Influence of Travel Information on Choices of Inter-city Travel Modes

A Case Study of Shanghai-Nanjing Transport Corridor

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Abstract—**Multimodal travel information is expected to affect people's choices of travel modes. The objective of this research is to identify the impacts of travel information, specifically for travelers traveling between cities along Shanghai-Nanjing transport corridor in Yangtze River Delta. Firstly, data gleaned from a questionnaire survey, which investigated information preferences when travelling between cities along the Shanghai-Nanjing high-speed railway, is statistically analyzed. The analysis explores correlations between travelers' attributes, typical travel modes and information requirements at different journey stages. Travelers' occupations and travel purposes turns out to be significantly relevant to traveler information. Secondly, a Multinominal Logit (MNL) model is established and calibrated by the multi-log logistic in SPSS. Thus the influence of travel information on travel-mode choices can be investigated with constraints of travelers' socio-economic attributes, travel attributes, and journey stages. Finally, the results show that travelers with various occupations and travel purposes have varying needs for multimodal travel information, and inter-city travel mode choices can be impacted by multimodal travel information at different levels.**

Keywords— transport corridor; inter-city travel; information service; travel mode; Multinominal Logit Model (MNL) Introduction

I. INTRODUCTION

A well-developed transport corridor in urban agglomeration has to face tremendous inter-city travels, and intensively requires a multimodal transportation system that is informative and convenient, providing high-frequency and high-capacity services [1]. One of the core functions of such system is travel information service, which provides sufficient information that enables travelers to make appropriate decisions consistent with traffic managers' expectations [2-4]. It helps to balance supplies and demands of individual facilities within a multimodal transportation system, therefore improves efficiency and reliability of inter-city travels [5].

As travel information is getting ubiquitous and easier to access, empirical evidence suggests that the influence of multimodal traveler information on inter-city travel modes is accordingly increasing. Hu et al utilized the Nested Logit model and proved that the multi-modal bus information service can effectively divert travelers from cars and other private vehicles to the bus system and thus improve the proportion of bus travels [6]. Khattak et al. analyzed the results of a travel survey on residents in the San Francisco Bay Area and concluded that travel mode is less sensitive to traveler information than travel time and route [7]. Mahmassani et al. found out that induced information has different effects on travel mode choices of different purposes among different groups, and that the information required by non-commuters without time limits is quite different from that by commuters [8]. Most previous works focused on experimental evidences and seldom emphasized on theoretical analyses. Despite those convincible outcomes, the principle of how travel information impacts traveler behaviors is still unclear, and what kinds of traveler information people really want still needs more attention. Therefore, this paper is to develop a method to model the impacts of multimodal traveler information on travelers' choices of inter-city travel models.

II. DEFINITION OF INTER-CITY TRAVEL

In this paper, inter-city trips are categorized as traveling by private cars and traveling by public transit. A journey on the latter can be divided into three stages: pre-transit, trunk-transit and post-transit [9], where pre-transit and post-transit are transportations in the departure city and the arrival city, respectively, while trunk-transit means the part between the two cities. Three stages of typical multimodal inter-city travels in an urban agglomeration are shown in Table 1.

TABLE I. THREE-STAGES OF MULTIMODAL INYERCUTY TRAVELS

pre-transit	trunk-transit	post-transit
metro bus car taxi	High-speed train train coach	metro bus taxi
car		

III. QUESTIONNAIRES

To better understand the relationships between travelling information and travelers' choices, we conducted a survey targeting travelers on inter-city trips between cities along the Shanghai-Nanjing high-speed railway due to the limitations of survey samples. The questionnaire combines RP (Revealed Preference) and SP (Stated Preference) [10], concerning personal attributes, travel conditions, major transportation options and required travel information at different situations. Personal attributes include gender, age, occupation, income, and whether a traveler possesses a car. Travel conditions regards

origins-destinations (OD) of trips, usage of traveler information, and factors that may affect travel modes.

Potential respondents are divided into two categories with different contents: one is for those who drive cars throughout their whole trips, and the other is for those who choose public transit. For those driving cars, items such as purpose of travel, source of information, time of enquiry, and what requirement for information during planning/actual travel are surveyed; while for those choosing public transit, items such as source of information, transportation and required information at three different stages of a journey are investigated. Respondents should also conform to the following criteria: ①They live in the Yangtze River Delta and have one or more inter-city travel experiences between cities along the Shanghai-Nanjing high-speed railway; ②They age between 18-60; ③They care about traveler information when travelling.

Questionnaires were distributed at Shanghai Long-distance Bus Station (Terminal Station), Shanghai Hongqiao Railway Station and the other stations along Shanghai-Nanjing Railway during January-March, 2018. And we also conducted an online version at the same time. We received 1096 responses, and 665 of them were valid.

IV. DATA ANALYSIS

Among those 665 respondents, the ratio of male to female was close to 4:5; 67% of them aged between 25-50; 72% earned more than 3,000 RMB a month; about 68% of them owned at least one car; and students, professionals, public officials and service personnel accounted for a large proportion.

