Holiday Travel Behavior Analysis and Empirical Study under Integrated Multimodal Travel Information Service

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Abstract

Holidays are special periods and give rise to many kinds of non-mandatory trips, such as shopping trips and tourist trips. This study investigates the relationship between Integrated Multimodal Travel Information (IMTI) service and holiday travel behavior characteristics in a trip chain. The Exploratory Factor Analysis (EFA) method is first used to extract the common factors based on the RP-SP fusion data under the pre-trip IMTI and en-route IMTI services, respectively. The Structural Equation Modeling (SEM) method is then applied to examine causal effects and quantitative relationships between the influencing factors and trip chain characteristics based on the EFA results. The results show that pre-trip IMTI has a significant negative effect on the holiday travel behavior. The more pre-trip IMTI is obtained by the traveler, the simpler the trip chain spatiotemporal and structural complexity will be. In addition, although the effect of en-route IMTI is less than pre-trip IMTI, it still plays an important role compared to other factors. Therefore, providing IMTI is a new and good alternative to alleviate holiday traffic congestions.

Keywords: Holiday travel behavior; Integrated Multimodal Travel Information (IMTI); Trip chain; Exploratory Factor Analysis (EFA); Structural Equation Modeling (SEM)

1. Introduction

With the improvement in household income, there is a significant increase in the inevitable holiday travel demand. There are many different holidays in China, such as the Spring Festival, Tomb-Sweeping Day, May Day, National Day, etc. Take the Spring Festival as an example, nearly 211 million Chinese tourists traveled during the 2013 Spring Festival holiday as compared to 40 million in 1999. Since the majority of people prefer to drive to their destinations, holiday traffic congestion has become more and more serious. It was reported that there were 4.8 million motor vehicles by the end of 2010 in Beijing, with average trips of 2.11 times per day during the holidays. The maximum traffic index value in Beijing during the 2010 holidays was 7.97, which was close to “serious congestion” level (Guo, 2011) [1]. The huge holiday travel demand exceeds the service capability of the infrastructure, considering the limitation of traffic resources. Therefore, it is necessary to carry out intensive research in the field of holiday traffic.

Travel behavior research is an essential issue for traffic generation and plays an important role in solving holiday traffic problems. In this study, “holiday” is not an influencing factor, but a specific period. The term “holiday travel” includes all kinds of non-mandatory trips from the public, such as tourist trips, shopping trips, dining trips, etc. Holiday travel demand is elastic as opposed to the rigid demand of daily commuter traffic. With more flexibility in time and space, holiday travel behavior is more random and

[1] Traffic index (i.e. Traffic Performance Index, TPI) is an index that shows congestion status on Beijing’s roads. It ranges from 0 to 10 and is divided into five levels: 0-2 means no congestion; 2-4 means slight congestion; 4-6 means part of the ring roads and main roads are congested; 6-8 means many ring roads and main roads are congested; 8-10 means most of the roads are congested.

diverse. Therefore, it is necessary to understand travel behavior during this particular period in order to make appropriate travel demand management (TDM) plans.

Travel behavior analysis is the basis of transportation planning and management and has been undergoing a shift from the traditional trip-based approach to the tour-based approach (Nurul Habib, 2012). The analysis of tour-based travel behavior mainly focuses on the individual travel rules and decision characteristics of trip chains. A better understanding of decision-making behavior for trip chains is needed to extend travel behavior research and develop improved transportation policy (Ma et al., 2014). Moreover, understanding of trip-chain behavior will help with the development of TDM strategies (Lee et al., 2007). Therefore, focusing on the trip chain is important for holiday travel behavior research.

Furthermore, with the development of the Advanced Traveler Information System (ATIS), travel information influences individual travel behavior in different ways (Parvaneh, 2012). As the core element of the Intelligent Transport Systems (ITS), ATIS provides the traveler with Integrated Multimodal Travel Information (IMTI), which includes route planning, navigation, news on disruptions, real time information alerts, etc. (Grotenhuis et al., 2007; Farag and Lyons, 2008; Parvaneh et al., 2012; Zhang et al., 2012). Many developed countries have implemented ATIS and offer IMTI. For example, the USA utilizes its ATIS to provide IMTI covering all kinds of trip modes. There are a variety of ways to disseminate travel information, including web portals, traffic radio, Variable Message Sign (VMS), call centers, Short Messaging Service (SMS) platforms, mobile communication terminals, electronic information boards, etc. The “traffic information service hotline 511” has been publicized throughout the country, and more than half of all Americans use this service. Moreover, ATISs in other countries, such as the “Vehicle Information and Communication System (VICS)” in Japan, “Travel Pilot” in Germany (static route guidance system), “Traffic Master” in the United Kingdom (real-time traffic and travel information system) and “SMARTBUS” in France (public transportation management and information system), provide comprehensive travel information for the traveler.

Information plays an important role in the process of individual travel decision and its influence is widely discussed. However, most studies focus on the influence on travel-related decisions, such as mode choice, destination choice and route choice, and take commuting as the research object (Kraan et al., 2000; Liu et al., 2013). Very few studies investigate how IMTI affects the overall activity scheduling of holiday travel behavior. In reality, IMTI is a critical factor that may influence and constrain the holiday trip chains significantly.

Therefore, this study investigates the relationship between IMTI and holiday travel behavior from the perspective of trip chains. The causal effects and quantitative relationship between the influencing factors and trip chain characteristics are discussed based on the tour-based approach and Revealed Preference (RP)-State Preference (SP) fusion data. Moreover, in order to analyze the influence of travel information comprehensively and practically, IMTI is divided into pre-trip IMTI and en-route IMTI, which are discussed separately (Hine and Scott, 2000). The pre-trip IMTI is the information obtained at the origin of a trip for the traveler in order to prepare his/her trip chain. Travelers can obtain the pre-trip IMTI at many activity places, such as home, office, mall or hotel. The en-route IMTI includes wayside information and on-board information, which can be obtained through all kinds of electronic equipment in the process of travel. The access locations are mainly vehicles, stations, public transport centers, park and rides, etc.

This study is organized as follows. Section 2 briefly reviews the literature on tour-based analysis, holiday travel behavior analysis and the impact analysis of IMTI on travel behavior. It also indicates the shortage of existing research and then clarifies the contribution of this study. Section 3 describes the modeling approaches and explains the meaning of the variables used in the models. Section 4 contains the data and survey, and a discussion of the model results is then presented in Section 5. Finally, the important findings and recommendations for future study are summarized.

2. Literature review

2.1 Tour-based analysis

The traditional trip-based approach divides travel into different types of trips (Manaugh et al., 2010). However, it may cause many problems. It considers each type of trip in an isolated manner and does not account for a travel with multiple purposes (Krizek, 2003). During a tour, the trips interrelate and interact with each other. For example, the destination of a previous trip decides the origin of the subsequent trip, and the travel time of the previous trip also constrains the subsequent trip. In order to fill the gap in trip-based analysis, a new concept is proposed for the tour-based approach known as tours or trip chains. A tour is defined as chains of trips starting and ending at home (Maat and Timmermans, 2006; Primerano et al., 2008). Tour-related research in the field of transportation began in the 1960s with the earliest research being about consumer shopping behavior (Baumol and Ide, 1956; Berry et al., 1962). The components of a tour include not only a series of trips, but also the activities derived from the trips. There is a direct causal relationship between the activities and the trips (Ho and Mulley, 2013). Studies have shown that the generation of complex travel is due to individual intent to choose a trip chain combining activities with trips (Recker, 1981). Therefore, a comprehensive analysis of tours, as opposed to unlinked trips, can provide a better understanding of holiday travel behavior and a more appropriate framework for examining responses to transport policies (Recker, 1986; Ding et al., 2014).

Tour-related characteristics include trip chain length, total time travelled, number of activity locations, tour frequency, number of transfers, trip mode, etc. (Chu, 2003; McGuckin and Nakamoto, 2004; Li et al., 2013). Some studies use these characteristics as dependent variables to explore the effect of land use on tour characteristics (Limanond and Niemeier, 2004; Maat and Timmermans, 2006; Van Acker et al., 2014). Some consider tour-related characteristics simultaneously with trip-related characteristics (Srinivasan, 2002; Frank et al., 2008; Van Acker and Witlox, 2011). Moreover, some researchers think personal preferences, socio-demographic characteristics and the built environment could influence people’s activity choice (Chang and Mahmassani, 1988; Kim et al., 1994; Jenelius et al., 2011; Grigolon et al., 2013). However, the influencing factors are usually provided first and most studies verify the relationship between the factors and the tour characteristics based on confirmatory factor analysis. Therefore, few studies have identified the major true influencing factors and considered their influence integrally.

