

An Analysis on Commuting Travel Time Reliability: A Case study in Beijing

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Abstract: Based on the AFC data of Beijing metro, this paper analyzes the travel time distribution and reliability of subway commuter travel. This paper first analyzes the OD commuter travel time distribution by combing a large amount of actual data. The results indicate that the OD commuter travel time distribution follows the Lognormal distribution. Then the paper analyzes the applicability of travel time reliability evaluation index, which shows that the Buffer time index is suitable for evaluating the reliability of subway OD travel time.

1 INTRODUCTION

With the rapid development of China's subway industry, People's travel requirements include not only comfort, convenience, economy and security, but also increase the accuracy of travel time, especially commuters. They are more demanding on travel time reliability.

In previous works, the research on the reliability of the travel time mainly focuses on the urban road network, and there are relatively few studies on the reliability of the OD between the metro stations. Commonly, the evaluation indexes of the reliability of the travel time of the road network include the reserved time index, the planned time index and the 95% time. At present, there is a lack of evaluation index suitable for evaluating the reliability of travel time of subway OD.

Therefore, this research takes Beijing metro OD as the research object and Combine AFC data to study the distribution rule of OD travel time. Based on the reliability evaluation index of road network travel time, through the index applicability analysis, Select the appropriate indicators for evaluating the reliability of subway commute travel time.

2 OVERVIEW OF COMMUTER TRAVEL TIME RELIABILITY

2.1 Definition

Subway travel time means the time passenger spend on the process from credit card into the station into credit card off the station. Travel time components includes the pit stop walking time, platform waiting time, in the car time, outbound travel time form. If need to transfer, plus travel time, transfer station waiting time, etc.. Commuter passengers before the trip have the psychological expectations of the time required, and set aside a certain period of time. The time reserved by passengers is called planned travel time.

Travel time reliability is the probability that a traveler will be able to travel successfully during a scheduled travel time and may also indicate the percentage of passengers who have successfully completed their travel during the planned travel time.

2.2 Probability distribution model of commuting travel time

OD commuter travel time probability density distribution in the form shown below, it can be divided into three stages, the first stage $a \sim b$ travel time increases, the corresponding probability increases gradually until the probability of b maximum. In the second stage, the probability of $b \sim$

c gradually decreases, which is symmetrical with that of the first stage about $x = b$. The third phase $c \sim d$ probability is at a relatively low value and is still decreasing. According to the characteristics of probability density distribution of OD travel time, we assume that its distribution obeys normal distribution and logarithmic normal distribution, and performs curve fitting and test.

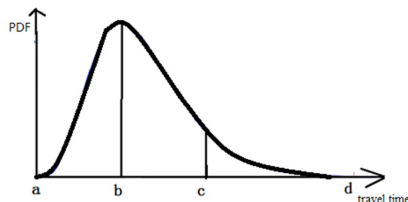


Fig. 1. OD travel time actual probability density distribution

The data source in the study is the AFC data of full network include the morning rush hour from March 16 to March 20, 2015. The AFC system provides detailed passenger travel information, extracts each passenger's arrival and departure stations and the time of inbound and outbound credit card.

According to the probability density function of normal distribution and lognormal distribution model and distribution model hypothesis testing method, the fitting procedure of commuting travel time distribution model is as follows:

Step1: Take a single OD pair of commuting time as a general, data preprocessing. Draw a histogram of commuting travel time distribution, and conduct a preliminary analysis of the probability distribution characteristics of OD travel time.

Step2: Using the cftool fitting toolbox in MATLAB, we can obtain the probability density function image and parameter μ, σ of OD commute travel time after the commuting travel time of the OD pair is respectively normalized and logarithm normal distribution curve fitting.

Step3: Use the goodness of fit parameters SSE and R2 and other statistical indicators and P-P map, travel time empirical distribution function chart and the probability distribution chart to compare the differences to test the rationality of the distribution model assumptions.

Through a large number of ODs, the actual data of commuter travel time verifies that 98% of OD commuting trips are logarithmically normal. Therefore, it can be assumed that the probability distribution model of OD commuting travel time is lognormal distribution, which is:

$$T \sim \ln N(\mu, \sigma^2) \tag{1}$$

$$f(T) = \frac{1}{T\sigma\sqrt{2\pi}} \exp\left(-\frac{(\ln T - \mu)^2}{2\sigma^2}\right) \tag{2}$$

(T)Represents OD Excursion Travel Time,

where μ and σ^2 represent the expected value and variance of the logarithm of travel time respectively.

3 COMMUTER TRAVEL TIME RELIABILITY EVALUATION INDEX SYSTEM

Travel time reliability evaluation indicators can be divided into mathematical statistics based on indicators, and based on probability travel time class indicators. The evaluation index based on mathematical statistics mainly describes the degree of variation of travel time and the degree of dispersion of distribution. Based on the historical travel time data, the evaluation index based on the probabilistic travel time class describes the uncertainty of travel time and is relatively close to the actual feelings of passengers.

3.1 Travel time reliability evaluation index

The evaluation indexes based on mathematical statistics include the mean value, standard deviation, variance and the like. The evaluation indexes based on probabilistic travel time class include planned travel time (PT), planned travel time index (PTI), buffer time (BT), and buffer time index (BTI).