Table II indicates that travelers of different occupations concern various factors. Students and service staff pay more attention to travel expenses, travel time and convenience; while professionals and public officials value travel time, convenience and comfort more than expenses. Further, public officials take safety more seriously than others do.

TABLE II. THREE-STAGES OF MULTIMODAL INYERCUTY TRAVELS

Factor	Average Composite Score			
	Student	Professional	Service personnel	Public official
Expense	4.39	2.75	3.89	2.71
Time	3.9	3.85	3.62	3.88
Convenience	3.84	3.99	3.28	3.73
Comfort	2.85	3.12	2.4	3.35
Safety	1.97	2.23	2.05	2.97
Others	0.07	0.06	0.03	0.01

*Note: Respondents were asked to sort the six factors in order of their attentions. The average composite score was calculated based on their orders. It reflects the overall ranking of the factors. The higher the score, the higher the overall ranking. The calculation method is: average comprehensive score for a factor = (Σ frequency × weight) /number of responses for this question. The weight is related to the ranking of the factors.

Besides personal attributes, we assumed that purpose of a trip were also a function factor affecting travel mode choice. Thus, we carried out a Pearson correlation test to investigate relationships between personal socio-economic attributes,

purpose of travel, information received during trip preparation and travel modes. Since the results demonstrated that not all socio-economic attributes have significant correlations with received information, we chose "occupation" and "purpose", the most related ones, and respondents who were students, professionals, service personnel, and public officials for further analysis.

Thus, we found out that most students' purposes of inter-city travel were visiting relatives and friends, and for tourism (as shown in Figure I; professionals were most likely for tourism and business (as shown in Figure II); service personnel traveled most for vacation and commuting (as shown in Figure III); and public officials were mainly for business purpose (as shown in Figure IV).
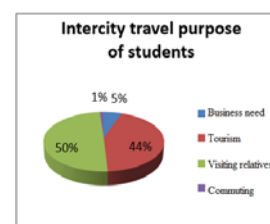

FIGURE I. DISTRIBUTION OF STUDENTS' INTER-CITY TRAVEL PURPOSE

FIGURE II. DISTRIBUTION OF PROFESSIONAL AND TECHNICAL PERSONNEL'S INTER-CITY TRAVEL PURPOSE
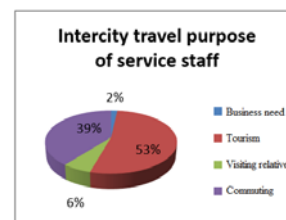

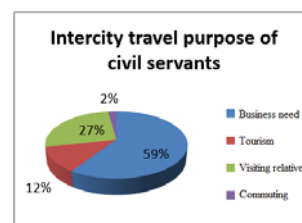FIGURE III. DISTRIBUTION OF SERVICE STAFF'S INTER-CITY TRAVEL PURPOSE

FIGURE IV. DISTRIBUTION OF CIVIL SERVANTS' INTER-CITY TRAVEL PURPOSE

Therefore, we obtained 7 groups of respondents for modeling: (1) students traveling for visiting relatives and friends, (2) students for tourism, (3) professionals for tourism, (4)

professionals for business, (5) service personnel for tourism, (6) service personnel for commuting and (7) public officials for business. Since traveling by private cars is not suitable for our model, it is not the focus of this study.

V. MNL MODEL

First, a single travel mode choice is concerned. A_n is the set of travel mode options , then the total utility U_{ni} of the i-th travel mode alternative can be expressed as[11]:

$$U_{ni} = \sum_k \beta_{ki} f \left(X_{ni}^k \right) + \varepsilon_{ni} \tag{1}$$

Second, a binary indicator W_{ni}^k is introduced to describe the closeness of between the traveler and the information environment. W_{ni}^k can be either 0 or 1. When $W_{ni}^k=0$, traveler n does not receive the k-th information W_{ni}^k when selecting travel mode i; and vice versa when $W_{ni}^k=1$. Thus, W_{ni}^k can be considered as the extent to the closeness of traveler n with the information environment when selecting travel model, and expressed as [12]:

$$W_{ni} = \sum_k^K W_{ni}^k \tag{2}$$

The closeness between traveler n and the information environment can be simplified as the number of types of received information, so W_{ni} falls within [0, K]. When $W_{ni}=0$, the traveler does not receive any relevant information; when $W_{ni}=K$, the traveler has fully understood all information when making a decision.

Third, travelers' occupations and travel purposes are taken into consideration, as our survey indicated that the two factors are the most correlated factors with respondents. Travelers can be classified according to the two factors. Thus, the travel mode selection utility of different categories of travelers is calculated, and then the observable utility of the traveler can be expressed as:

$$V_{ni}(\text{Occupation, Travel Purpose}) = ASC_{ni} + \beta_W W_{ni} + \sum_{k=1}^K \beta_I^k I_{ni}^k + \sum_{k'=1}^{K'} \beta_X^{k'} X_{ni}^{k'} \tag{3}$$

where ASC_{ni} is the selected limb intrinsic constant, indicating the unobserved utility mean value which is unique to the selected limb; I_{ni}^k indicates the related information variables, and the number of them is K; $X_{ni}^{k'}$ is the characteristics of the travel mode itself, and there are K' of them; $\beta_W, \beta_I^k, \beta_X^{k'}$ are the parameters to be calibrated corresponding to $W_{ni}, I_{ni}^k, X_{ni}^{k'}$, respectively.