2.2 Holiday travel behavior analysis

Holiday travel behavior research has recently received increasing attention (Asakura and Iryo, 2007; Kaplan et al., 2015). Liu et al. (2006) and Cools et al. (2007) thought it is necessary to incorporate holiday effects in travel behavior models. Liu and Sharma (2008) presented a non-parametric hypothesis test method to examine the changes in traffic volume patterns during holiday periods while Cools et al. (2010) found that public holidays have a non-ignorable impact on daily travel behavior, based on the zero-inflated Poisson regression approach. Shailes et al. (2001) found that approximately 54% of respondents took action to avoid congestion, commonly in the form of trip timing adjustments rather than route diversion during the holidays. Anowar et al. (2013) examined the factors associated with statutory holiday crashes and found they significantly differed from the factors associated with weekend crashes.

However, existing research focusing on holiday travel behavior is rare and limited. No matter whether the "holiday" is treated as an influencing factor or a special period, research pays more attention to the holiday traffic characteristics or the analysis of holiday travel choice behavior (Choo et al., 2012), whereas the influencing factor of the holiday travel behavior is seldom investigated. Moreover, most studies are only based on the confirmatory factor analysis rather than exploratory factor analysis (Van Cranenburgh et al., 2014). To date, studies employing exploratory factor analysis combined with the confirmatory factor analysis to analyze holiday travel behavior have seldom been performed.

2.3 Impact of IMTI on travel behavior

Some researchers have been studying the impact of traffic information on travel behavior since 1980. Kenyon and Lyons (2003) thought that bus travel information service could realize a shift from other travel modes to the bus system. Lo et al. (2004) provided a Nested Logit model to examine the influence of information on travel destination, travel mode and route choice behavior. Grotenhuis et al. (2007) pointed out that the pre-trip stage is the preferred choice for gathering IMTI when planning multimodal travel. Based on Bayesian theory, Shi et al. (2009) established the dynamic update model of pre-trip time perception for commuters. Farag and Lyons (2012) used the structural equation model to explore the relative strength of various factors affecting the use and non-use of Public Transport (PT) information. The results demonstrated that travel behavior and personal attributes are the most important factors.

IMTI provides a new perspective to study individual travel behavior in holidays, but this is seldom investigated. Most studies focus on the influence of IMTI on travel-related decisions, such as mode choice, destination choice, and route choice (Ben-Elia et al., 2013; Bekhor and Albert, 2014). Few studies analyze the effect on the overall activity scheduling. Moreover, most research takes commuting as the research object (Kattan et al., 2013). Therefore, taking IMTI with holiday travel behavior into account is an innovation point of this study.

In light of the three parts mentioned above, the contribution of this study is three-fold: (1) Using the combined method of Exploratory Factor Analysis (EFA) and Structural Equation Modeling (SEM) to analyze the relationship between the influencing factors and trip chain characteristics under an IMTI service. (2) Taking IMTI with holiday travel behavior into account is an innovation point. (3) Providing a theoretical support for the formulation of holiday traffic policy.

3. Methodology

3.1 Research thinking

Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) are different types of factor analysis. The former uses specific criteria to explore the factorial structure from the measurement scales with no information of the influencing factors, while the latter is used to verify whether the measurement scales can measure the factorial structure effectively based on prior analysis results (Brown, 2012; Comrey and Lee, 2013). However, although EFA and CFA are different in their basic ideas, theoretical hypotheses and analytical procedures, they interrelate and interact with each other in the practical application of management research. In the development of the factor analysis theory, an EFA is often performed first, and analysis of the results can provide a theoretical basis for the subsequent CFA (Anderson and Gerbin, 1988; Golob, 2003). Generally, if there is no solid theory foundation on which to build the factorial structure, an EFA is usually performed first to generate a theory about the internal structure and, then, a CFA is used to verify this structure. In addition, EFA and CFA should have non-overlapping samples (Anderson and Gerbin, 1988). Therefore, it is reasonable to select a part of the data to perform EFA first and then utilize the remaining data for CFA.

CFA is the basis of Structural Equation Modeling (SEM). It is the CFA method that the SEM measurement model uses to verify the factorial structure of measurement scales. SEM is a confirmatory method used to test whether the theoretical model holds and corresponds to real data or not. An SEM with latent variables is composed of two sub-models: (1) A measurement model is used to specify latent (unobserved) variables as the linear functions (weighted averages) of other variables. (2) A structural model is used to capture the causal influences (regression effects) of the exogenous variables on the endogenous variables and the causal influences of endogenous variables upon one another (Bentler, 1980; Bollen, 1998; Golob, 2003). From the methodological point of view, it is recommended that the measurement model should be developed first, followed by the structural model (Anderson and Gerbing, 1988; Van Acker et al., 2007; Wang et al., 2011). Moreover, the fruits of EFA can provide a theoretical basis to guide construction of the SEM measurement model. Therefore, this study uses EFA before the SEM analysis.

3.2 Exploratory factor analysis

EFA is a statistical method used to identify the underlying relationships between observable variables (Ruotoistenmäki and Seppälä, 2007). It attributes most of the variation to a few common factors through the covariance matrix, or correlative coefficient matrix, based on the relevance theory (Hair et al., 2010). The mathematical model is as follows:

$$x_i = \lambda_{i1}\xi_1 + \lambda_{i2}\xi_2 + \cdots + \lambda_{in}\xi_n + \delta_i,\ i = 1, 2, \cdots, \mathrm{q},\ \mathrm{n} \le \mathrm{q} \quad (1)$$

where $x_1, x_2, \cdots, x_q$ are observable variables (or indicators); $\xi_1, \xi_2, \cdots, \xi_q$ are common factors (or latent variables); λ_{ij} is estimated coefficient, called factor loading. Its statistical significance represents the correlation between the observed variables and common factors (Fabrigar et al., 1999). Since the observed variables and common factors are standardized variables, the correlative coefficient matrix is equal to the covariance matrix, and δ_i is the error term.

The key task is to obtain λ_{ij} and the most common method to determine this parameter is Principal Component Analysis (PCA). PCA is a statistical method that uses orthogonal transformation to convert a set of possibly correlated observed variables into linearly uncorrelated principal components, i.e. the common factors in EFA (Jollifee, 2005). The general form of PCA can be expressed as follows:

$$\begin{cases} y_1 = r_{11}x_1 + r_{12}x_2 + \cdots + r_{1q}x_q \\ y_2 = r_{21}x_1 + r_{22}x_2 + \cdots + r_{2q}x_q \\ \cdots\cdots \\ y_n = r_{n1}x_1 + r_{n2}x_2 + \cdots + r_{nq}x_q \end{cases} \quad (2)$$

where r_{ij} is the orthogonal eigenvector component of their corresponding eigenvalue for the covariance matrix of observed variables. The first principal component has the largest possible variance, and each succeeding component in turn has the highest variance possible under the constraint. Because the observed variables and the common factors are standardized variables, their variance is equal to one. This study utilizes the eigenvalue-greater-than-one rule to determine the number of principal components or common factors included in the model (Kaiser, 1960).

Usually, the meaning of the initial common factors is vague and confused. Therefore, the goal of factor rotation is to simplify and clarify the data structure in multidimensional space. There are various methods for factor rotation. Maximum variance rotation is by far the most common choice and, therefore, is adopted in this study. Factor loading indicates the strength and direction of a factor on a measured variable, and is analyzed after factor rotation. In general, there are two basic principles to determine whether the variables are valid without cross loadings or not: (1) The variable commonalities are considered "high" if their factor loadings are more than 0.5; (2) The variable should be dropped from the analysis if there are several high loadings (0.5 or better) on two or more factors (Costello and Osborne, 2005).

In addition, the Kaiser-Meyer-Olkin (KMO) and Bartlett testing are usually performed first to verify whether the correlation matrix is the identity matrix at the beginning of EFA. It is necessary to carry out the factor analysis if the KMO values are above 0.7 and Bartlett testing statistical significance is less than 0.01in the measurement table.

3.3 Structural equation modeling analysis

There are many factors influencing people's holiday travel behavior. In order to provide an insight into the relationship between the influencing factors and holiday travel behavior under IMTI, SEM is used to verify the interaction strength between them based on the EFA analysis results. From a methodological point of view, SEM is a statistical technique for testing and estimating causal relations using a combination of statistical data and qualitative causal assumptions. It has advantages that the other common statistical methods do not have: (1) SEM allows the independent variables' existing error terms, which brings the results into line with the actual situation; (2) SEM allows the existence of more than one dependent variable, and these can influence each other; (3) SEM estimates the fitting degree of the overall model rather than the individual coefficients (Wang, 2010; Ripplinger et al., 2012).