Planned travel time (PT) indicates the estimated travel time for the passenger when traveling. General 95% travel time said. Reflects the vast majority of passenger travel time required. The planned travel time index (PTI) is a measure of the ratio of planned travel time to median to assess the planned travel time for different OD pairs. The larger PTI is, the lower the reliability of travel time is. Where: TT_{95} Represents 95% of travel time; TT_{50} Represents the median travel time.

$$PT = TT_{95} \tag{3}$$

$$PTI = \frac{TT_{95}}{TT_{50}} \tag{4}$$

The buffer time (BT) indicates the amount of time a passenger must reserve in order to travel on

time. The buffer time exponent (BTI) expresses the ratio of buffer time to median as a percentage to evaluate the buffer time for different OD pairs. The greater BT and BTI are, the lower the reliability of travel time is.

$$BT = TT_{95} - TT_{50} \quad (5)$$

$$BTI = \frac{TT_{95} - TT_{50}}{TT_{50}} \quad (6)$$

In Section 2.2, it has proved that OD commuting travel time obeys lognormal distribution, so all the reliability evaluation indicators of travel time are based on lognormal distribution. The following is a derivation based on the logarithmic normal distribution of travel time reliability formula:

$$Mean = \exp(\mu + 0.5\sigma^2) \quad (7)$$

$$PT = \exp(\mu + 1.645\sigma) \quad (8)$$

$$PTI = \exp(1.645\sigma) \quad (9)$$

$$BT = \exp(\mu)[\exp(1.645\sigma) - 1] \quad (10)$$

$$BTI = \exp(1.645\sigma) - 1 \quad (11)$$

3.2 Commuter Travel Time Reliability Evaluation Index Applicability Analysis

(1) Evaluation of reliability of each travel time in different periods of evaluation results

In the process of selecting the appropriate evaluation index of the reliability of the travel time of the subway, although the indexes have different measurement scales, the reliability of the travel time should be consistent. The figure below shows the travel time of one OD in each day of the day Travel time reliability evaluation bar chart As can be seen from the figure, the trend of all the reliability indexes are basically the same, only some indexes magnify the reliability of time periods with less reliable reliability and reduce the reliability measures with better reliability periods so that the reliability of different time periods The level of reliability is more obvious.

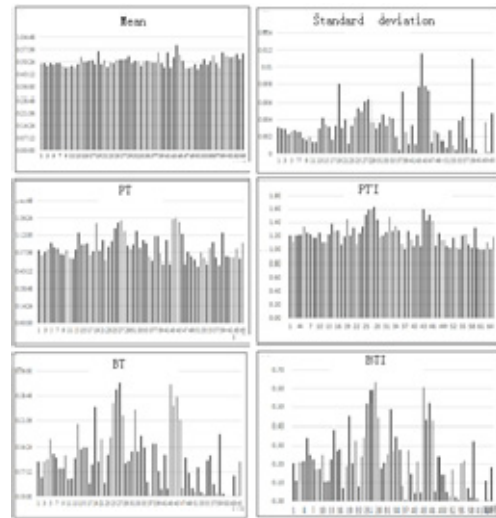


Fig. 2. reliability evaluation index of different travel time in a certain day of OD

Obviously, the average travel time of the same OD changed more smoothly and the variance changed a lot. The planned travel times and indices have also been changing steadily during the day. The buffer time and index can be very intuitive to reflect the reliability of travel time changes over different periods of time.

(2) Comparison of reliability evaluation index of different travel time for different OD evaluation

The purpose of this chapter is to select all of the reliability evaluation indicators that can objectively evaluate the reliability of different OD travel time. Randomly select a number of OD, according to the average travel time from small to large sorting OD traffic weekday travel time data obtained from the calculation of the reliability of travel time bar chart. As can be seen from the figure, when the mean and planned travel time are used to evaluate the reliability of multiple OD commuter travel times, it is impossible to directly compare the reliability levels and is used to describe the reliability of OD travel time alone. The standard deviation, the planned travel time index, the buffer time and the buffer time index can all be used to compare the reliability of OD travel time, but the effect is obviously different. Among them, the planned travel time index fluctuated less, and the evaluation result was slightly worse. Therefore, choosing the buffer time and buffer time index as the evaluation index of commuting time reliability can directly compare the reliability of different OD commuter travel time. Considering the influence of avoiding the mean value of travel time on the reliability evaluation, this paper chooses the buffer time index as the

evaluation index of commuting time reliability finally.

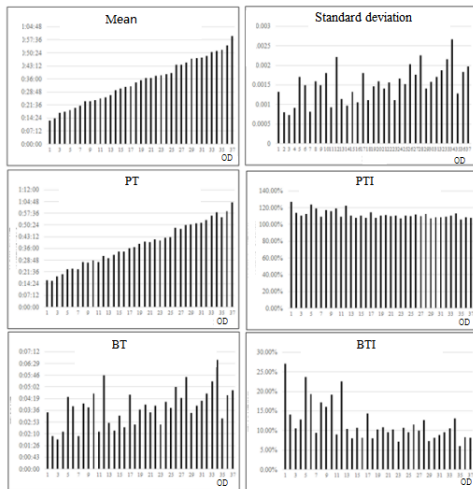


Fig. 3. reliability evaluation index of different OD commuter travel time and travel time

4 CONCLUSIONS

In this paper, According to the index applicability analysis, we select the indexes that are suitable for the evaluation of the subway commuter travel time reliability and finally choose the BTI as the evaluation index of the subway commuter travel time reliability.

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