Therefore, the probability that traveler n chooses the i-th travel model

$$P_{ni} = \frac{exp(V_{ni})}{\sum_{j\epsilon A_n} \exp(V_{nj})} \tag{4}$$

In this paper, SPSS statistical software is used to calibrate the model by involving "other types" as a reference. SPSS multi-value logistic regression analysis is utilized to obtain the parameter results.

According to statistical theory, when degree of freedom is 1 and confidence α equals 0.05, the critical value of Wald is 3.841. When Wald is much larger than 3.841, the independent variable is considered to be significantly correlated with the dependent variable; when Wald is slightly smaller than 3.841, the independent variable has a small effect on the dependent variable; when Wald is fairly smaller than 3.841, the independent variable is completely independent from the dependent variable. When the result of the calibration parameter is negative, the increase of the variable value has a side effect on the utility function. The higher the value of the variable, the larger the side effect, and the smaller the probability of selecting such a transportation mode. Based on this theory, the calibration results of the parameters are analyzed and summarized. The following tables list the results for students traveling for tourism.

Based on the results of the calibrating model parameters, we can draw the following conclusions:

- When students travel for tourism and vacation, their choices of travel modes are significantly affected by ticket information, weather, estimated travel time and estimated travel cost, while barely influenced by traffic conditions. When they choose connecting mode in departure cities, they tend to ignore waiting time but pay more attention to weather forecasting, road condition information, transfer information, expected travel time and estimated travel expenses. When they choose connecting mode in destination cities, waiting time turns out to be more noticeable, while traveler information becomes less important; meanwhile, weather information, estimated travel time and travel expense still matter. The word "data" is plural, not singular.

- When students travel for visiting relatives and friends, their travel choices are significantly affected by the ticket information, traffic conditions, estimated travel time and estimated travel cost, while weather information can barely influence them. When they choose connecting modes in both origin and destination cities, they are more inclined to concern waiting time, transfer information, estimated travel time and the estimated travel expenses than weather and traffic conditions.

- When professionals travel for tourism and vacations, their choices of travel modes are more likely to be affected by ticket information, traffic and weather conditions, as well as travel cost; while expected travel time has no significant impact. When they choose connecting vehicles in origin cities, they emphasize on weather, traffic, transfer information and travel expenses, while barely notice expected waiting time and

estimated travel time. When they choose travel mode in destination cities, they shift to value waiting time and estimated travel time and keep weather information, transfer information, and travel expenses as significant factors, while ignore traffic conditions.

- Professionals' choice behaviors are significantly affected by ticket information, weather, traffic conditions, and estimated travel time when they start for business trips, while expected travel expenses have no significant impact. When they choose vehicles in origin and destination cities, waiting time, weather, traffic conditions, transfer information and estimated travel time have significant impact, but travel cost barely function.

- Service personnel's choices are significantly affected by ticket information, weather, estimated travel time and estimated travel cost when they travel for tourism, while traffic conditions have no significant impact. When they choose travel modes in starting and ending cities they are more likely to be affected by waiting time, weather, transfer information, estimated travel time and estimated travel cost, but traffic conditions has no obvious influence.

- When service personnel travel for commuting, they barely notice ticket information and their choices are more likely to be affected by weather, traffic conditions, estimated travel time and estimated travel cost. When they choose connecting transportation in origin and destination cities, their choices are influenced by waiting time, transfer information, estimated travel time and estimated travel expenses, while weather and traffic conditions information have no significant effect.

- When public officials travel for business, their choices are significantly affected by ticket information, weather, traffic conditions and estimated travel time, while estimated travel expenses have no significant impact. When they choose connecting modes in origin and destination cities, estimated waiting time, weather, traffic conditions, transfer information and estimated travel time have significant influence, but estimated travel cost information barely matter.

VI. CONCLUSIONS

We investigated the influence of travel information on people's travel mode choices when they are traveling between cities along the Shanghai-Nanjing high-speed railway within the urban agglomeration in Yangtze River Delta. We collected data from a questionnaire survey and selected typical respondents of different occupations and with different purposes. Based on this, we established a Multinominal Logit Model, which reflecting the closeness between travelers and travel information, through considering social and economic attributes of travelers, travel modes, relevant information and travel proposes. The results demonstrate that: 1) Travelers of different occupations have different propensities for different travel modes when planning inter-city travels; 2) Travelers of different occupations and for different travel purposes have different information needs when choosing inter-city travel modes. The extents of information

influences are also different. Our study suggests that different types of travelers should be provided with different customized information, for better and qualified travel experiences. The model proposed in this paper can provide theoretical means for the study of public inter-city travel information services within other similar urban agglomerations. Further research will consider what more specific criteria could be used to classify travelers and how to provide better travel information for travelers by cars during inter-city trips.

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