In general, a full SEM consists of two sub-models: a measurement model for observed variables and a structural model for latent variables. The measurement model can be expressed by

$$y = \Lambda_y \eta + \varepsilon \tag{3}$$

$$x = \Lambda_x \xi + \delta \tag{4}$$

where equation (3) is the measurement model for the endogenous variables, and equation (4) is for the exogenous variables. y is a $p \times 1$ vector that contains p endogenous indicators, and η is a $m \times 1$ vector that contains m endogenous latent variables. Λ_y is a $p \times m$ factor loading matrix of y in η, and ε is a $p \times 1$ vector with p errors. In the same way, x is a $q \times 1$ vector that contains q exogenous indicators, and ξ is a $n \times 1$ vector containing n exogenous latent variables. Λ_x is a $q \times n$ factor loading matrix of x in ξ, and δ is a $q \times 1$ vector with q errors.

The structural equation is written as

$$\eta = B\eta + \Gamma\xi + \zeta \tag{5}$$

where B is a $m \times m$ coefficient matrix, which describes the causal influences of endogenous latent variables upon one another. Γ is a $m \times n$ coefficient matrix, which describes the causal influences between exogenous latent variables and endogenous latent variables; ζ is a $m \times 1$ residual error vector.

A full SEM contains eight parameters including Λ_y, Λ_x, B, Γ, Φ, Ψ, Θ_ε, Θ_δ. Here, Φ and Ψ are the covariance matrixes of ξ and ζ. Θ_ε and Θ_δ are the covariance matrixes of ε and δ.

There are five steps of the solution of SEM: (1) Specification. Set up the initial hypothesis model, based on the mature theory or previous research results. (2) Identification. This step decides whether the model can obtain the unique solution in estimation. (3) Estimation. Input the sample data into the initial model and estimate the eight parameter matrices. (4) Evaluation. Evaluate the effectiveness of the calculated model, including the significance of the model parameters, the goodness of the fitted values, etc. (5) Modification. If the evaluation result is not satisfactory, modify the model and repeat the previous steps until obtaining the most reasonable and best-fitted model.

This paper uses the Maximum Likelihood Estimation (MLE) method and chooses five goodness-of-fit indicators to evaluate the model performance, namely: the ratio of chi-square value to the degrees of freedom (χ^2/df); the goodness of fit index (GFI); the root mean square error of approximation (RMSEA); the Bentler-Bonett normed fit index (NFI); and the comparative fit index (CFI). In practice, the recommended acceptance of a good fit to a model requires that the obtained GFI, NFI and CFI value should have a range from 0 to 1, with higher value indicating better model fit. A cut-off criterion of $CFI \geq 0.95$ is presently recognized as indicative of good fit (Hu and Bentler, 1999), while values of GFI and NFI greater than 0.90 are usually interpreted as indicating an acceptable fit (Hu and Bentler, 1999; Schermelleh-Engel et al., 2003; Sanders et al., 2005). Traditionally, $RMSEA \leq 0.05$ can be considered as a good fit, value between 0.05 and 0.08 as an adequate fit, and value between 0.08 and 0.10 as a mediocre fit, whereas $RMSEA > 0.10$ is not acceptable (Browne and Cudeck, 1993; Van Acker and Witlox, 2010). However, a cut-off value close to 0.06, or a stringent upper limit of 0.07, seems to be the recent general consensus amongst authorities (Hu and Bentler, 1999; Steiger, 2007). Moreover, there is no absolute standard for an acceptable of χ^2/df; the recommendation is that $\chi 2$/df < 2 is indicative of a good fit (Byrne, 1991; Hooper et al., 2008). However, this value may increase with larger samples (Bollen, 1989).

3.4 Variables

Some researchers have found that personal preferences, socio-demographic characteristics and the built environment could influence people’s activity choice. Therefore, the observed variables used in the EFA and SEM models are shown in Table 1.

Table 1

The definition of variables

Variable category	Variable name (unit)	Explanation
Personal attributes	Age (year)	1=18~20; 2=21~30; 3=31~40; 4=41~50; 5=51~60; 6=61~70
	Occupation	1=manager; 2=staff; 3=migrant worker;4=freelance; 5=retired/unemployed; 6=student; 7=other
	Personal monthly income (RMB)	1=0; 2=1~500; 3=501~2000; 4=2001~4000; 5=4001~6000; 6=6001~8000; 7=8001~10000; 8=above 10000
Household characteristics	Family size	≥0 integers
	Family monthly income (RMB)	1=0~4000; 2=4001~8000; 3=8001~12000; 4=12001~16000; 5=16001~20000; 6=above 20000
	Number of family cars	≥0 integers
	Number of children	≥0 integers

Travel costs	Trip cost (RMB)	1=0~10; 2=11~20; 3=21~30; 4=31~40; 5=41~50; 6=51~60; 7=above 60
	Parking charge (RMB)	1=0; 2=1~10; 3=11~20; 4=21~30; 5=31~40; 6=41~50; 7=above 50
	Physical output	1=very small; 2=small; 3=moderate; 4=big; 5=very big
	Number of personal cars	≥0 integers
Information influence	Departure time changes	1=no; 2=yes
	Trip mode changes	1=no; 2=yes
	Reroute	1=no; 2=yes
	Amount of information	1=a few; 2=moderate amount; 3=a great many
Trip chain spatiotemporal characteristics	Trip origin	1=in the 2nd ring road; 2=2nd~3rd ring road; 3=3rd~4th ring road; 4=4th~5th ring road; 5=outside the 5th ring road;
	Trip distance (km)	≥0
	Departure time	1=6:00~8:59; 2=9:00~9:59; 3=10:00~10:59; 4=11:00~11:59; 5= 12:00~12:59; 6=13:00~13:59; 7=14:00~14:59; 8=15:00~15:59; 9=16:00~16:59; 10=17:00~17:59; 11=18:00~18:59; 12=19:00~19:59; 13=20:00~20:59; 14=21:00~21:59; 15=22:00~5:59
	Travel time (minute)	≥0
Trip chain structural characteristics	Type of trip mode	1=Walk; 2=Bike; 3=Bus; 4=Metro; 5=Car; 6=Taxi; 7=Combined mode
	Trip chain length	≥2 integers
	Number of activity locations	≥0 integers
	Number of transfers	≥0 integers
	Trip chain complexity	1=simple; 2=complex

Some indicators are explained, especially:

(1) Information influence: in the survey, respondents were provided two lists of information demand options. One is for the pre-trip IMTI, such as road congestion information, travel time prediction, trip mode suggestion and departure time suggestion, and one is for the en-route IMTI, such as congestion information of the road ahead, traffic control information of the road ahead and alternative route information. The amount of information under 2 means a few, between 3 and 5 means moderate amount, and above 5 means a great many.

(2) Trip chain spatiotemporal characteristics: the trip origin indicates the origin of a trip. Its options are designed according to the specific circumstances of Beijing. The urban roadway structure in Beijing is a radial-hoop network with five ring roads; therefore, the trip origin is divided into five options. Similarly, the departure time is the starting time of a trip. Its options are allocated according to the time period. In order to make the study more specific, the spatiotemporal indicators are statistics for a single trip where the destination is Xidan or the Summer Palace, Beijing.

(3) Trip chain structural characteristics: the four indicators are the statistical result of a traveler's one-day trip chain in the holidays. The type of trip mode means the combination of trip modes in one-day travel, and can be divided into single mode and combined mode. The trip chain length refers to the sum of the trips, whose value is equal or greater than 2. The number of activity locations refers to the number of the traveler's main destinations, excluding the starting and end points (i.e. home). The number of transfers is the sum of the number of transfers between different trip modes and the number of transfers between different routes for the same trip mode.

4. Data and survey

4.1 Data

In order to investigate holiday travel behavior under IMTI, actual travel activity should be first obtained by researching people's revealed preferences. Meanwhile, a survey is necessary in a virtual situation to obtain trip chain changes under IMTI service by researching people's stated preferences. Therefore, the survey uses the combined method of Revealed Preference (RP) and Stated Preference (SP), and applies a simple random sampling technique during the survey (Zhao et al., 2010; Carrion and Levinson, 2012).

The questionnaire includes the information regarding : traveler characteristics, IMTI attributes, actual travel activity, travel activity under a pre-trip IMTI service and travel activity under an en-route IMTI service. The traveler characteristics include 12 variables: age, occupation, personal and family income, education, number of personal and family cars owned, family size, number of children, trip cost, parking charge and physical output. IMTI attributes include seven variables: information guidance, trip mode changes and reroute under the pre-trip and en-route IMTI service separately, departure time changes under the pre-trip IMTI service. The other three have seven variables: trip origin, trip distance, departure time, travel time, activity time, end time and type of trip mode. The researchers need to first investigate the traveler's actual travel activity, and then obtain their virtual travel activity by asking, "if you can obtain the information about traffic conditions before the trip, how will you change your travel?" or "if you obtain the information regarding traffic conditions during the trip, how will you change your travel?"

