more fiercely, especially in the medium to long distance market. Since passengers have more chances to choose a prefer travel mode, competition relationship between different travel mode has been a popular topic. Especially in recent years, it has been widely studied.

Visitors travel mode selection method based on travel cost was proposed and tested by Saad [1]. Chaug-Ing Hsu proposed a model to analyze market share distribution between high-speed and conventional rail services in a transportation corridor [2]. Work of studying disaggregate travel demand models has taken place since the 1960s', Richard Barff et al. mentioned the majority of research on modeling the mode-choice process [3]. Many models are available to handle mode-choice problems, but three have dominated in this literature: logit models, probit models and discriminant models. Logit models have been widely applied, ease of estimation is the reason. But its character of IIA makes it limited in application. Numerous efforts have tried to improve the model [3-5]. Lots of scholars put forward a series of improvements on logit model, such as NL model, GNL, photo, etc [4, 6]. However, the above models were too difficult to solve, and did not fully consider the practical reality decision-making factors.

With the rapid development of high-speed railways, there is a more concern over the competitive relationship between civil aviation and high-speed railways. In this paper, we present an improved logit model to estimate market share distribution in an individual behavior point of view. Our subsequent discussions focus on the following aspects:

- 1) Updating the conception and algorithm for the factors that affect passengers' traffic choice decision. Introduce revenue into the factors by calculating them in grades.
- 2) Improving the utility functions and logit model to make the result closer to reality.
- 3) Parameters of the model are calculated by using maximum likelihood estimation.

The high-speed rail contributes a new option to people, and also affects the structure of passenger transport. Study on the competitive relationship between high-speed railway and air transport, in order to realize the win-win cooperation between them and build a reasonable allocation of resources.

2. FOUNDATION OF MODEL

Improved model of travel choice in this paper is based on the theory of utility maximization. This theory has a basic assumption: Passengers are "rational economic man", which means the travelers under certain constraints such as social conditions, economic conditions etc., always choose to make their own utility maximized. We specify foundational model as follows:

$$U_{ig} = V_{ig} + \varepsilon_{ig} \quad (1)$$

As is shown in equation (1), U_{ig} is the total utility when decision maker g choose option i; V_{ig} means the observable utility when decision maker g choose option i; ε_{ig} is random disturbance when g choose i.

$$V_{ig} = \sum_{i=1}^n \theta_{ig} X_{ig} \quad (2)$$

X_{ig} refers to the observable characteristics cause g to select and θ_{ig} means parameter of observable utility when g choose i. According to theory of utility maximization, travelers will choose travel mode i if the utility of mode i is greater than mode j. The formula can be expressed as(3).

$$V_{ig} + \varepsilon_{ig} > V_{jg} + \varepsilon_{jg} \quad (3)$$

Then we can obtain P_{ig} , the probability when passenger g choose travel mode i, which is presented as (4).

$$P_{ig} = P\{\varepsilon_{ig} \leq \varepsilon_{jg} + (V_{ig} - V_{jg})\} \quad (4)$$

The general form of (4) can be expressed as (5). The value of k ranges from 1 to n.

$$P_{ig} = \frac{\exp[U_{ig}]}{\sum \exp[U_{kg}]} \quad (5)$$

The logit model based on utility maximization theory has caused more attention in area of travel mode choice. We will establish a developed model in the next section.

3. MODEL DEVELOPMENT

3.1 Notations

Before establishment of the developed logit model, related notations are defined as follows.

- V_k observable utility of travel mode k
- T_k generalized travel time of travel mode k
- t_{k1} one-way travel time of mode k
- t_{k2} city travel time of mode k
- t_{k3} delay time of mode i (time of going in and out the station)
- w_k delay rate of mode k
- C_k generalized travel cost of travel mode k
- A_k security of mode k
- S_k accident rate of mode k
- L_k successful rate of buying ticket for mode k
- a_k 、 b_k parameters to be estimated
- φ_h time value coefficient
- $\overline{GDP_h}$ per capita gross national product for city h
- D number of working days for one year (Data based on 2015)

3.2 Influencing Factors Analysis

Numerous factors affect the travel mode choice of passengers, their behavior may be influenced by several internal and external factors.