This study chose Xidan and the Summer Palace, Beijing, as the survey sites, where the transportation infrastructure is sufficiently complete for the traveler to choose their trip modes and travel routes flexibly. Xidan, Beijing, is a prosperous commercial street, while the Summer Palace is one of the most famous imperial gardens, with a large number of tourists. These two sites have strong representativeness among holiday attractions. The survey was carried out during Tomb-Sweeping Day, when people sweep away the weeds of tombs in remembrance of deceased relatives. The holiday last for three days (Apr. 2nd- Apr. 4th), and people usually have an outing in spring during this holiday.

Respondents were randomly chosen in the survey at the two sites. The respondents were mainly Chinese citizens, among whom some were from Beijing, while others were from the other parts of China. Moreover, only respondents who met the following conditions could participate: (1) Aged 18-70; (2) Have the ability to make independent choices for his/her own journey and be familiar with the traffic situations around the sites; (3) Be able to understand the guiding information.

Data were collected via a postal survey, combined with face-to-face interview, for a random sample of 1688 respondents. Some investigators sent respondents stamped addressed envelopes containing the questionnaire and instructions on how to fill the questionnaire form. Other investigators interviewed the respondents face-to-face. With a pre-paid self-addressed envelope, the respondents were required to fill in the questionnaire and drop the envelope into a mailbox. Note that the purpose of using these two survey modes was to compare their advantages and disadvantages.

1688 questionnaires were distributed and 415 effective samples were obtained. The results of the survey are as follows: (1) 656 and 657 envelopes were distributed in Xidan and the Summer Palace, respectively, of which a total of 245 envelopes was returned after one month (recovery of 18.66%). Among the returned questionnaires, 86 were effective (effective response rate of 6.55%), with 30 from Xidan and

56 from the Summer Palace. (2) 375 questionnaires were obtained through face-to-face interview, with 329 being effective (effective rate of 87.73%). Among the valid questionnaires, 177 were from Xidan and 152 from the Summer Palace. Invalid questionnaires were mainly due to the incompleteness of the trip chain or missing data. By comparing the postal survey with face-to-face interview, the efficiency of the latter was higher than the former. Therefore, face-to-face interview is more suitable for an RP-SP survey of holiday travel behavior in terms of sample size, validity rate and survey period.

4.2 Sample difference and questionnaire reliability analysis

The two samples, including the survey location, time, questionnaire and sampling method (random selection), were all the same. Therefore, there should be no difference between them. However, because the sample size was limited and the two samples had different sizes, it was necessary to analyze the sample difference. This study uses one-way analysis of variance (one-way ANOVA) for the numerical variables and Spearman's rank correlation coefficient (Spearman's rho) for the discrete variables.

Table 2

Sample difference analysis

Variables	ANOVA Sig.	Variables	Spearman's rho	Variables	Spearman's rho
Personal car	0.053	Age	-0.063	Trip origin 1	-0.046
Family size	0.005**	Occupation	0.077	Departure time 1	-0.341**
Number of children	0.498	Personal income	-0.158**	End time 1	-0.402**
Family car	0.254	Education	0.137**	Trip modes 1	0.084
Trip distance 1	0.536	Family income	-0.055	Trip origin 2	0.047
Travel time 1	0.717	Trip cost	-0.083	Departure time 2	-0.202**
Activity time 1	0.126	Parking charge	-0.043	End time 2	-0.282**
Trip distance 2	0.27	Physical output	0.088	Trip modes 2	0.0129
Travel time 2	0.402	Information guidance 2	0.093	Trip origin 3	-0.0341
Activity time 2	0.152	Time changes 2	0.028	Departure time 3	-0.402**
Travel time 3	0.692	Mode changes 2	-0.156**	End time 3	0.108*
Trip distance 3	0.454	Reroute 2	-0.165**	Trip modes 3	-0.055
Activity time 3	0.103	Information guidance 3	0.099*	Reroute 3	0.009
		Mode changes 3	0.018		

"1" represents the actual trip chain; "2" represents the trip chain affected by the pre-trip IMTI; "3" represents the trip chain affected by the en-route IMTI. "**" means the correlation is significant at the confidence level of 0.01; "*" means the correlation is significant at the confidence level of 0.05.

In Table 2, some variables remain unaffected by the survey mode, while some variables' sample differences are significant. Therefore, the two samples can be combined for general statistical analysis, but it would be better to take a stratified sample for model analysis, with the survey mode as the stratification variable.

Moreover, reliability generally refers to the consistency of a measure. The estimated results can be used to decide whether the questionnaire accurately reflects the construct of the measure or not. The most common method of estimating the reliability of a questionnaire is to use the Cronbach's Alpha coefficient, which estimates the consistency of variables. A high coefficient indicates that the variables are consistently measuring the same underlying construct (Zinbarg et al., 2005). Traditionally, $\alpha \geq 0.9$ can be considered as an excellent internal consistency, the value between 0.7 and 0.9 is good, and the value between 0.6 and

0.7 is acceptable, whereas $\alpha < 0.6$ is not acceptable (Moss et al., 1998). Table 3 presents the Cronbach's Alpha coefficient of each construct, and is the result of the total sample of postal survey and face-to-face interview.

Table 3

Analysis results of questionnaire reliability

Constructs	Variables	Cronbach's Alpha coefficient
1. Traveler characteristics	12	0.678
2. IMTI attributes	7	0.645
3. Actual travel activity	7	0.665
4. Travel activity under the pre-trip IMTI service	7	0.745
5. Travel activity under the en-route IMTI service	7	0.740

In Table 3, each Cronbach's Alpha coefficient is above 0.6, which means the questionnaire is acceptable and can be used for further data analysis.

4.3 Operationalization of variables

The general statistical analysis of the total sample is as follows:

The traveler characteristics: for personal attributes, the majority of the travelers at these two sites were 20-30 years old (Xidan=61.35%, the Summer Palace=61.06%), most of whom were staff (36.87%) and students (35.18%). Additionally, 90% of them had high school certificate or above, which means most of the travelers at the two sites were young and well educated. Moreover, more than 80% travelers had no children and about two-thirds (69.63%) had monthly incomes lower than 4000 RMB. In the household characteristics, most of the travelers (71.5%) in Xidan were married while about half (42.79%) in the Summer Palace were single. Nearly one-third (30.38%) of the families had cars. Among the car owners, more than half (53.47%) were from Xidan. By contrast, the ratio of bicycle owners was much greater than those of car owners, and more than half (56.38%) of the families had bicycles. In addition, the travelers at these two sites were mainly working-class young people, so most individuals and families had traveled by public transportation with lower travel costs.

Travel activity: the data of the travel activity variables are statistics for the single trip, the destination of which was Xidan or the Summer Palace. With Xidan and the Summer Palace as the activity locations, the trip origins were evenly distributed in each loop of Beijing (about 20% between each ring road), which indicates the random nature of the sample. The average trip distance was 18.87 km and the average travel time was about one hour. The single mode mainly included bus (18.55%) and metro (28.19%), while the combined mode was in the majority (45.06%). The trip chain's statistical indicators show that 35.18% of the trip chains had more than one activity location and the average trip chain length was 2.49, while the average transfer time was 0.96.

IMTI: for the pre-trip information, 63.46% of the Summer Palace travelers needed to obtain the information of traffic conditions in advance, while the number for Xidan was only 41.55%. The precise question was "Do you need to obtain the information regarding traffic conditions before going to Xidan or the Summer Palace: yes/no". This might be relevant to the main trip modes in these two places. There were more travelers in Xidan who took the metro for the trip, which has a fixed frequency and time schedule. This study also investigated travelers at Xidan who didn't need to obtain information about traffic conditions in advance, and most of them said that the metro was reliable and punctual. In addition, respondents had to choose the information they needed before going to Xidan or the Summer Palace from the information list, and order it by importance. According to the ranking of the pre-trip IMTI, travelers at

Xidan cared more about traffic congestion while travelers at the Summer Palace cared more about travel time. Compared with pre-trip IMTI, the demand of the en-route IMTI was lower. Only 35.75% of the Xidan travelers took the travel information guidance during the trip, while 51.92% of the Summer Palace travelers did likewise. The precise question was: "Do you accept the travel information guidance during the trip to Xidan or the Summer Palace: yes/no". As for the content of en-route information, travelers at both sites cared more about traffic congestion and public transport schedules.

In order to demonstrate the influence of IMTI on the travel activity, Table 4 presents a comparison of statistical indicators between the actual trip chain and the trip chain affected by pre-trip and en-route IMTI.

Table4

Comparison between the actual trip chain and the trip chain affected by the integrated multimodal travel information (IMTI)

Factor	Level	Actual trip chain			Trip chain affected by pre-trip IMTI			Trip chain affected by en-route IMTI		
		N	%	Mean	N	%	Mean	N	%	Mean
Amount of information	1=A few				107	26		123	30	
	2=Moderate amount				246	59		256	62	
	3=A great many				62	15		36	9	
Trip origin	0=Cancel the trip				38	9				
	1=In the 2nd ring road	69	17		65	16		69	17	
	2=Between the 2nd and the 3rd ring road	93	22		84	20		93	22	
	3=Between the 3rd and the 4th ring road	72	17		65	16		72	17	
	4=Between the 4th and the 5th ring road	68	16		64	15		68	16	
	5=Outside the 5th ring road	113	27		99	24		113	27	
Trip distance				18.87			16.78			18.71
Departure time	0=Cancel the trip				38	9				
	1=6:00~8:59	77	19		91	22		77	19	
	2=9:00~9:59	75	18		67	16		75	18	
	3=10:00~10:59	45	11		30	7		45	11	
	4=11:00~11:59	46	11		39	9		46	11	
	5=12:00~12:59	56	13		56	13		56	13	
	6=13:00~13:59	46	11		35	8		46	11	
	7=14:00~14:59	28	7		26	6		28	7	
	8=15:00~15:59	18	4		15	4		18	4	
	9=16:00~16:59	15	4		13	3		15	4	
	10=17:00~17:59	7	2		3	1		7	2	
	11= 18:00~18:59	2	0.00		2	0.00		2	0.00	
Travel time				59.58			53.20			56.22
Type of trip mode	0=Cancel the trip				38	9				
	1=Walk	4	1		3	1		6	1	
	2=Bike	2	0.00		3	1		2	0.00	

	3=Bus	77	19		59	14		64	15	
	4=Metro	117	28		121	29		105	25	
	5=Car	20	5		12	3		16	4	
	6=Taxi	8	2		6	1		16	4	
	7=Combined mode	187	45		173	42		206	50	
Number of activity locations	0=Cancel the trip			1.49	38	9	1.34			1.48
	1=One	269	65		246	59		271	65	
	2=Two	97	23		89	21		96	23	
	3=Three	41	10		36	9		40	10	
	4=Four	8	2		6	1		8	2	
Average length of the trip chain	0=Cancel the trip			2.49	38	9	2.25			2.48
	1=Two	269	65		246	59		271	65	
	2=Three	97	23		89	21		96	23	
	3=Four	41	10		36	9		40	10	
	4=Five	8	2		6	1		8	2	
Number of Transfers	0=Zero	223	54	0.96	248	60	0.87	235	57	0.88
	1=One	64	15		49	12		64	15	
	2=Two	91	22		81	20		84	20	
	3=Three	15	4		15	4		12	3	
	4=Four	13	3		12	3		11	3	
	5=Equal or greater than five	9	2		10	2		9	2	

It can be seen from Table 4 that:

(1) Under the pre-trip IMTI service, 9% travelers would cancel their trips. The average trip distance reduces from 18.87 km to 16.78 km and the travel time reduces from 59.58 min to 53.20 min. Moreover, the number of activity locations, average trip chain length and the number of transfers are much less than the actual trip chain under the influence of pre-trip IMTI. Therefore, the pre-trip IMTI has an effect on holiday travel activities.

(2) Under the en-route IMTI service, the value of relevant indicators reduces by a certain degree, but the effect is not obvious from the results in Table 4. However, it is not yet statistically tested, and further studies are needed to investigate the relationship between the en-route IMTI and holiday travel activities.

In order to provide greater insight into the relative strength of IMTI on holiday travel behavior, a combined method of EFA and SEM was adopted for the model analysis. It should be noted that: (1) The pre-trip IMTI and en-route IMTI are considered separately; (2) Because the departure time and location cannot be changed during the trip, the en-route IMTI influence on them will not be discussed.

5. Result analysis

EFA and SEM should have non-overlapping samples. Hence, a stratified sampling method was applied with the survey mode as a stratification variable. Moreover, from the 415 valid questionnaires, 115 were selected for EFA and 300 for SEM.

5.1 Exploratory factor analysis

According to the basic principles and data type requirements of EFA, 20 variables were selected from the questionnaire under the pre-trip and en-route IMTI service, respectively. First, the KMO and Bartlett testing results show that the KMO values are 0.749 and 0.717 and Bartlett testing statistic Sig. are both equal to 0.00. Therefore, there is a significant correlation between the variables and it is necessary to carry out factor analysis. Next, the study uses principal component and maximum variance method to estimate the factor loading matrix and extract the common factors. The results are shown in Tables 5-6.

Table 5

Exploratory factor analysis (EFA) results under the pre-trip IMTI service.

Factor	Common factors					
	1	2	3	4	5	6
Trip chain length	0.886	--	--	--	--	0.282
Number of activity locations	0.873	--	--	--	--	--
Type of trip mode	0.709	--	0.225	-0.213	--	--
Number of transfers	0.628	--	--	--	--	--
Family size	--	0.816	--	--	--	--
Number of family cars	--	0.690	--	--	0.298	--
Family income	--	0.643	--	0.353	--	--
Number of children	--	0.500	--	0.237	--	0.361
Trip distance	--	--	0.916	--	--	--
Travel time	--	--	0.915	--	--	--
Trip origin	--	--	0.535	--	--	0.535
Personal income	--	--	--	0.849	--	--
Occupation	--	--	--	-0.796	--	--
Age	--	--	--	0.632	--	--
Trip cost	--	--	--	--	0.802	--
Parking charge	--	0.240	--	--	0.796	--
Physical output	--	--	--	--	0.578	--
Number of personal cars	-0.266	0.477	--	0.251	0.500	0.209
Reroute	-0.501	--	--	--	--	-0.698
Trip mode changes	-0.431	--	--	--	--	-0.672
Variance contribution rate (%)	15.520	11.296	11.289	11.064	10.115	8.779
The cumulative variance contribution rate (%)	15.520	26.816	38.105	49.169	59.285	68.064

Table 6

Exploratory factor analysis (EFA) results under the en-route IMTI service.

Factor	Common factors					
	1	2	3	4	5	6
Number of activity locations	0.980	--	--	--	--	--
Trip chain length	0.980	--	--	--	--	--
Trip chain complexity	0.936	--	--	--	--	--
Travel time	--	0.828	--	--	--	--
Trip distance	--	0.777	--	--	0.287	--
Trip origin	--	0.612	--	--	--	--

Departure time	--	-0.563	--	--	--	-0.346
Personal income	--	--	0.861	--	--	--
Occupation	--	--	-0.779	--	--	--
Age	--	0.230	0.675	0.243	-0.221	--
Family size	--	--	--	0.813	--	--
Number of family cars	--	--	--	0.599	0.395	0.253
Number of children	--	--	0.286	0.597	--	--
Family income	--	-0.328	0.269	0.584	--	--
Parking charge	--	--	--	0.230	0.770	--
Trip cost	--	0.306	--	--	0.764	--
Physical output	--	--	--	--	0.561	--
Number of personal cars	--	--	--	0.502	0.509	--
Trip mode changes	--	--	--	--	--	0.881
Reroute	--	--	--	--	--	0.850
Variance contribution rate (%)	14.873	11.760	10.874	10.809	10.649	8.773
The cumulative variance contribution rate (%)	14.873	26.633	37.507	48.317	58.965	67.738

Since the factor loadings of the common factors are all more than 0.50, there is no serious cross-load. Moreover, the cumulative variance values explained by the common factors under the pre-trip and en-route IMTI service are both greater than the minimum standards of 65%. Therefore, the extracting factors can explain the information contained in the original variables. According to the specific attributes of the variables, the meaning of the extracting factors in Tables 5-6 can be well explained. The definitions of the common factors are shown as follows:

(1) Personal attributes: personal income, occupation and age affects the travel decision-making and trip mode choices to some extent; therefore, they belong to the personal influencing factors.

(2) Household characteristics: family size, family income, number of family cars and number of children may lead to different holiday trip purposes, number of activity locations and travel patterns; therefore, they belong to the family influencing factors.

(3) Travel costs: people always want to complete more travel activities at minimal travel costs. Trip cost, parking charge, physical output and number of personal cars determine the travel distance and travel time to some extent, and belong to the travel cost constraints.

(4) Information influence: trip mode changes and reroute are generated by the impact of pre-trip IMTI or en-route IMTI; therefore, they belong to the information influencing factors.

(5) Trip chain spatiotemporal characteristics: these indicators reflect the order and continuity of the trip chain from the time dimension and space dimension, and constrain the overall travel schedule at the same time. It is the time-space continuum that produces the concept of a trip chain, so these indicators belong to the spatiotemporal characteristics.

(6) Trip chain structural characteristics: the number of activity locations, trip chain length, trip chain complexity and the number of transfers are statistical indicators of the trip chain. In the activity system, these indicators portray the traveler's travel choice and reflect the complexity of the trip chain. Furthermore, a trip chain is actually a combination of multiple activities, which reflect the connection form of different travel purposes with a certain time sequence.