- 1) Internal elements include the individual preference, such as personalities, wage level and travel purpose of passengers.
- 2) External items relate to the characteristics of different transport modes, such as safety, economy, speed ,etc.

According to the data based on survey in this article, age, sex, occupation elements have few effects on travel choice, so we do not choose these items in this paper. The following factors mainly take into account.

3.2.1 Generalized travel time

We use the generalized travel time rather than one-way trip time. General travel time includes one-way travel time, city travel time and delay time for different mode choice, which is shown in (6).

$$T_i = \frac{t_{i1} + t_{i2} + t_{i3}}{w_i} \quad (6)$$

3.2.2 Travel cost

C_i is the travel cost of mode, based on one-way ticket price which airfare includes fuel surcharge. City travel cost can be ignored in this paper because we focus on the long-distance travel.

3.2.3 Security

Security is one of the most important factors in mode choice. It is inversely proportional to the accident rate, which is presented in (7). We use the accident statistics' data since 2008, when the first high-speed railway was opened to traffic.

$$A_i = \frac{1}{1 + S_i} \quad (7)$$

In addition, we introduce the success rate of buying ticket L_i as a significant influencing factor. Because passengers will choose another travel mode while they fail or have difficult to buy ticket.

3.3 Improved Model

Previous literature often use "additive model" based on time, cost et al. However, some influencing factors, such as security, its relationship with the final utility is not simple addition. When travelers consider a kind of mode is not safe enough, the probability of choosing this mode will decline exponentially. Therefore, the problem is formulated as a "division model", shown in (8).

$$V_k = \frac{a_k * C_k + b_k * T_k}{A_k * L_k} \quad (8)$$

Owing to the difference of measuring unit between generalized travel time and travel cost, we use time value coefficient φ_h to convert cost and time into the same unit.

$$\varphi_h = \frac{\overline{GDP_h}}{8 * D} \quad (9)$$

4. EMPIRICAL ANALYSIS

As discussed above, the factors that affect mode choice of long-distance passenger also include age, gender, income, travel purpose, etc. For instance, lower income passengers are more sensitive with cost rather than travel time. So income of travelers is taken into consideration. The corresponding time value will be different, due to different income. It can be introduced in (9).

We use the actual data of Beijing-Guangzhou route to calculate in this study. For convenience of calculation, we can classify the income level. According to the questionnaire, revenue can be divided into the following grade, which is shown in table 1.

Passengers whose monthly income between three thousand and five thousand are divided into grade I₁.

Table 1: Parameter Calibration

Grades	Monthly income level
I ₁	0<Income<3000
I ₂	3000≤Income<5000
I ₃	5000≤Income<9000
I ₄	Income≥9000

From table 1, we classify the income level of passengers travelling through Beijing-Guangzhou route into four grades. Travelers for different income level have diverse select probability of transportation modes, which can be seen in table 2.

Table 2: Travel Mode Choice Ratio (%)

Grades	Typical Travel modes of long distance passengers			
	Aviation	High-speed railway	Ordinary railway	Other modes
I ₁	0.26	0.12	91.1	4.74
I ₂	20.8	10.7	66.7	1.8
I ₃	40.3	21.5	28.2	1
I ₄	43.5	53.5	2	0.28

According to table 2, we can conclude that civil aviation, high-speed railway and railway play a significant role in long- distance travel. Owing to the limitation of adjustment space in speed and fare, we will ignore common railway in this paper and focus on the study of high-speed rail and air.

4.1 Parameter Estimation

As we can see from table 1, traveler can be divided into four types according to income level. For each type, we give the same weight to travel

time and cost. We introduce the different income grade into formula (4) separately to calculate the time value coefficient. Then the maximum likelihood estimation is used to obtain the parameter estimation results in table3. We ignore the grade I_1 due to the low probability of choosing high-speed and air.