5.2 Structural equation modeling analysis

The structural equation modeling analysis is based on the priori information obtained from EFA. The trip chain structural characteristics, spatiotemporal characteristics, personal attributes, household characteristics, travel costs and information influence are all abstract concepts, which are considered to be latent variables. Moreover, the trip chain structural characteristics and spatiotemporal characteristics belong to the describing factors of the trip chain, which are endogenous latent variables. Similarly, personal attributes, household characteristics, travel costs and information influence are influencing factors of the trip chain characteristics, which are exogenous latent variables. In addition, the spatiotemporal characteristics could impact the overall structure of the trip chain; thus, the path diagram of the initial structural equation model is shown in Fig.1.

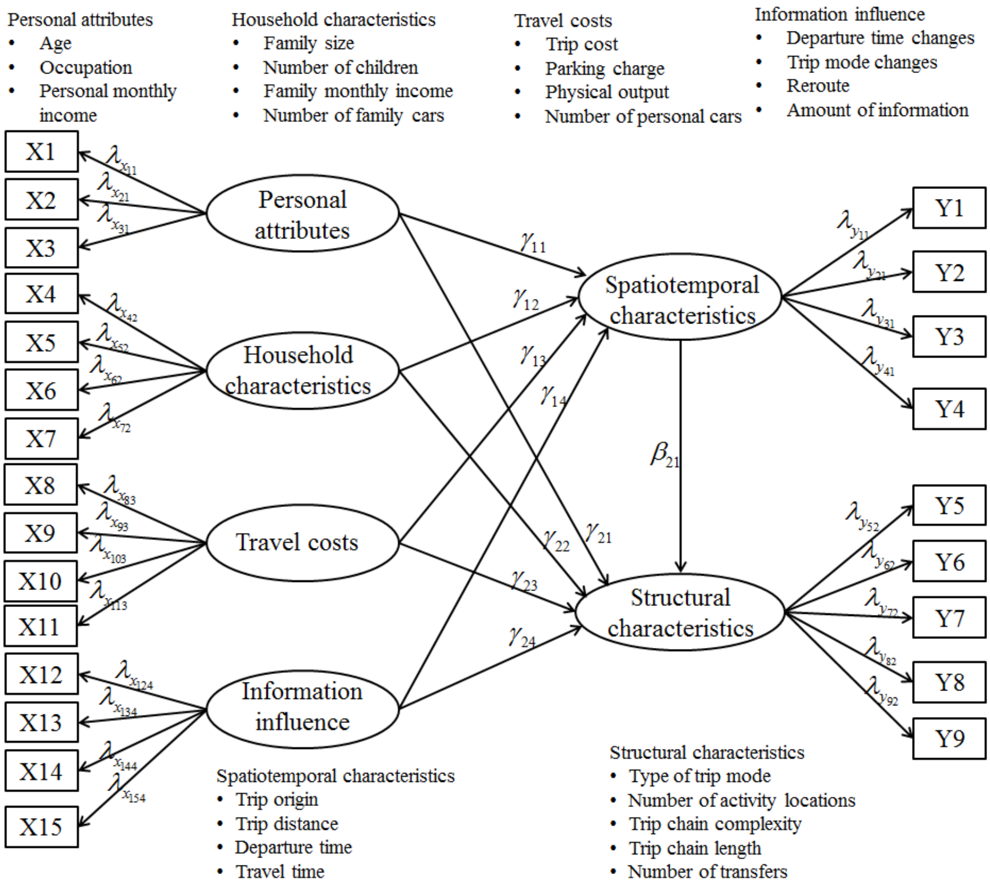

Fig.1. Initial path diagram of the holiday trip chain influencing factors

5.2.1 SEM measurement model

The SEM measurement model was built for the trip chains under the pre-trip and en-route IMTI service, respectively. The measurement model specified a set of six latent variables, namely personal attributes, household characteristics, travel costs, information influence, spatiotemporal characteristics and structural characteristics, as linear functions of their observed indicators. Such model contained the relationship between the six latent variables and their indicators based on CFA. The model parameters were estimated by the software Lisrel, using the combined method of T-value minimum value and Modification Indices (MI) maximum value corrections. The path diagrams for the measurement models under the pre-trip and en-route IMTI service are shown in Figs. 2-3, respectively. The coefficients are standardized.

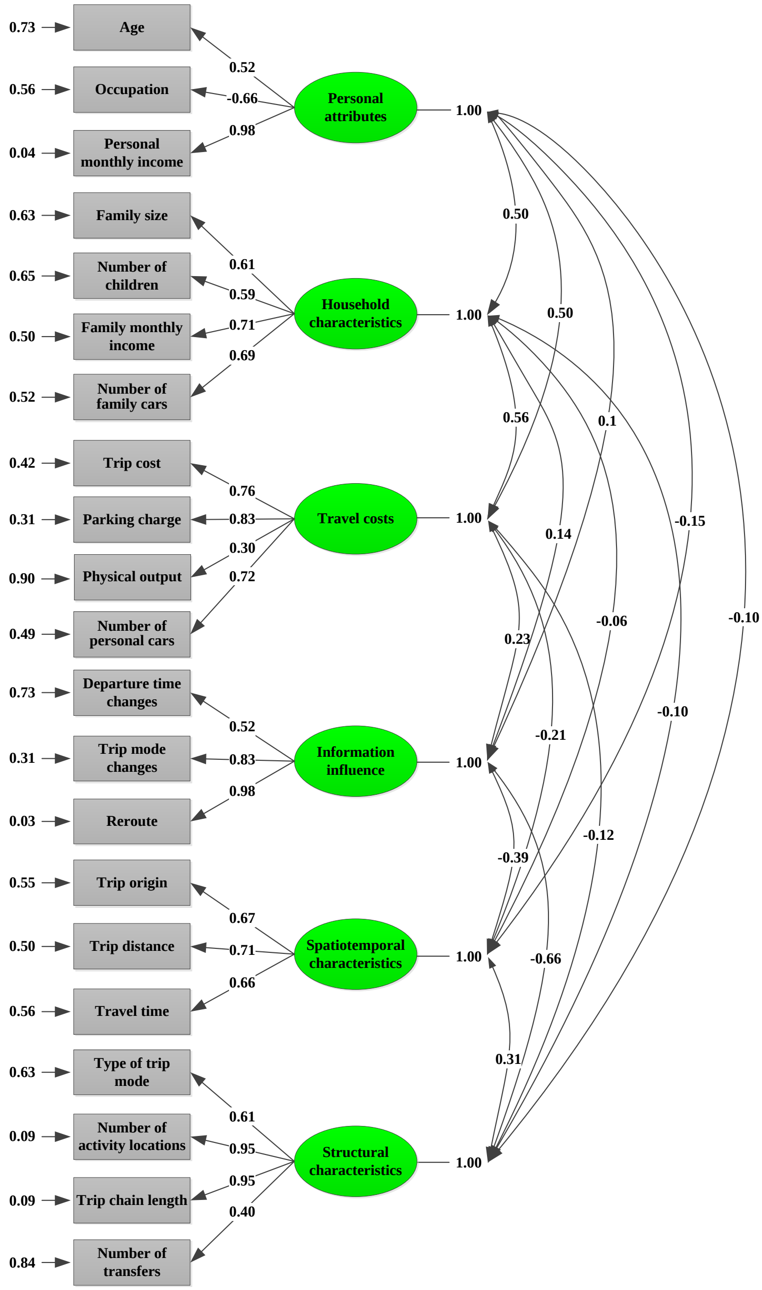

Fig.2. Path diagram for the measurement model under the pre-trip IMTI service

As shown in Fig. 2, the personal attributes have a higher standardized coefficient for occupation and personal monthly income, but lower standardized coefficient for age, which means the personal attributes mainly represent the traveler's social status and economic strength. Similarly, the household characteristics describe the traveler's family structure and economic strength (i.e. family size, number of children, family monthly income and number of family cars). Moreover, the trip cost, parking charge and number of personal cars have a stronger weight for the travel costs. Similarly, the trip mode changes and reroute have a stronger weight for the information influence. That means these factors have a strong measurement capability. In addition, the spatiotemporal characteristics give importance to the trip origin, trip distance and travel time, while the structural characteristics give more importance to the type of trip mode, number of activity locations and trip chain length rather than number of transfers.

It is important to note the positive standardized coefficient between the spatiotemporal characteristics and structural characteristics. This means there is a strong interaction between them.

The model has a χ^2 / df value of 1.98, suggesting that the model has a good fit. The RMSEA value of 0.05 indicates a good fit. Moreover, the GFI value of 0.93, the NFI value of 0.91 and the CFI value of 0.95 are considered within the acceptable range of 0 to 1. In addition, the model relationship between the factors can be explained reasonably. Hence, it can be inferred that the CFA result could provide the basis for SEM analysis.