Table 3: Parameter Calibration

Grades	Parameters		
	a	b	ε
I_2	-0.0506	-0.043	2.98E-10
I_3	-0.0473	-0.126	1.13E-06
I_4	-0.0163	-0.323	1.78E-05

It can be seen in table3, passengers for different income level have different consideration of travel time and cost. With the increasing of income level, influence of travel time on passengers has increased, but the sensitivity of the generalized cost presents a downward trend. This phenomenon means that travelers with higher revenue have more emphasis on time, but little attention to travel cost.

4.2 Sensitivity analysis

This article will discuss how the share rate of high-speed railway and aviation changes, when several factors are altered.

4.2.1 Changing the ticket price

Inputting parameters into logit model, the share rate of high-speed rail and aviation can be obtained. Making a little change in ticket price: high-speed railway decreases the ticket price by 10%, the share rate increases about 0.3%; And air fares reduced by 10%, share rate rise about 0.7%. The change performs more significant for travelers belonging to income grade of I_2 and I_3 .

4.2.2 Changing the ticket price

Statistic show that successful rate of buying high-speed railway's ticket is about 88%, and the aviation is about 98%. If the rate of high-speed railway rises to 98%, probability of buying railway ticket will increase nearly 5% for passengers in grade I_4 . It means that improving the rate of high-speed railway is an important measure to promote the share rate.

5. CONCLUSION AND FUTURE RESEARCH

This paper presents an improved logit model to estimate market share distribution in an individual behavior point of view. We are updating the conception and algorithm for the factors that affect passengers' traffic choice decision. Introducing revenue into the factors by calculating them in grades. Improving the utility functions and logit model to make the result closer to reality. Analyzing how share rate between high-speed and

aviation altered, when changing the influencing factors. Conclusions based on empirical data are obtained as follows:

Passengers with different income have different considerations in travel mode choice. With the increasing of income level, the influence of travel time on passengers has increased, but the sensitivity of the generalized cost presents the downward trend. Therefore, different marketing strategies can be taken in airlines and railway departments according to different income range of passengers. For instance, railway departments can increase high-speed railway service at night, in response to high income group which prefers time saving, etc. For high-speed railway, improving the success rate of buying tickets is more critical than reduce price. It calls the railway departments to update the web server, simplified buying process and broaden the way of buying tickets to enhance competitiveness. For airlines, ticket discounts is a vital measure to improve its share rate. For cost sensitive travelers, airlines could carry on promotion irregularly. But it needs to discount according to the different time, travel distribution and revenue of passengers.

In this study, graded income is taken into consideration as an important influencing factor. In the future research, personality of passengers, traveller's preference and policy factors will take into account. Furthermore, the article estimates market share distribution in an individual behavior point of view, which will be extended to aggregate level.

ACKNOWLEDGMENTS

This paper is supported by the project fund: 2017 youth innovation talents project of Guangdong education department (2017GWQNCX015)

REFERENCES

- [1] Saad, N., Aljarad, Black, W.R. 1995. Modeling Saudi Ara-bia-Bahrain Corridor Mode Choice. *Journal of Transport Geography*, 3 (4), 257–268.
- [2] Hsu, C.I., Chung, W.M. 1997. A model for market share distribution between high-speed and conventional rail services in a transportation corridor. *The Annals of Regional Science*, 31 (2), 121–153.
- [3] Petersen, E.R. 2002. A highway corridor planning model. *Transportation Research Part A*, 36 (2), 107–125.
- [4] Piet, R., Vanessa, D. 2004. Determinants of bicycle use: do municipal policies matter. *Transportation Research Part A: Policy and Practice*, 38 (7), 531–550.
- [6] Juan, L., Jinxian, W., Chunfu, S., Hongwei, G. 2016. Cluster-Based Logistic Regression Model for Holiday Travel Mode Choice, In *Green Intelligent Transportation System and Safety*. *Procedia Engineering*, 137, 729–737.
- [5] Yannis, T., Constantions, A. 2008. Public transit user satisfaction: Variability and policy implications. *Transport Policy*, 15 (7), 197–208.