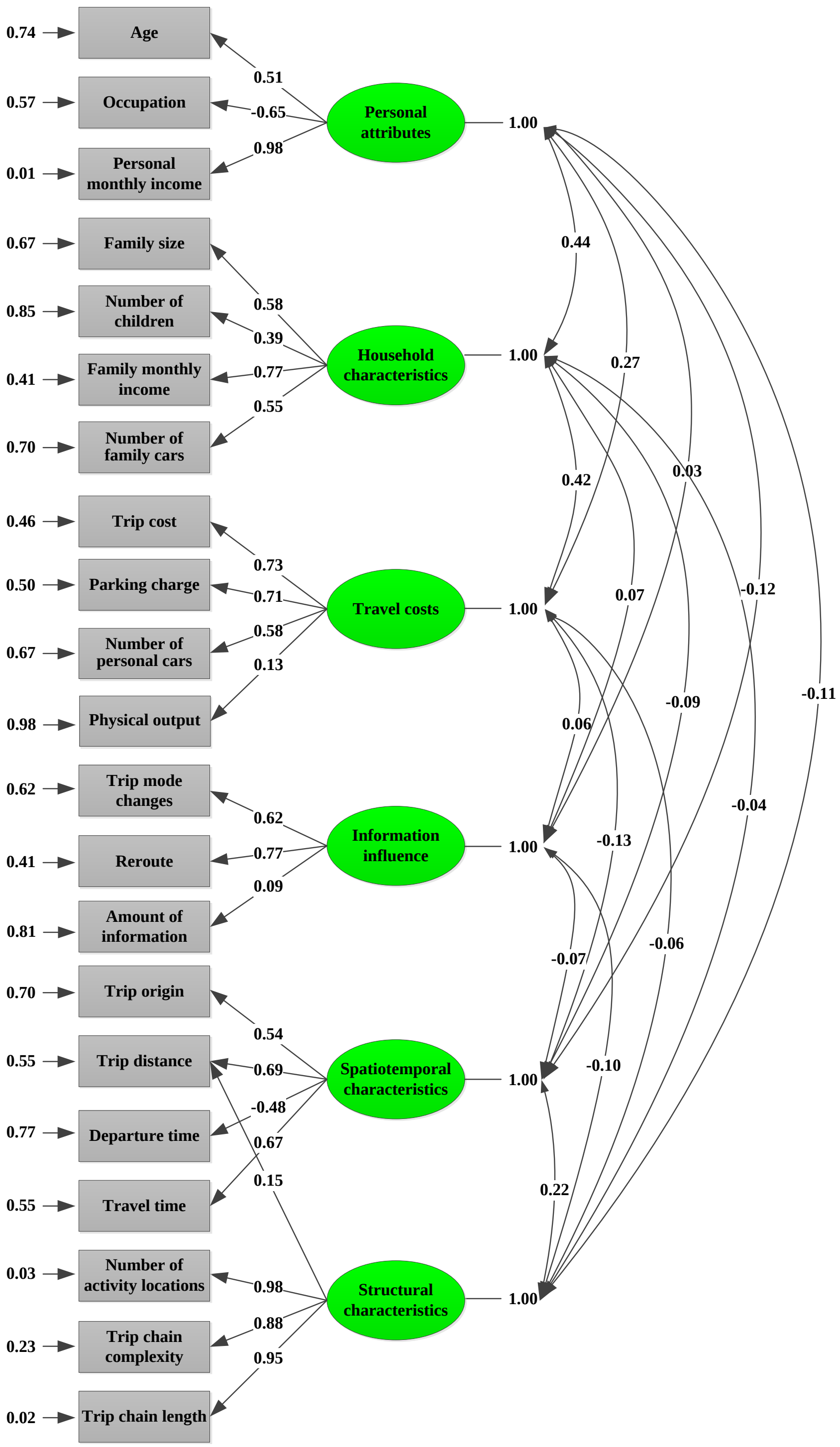

Fig.3. Path diagrams for the measurement model under the en-route IMTI service

A similar result was obtained while examining the trip chain under the en-route IMTI service. The personal attributes mainly represent the traveler's social status and economic strength, while the household characteristics mainly describe the traveler's family structure and economic strength (i.e. family size, family monthly income and number of family cars). Moreover, the trip cost, parking charge and number of personal cars have a stronger weight for the travel costs. Similarly, the trip mode changes and reroute have a stronger weight for the information influence. This means these factors have a strong measurement capability. In addition, the spatiotemporal characteristics place more importance on the trip origin, trip distance and travel time than the departure time, while the structural characteristics give more importance to the number of activity locations, trip chain length and trip chain complexity. Further, the coefficient between the spatiotemporal characteristics and structural characteristics is stronger.

The model has a χ^2 / df value of 1.58, implying that the model has a good fit. The RMSEA value of 0.042 indicates a good fit. Moreover, the GFI value of 0.95, the NFI value of 0.94 and the CFI value of 0.95 are considered within the acceptable range of 0 to 1. In addition, the model relationship between the factors can be explained reasonably and the CFA result could provide the basis for SEM analysis.

5.2.2 SEM structural model

The trip chain characteristic analysis under the pre-trip IMTI service

Based on the same inputs to the CFA model, the SEM structural model can be obtained using the Lisrel and the final path diagram of the relationship between the influencing factors and trip chain characteristics is shown in Fig.4.

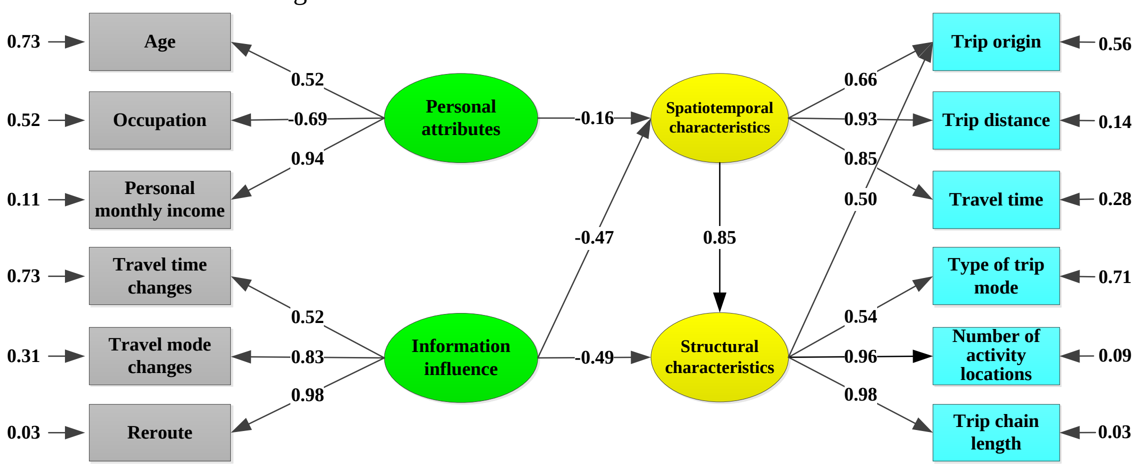

Fig.4. Final path diagram of the pre-trip IMTI influenced model structure relationship

As shown in Fig. 4, the information has an effect on the spatiotemporal characteristics and structural characteristics at the same time. This confirms the conclusion of Grotenhuis et al. (2007) that the pre-trip stage is the preferred stage to gather IMTI when planning multimodal travel. The personal attributes affect the spatiotemporal characteristics directly, and also have indirect effect on the structural characteristics. Moreover, the spatiotemporal characteristics have effect on the structural characteristics, which reveals the potential relationship between these two endogenous variables. Since the household characteristics and travel costs have little effect on these two endogenous latent variables, they were removed from the initial model during the process of model correction. In the results of the measurement model under the pre-trip IMTI service, the household characteristics describe the traveler's family structure and economic strength, and the travel costs mainly describe the trip cost, parking charge and number of personal cars. Therefore, holiday travel behavior is more influenced by personal attributes and pre-trip IMTI guidance than family economic strength and travel cost constraints. This can also be compared to the findings of Farag and

Lyons (2012) that travel behavior and personal attributes have the strongest effects on the pre-trip PT information use.

The standardized coefficient between the personal attributes and the spatiotemporal characteristics is -0.16, suggesting that the personal characteristics have limited effect on the trip chain spatiotemporal characteristics. On the other hand, the standardized coefficient between the information influence and the spatiotemporal characteristics is -0.47, while the standardized coefficient between the information influence and structural characteristics is -0.49. This indicates that pre-trip IMTI has negative influence on trip chain characteristics in the holidays. Hence, the more information received by the traveler, the greater the possibility of changing the trip mode and travel route, and the simpler the trip chain spatiotemporal and structural complexity will be. Similar results have been found in previous research (Grotenhuis et al., 2007). Therefore, it is important to investigate the effect of IMTI during holiday periods.

In addition, the standardized coefficient between the two endogenous latent variables is 0.85, which indicates that the holiday trip chain spatiotemporal characteristics are closely related to the structural characteristics. Namely, the diversity of the spatiotemporal characteristics will lead to the complexity of the trip chain structure.

SEM offers the opportunity to model complex relationships wherein one variable can be the dependent variable in one equation and an independent variable in another equation, resulting in indirect effects. The standardized coefficient between the personal attributes and structural characteristics is -0.14, which is calculated by multiplying the direct effects. This means that personal attributes have a negative effect on trip chain characteristics. Moreover, among the measurement indicators of spatiotemporal characteristics, trip distance and travel time have a strong measurement capability, indicating that the traveler's travel time and trip distance have influence on the trip chain structure complexity. Similarly, older people tend to choose a simple trip chain in the holidays, while low-income people may have transit trips which have more combined mode and number of transfers. In addition, information about trip mode and travel route could influence the traveler’s trip chain structure and spatiotemporal characteristics, such as route choice suggestion, trip mode choice suggestion, alternative bus route information or alternative subway line information.

Among the fitting indicators of the correction model, the χ^2 / df value is 1.72, the GFI value is 0.93, the RMSEA value is 0.042, the NFI value is 0.93 and the CFI value is 0.96. From the results, it can be seen that all of the correction model fitting indicators are within the recommended data range and the model has a good fit.

The trip chain characteristic analysis under the en-route IMTI service

After parameter fitting for the initial model under the influence of en-route IMTI, the final path diagram of the relationship between the influencing factors and trip chain characteristics is shown in Fig.5.

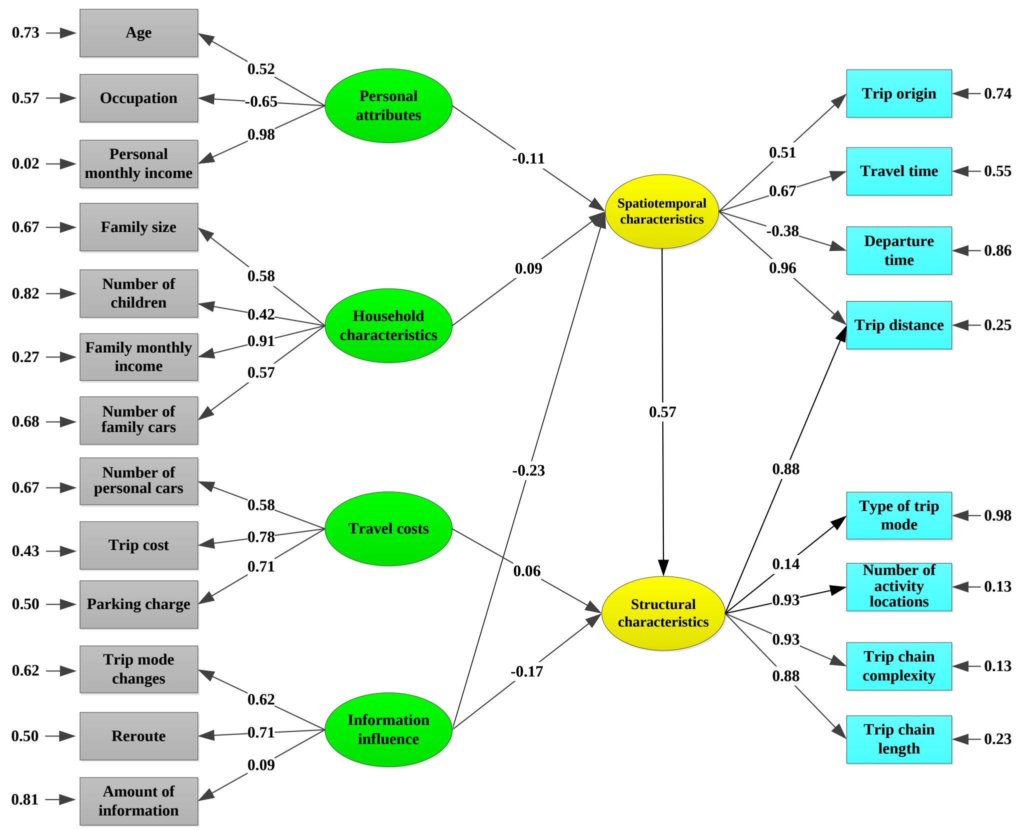

Fig.5. Final path diagram of the en-route information influenced model structure relationship

As shown in Fig. 5, household characteristics have more effect on the spatiotemporal characteristics compared to the SEM model under the pre-trip IMTI service, and travel costs have bigger effects on the structural characteristics.

The standardized coefficient between the personal attributes and spatiotemporal characteristics is -0.11, while the coefficient between the household characteristics and spatiotemporal characteristics is 0.09. The result indicates that personal characteristics have a negative effect on the trip chain spatiotemporal characteristics, while household characteristics have a positive effect. However, the influence is limited. Similarly, the influence of travel costs on structural characteristics is not great. On the other hand, the coefficient between the information influence and the spatiotemporal characteristics is -0.23, while the coefficient between the information influence and structural characteristics is -0.17. Although the coefficient is not too big, it is still larger than other factors. This indicates that the en-route IMTI has negative influence on trip chain characteristics in the holidays. In addition, the standardized coefficient between the two endogenous latent variables is 0.57, showing that the holiday trip chain spatiotemporal characteristics are closely related to the structural characteristics.

The indirect effect of household characteristics on structural characteristics is 0.05. This means that high-income families tend to choose a complex trip chain structure for holiday travel. Moreover, the earlier the departure time, the more complicated the traveler's trip chain structure. The more information received by the traveler about the trip mode and travel route, the simpler the trip chain spatiotemporal and structural complexity will be.

Among the fitting indicators of the correction model, the χ^2 / df value is 1.46, the GFI value is 0.95, the RMSEA value is 0.03, the NFI value is 0.93 and the CFI value is 0.97. From the results, it can be seen that all of the correction model fitting indicators are within the recommended data range and the model has a good fit.

6. Conclusions

Although most research on holiday travel characteristics focused on the behavioral characteristics and model analysis, the research related to the Integrated Multimodal Travel Information (IMTI) is rather limited. This study divided the IMTI into two stages (pre-trip and en-route) and first applied Exploratory Factor Analysis (EFA) to provide insight into the trip chain influencing factors and the trip chain characteristics. The Structural Equation Modeling (SEM) approach was then adopted to analyze the causal relationship between the various factors based on the prior information obtained from EFA. The empirical evidence was collected through the holiday travel behavior survey at Xidan and the Summer Palace during the 2012 Tomb-sweeping Day. IMTI covers all kinds of trip modes and there are a variety of ways to disseminate it, such as web portals, traffic radio, Variable Message Sign (VMS), call centers, Short Messaging Service (SMS) service platforms, mobile communication terminals and electronic information boards, etc.

The pre-trip IMTI has a significant effect on people's holiday travel behavior, e.g. the more travel information received by the traveler before the trip, the greater the possibility of changing the traveler's trip mode and travel route, and the simpler the trip chain spatiotemporal and structural complexity will be. The SEM results show that the pre-trip IMTI has significant influence on the number of activity locations, trip chain length, trip distance and travel time, has moderate influence on the trip origin, and has weak influence on type of trip mode. In addition, the pre-trip information has significant effect on the trip chain structure simplification, reducing travel time and travel distance, but has little influence on the choice of trip modes.

The influence of en-route IMTI on traveler's holiday travel behavior is not as strong as pre-trip IMTI. However, information still plays the most important role compared to other factors. The more information received by the traveler about the trip mode and travel route during the trip, the simpler the trip chain spatiotemporal and structural complexity will be. Moreover, household characteristics have positive effects on the spatiotemporal characteristics, and travel costs have positive effects on the structural characteristics. High-income families tend to choose a complex trip chain structure for holiday travel.

The pre-trip IMTI has bigger effects on the holiday travel behavior than en-route IMTI. This is because people's decisions cannot be easily changed with the changing environment. In general, the first impressions play a key role in the process of receiving information in the human brain. The pre-trip information often holds dominant position in the traveler's mind, which is difficult to change by en-route information. It is hard to ensure the accuracy of real time information. Therefore, different people have different acceptability of the changing information. In addition, the intelligent transportation system in China is in a fledging period, which lacks of comprehensive information types and publishing modes. People have neither an image nor a trust of the en-route information.

The pre-trip IMTI has the strongest effect on trip chain's structural characteristics, especially on the number of activity locations and trip chain length. The more pre-trip information received by the traveler, the less the number of activity locations and trip chain length will be. In addition, the influence of the information is mainly reflected in the trip mode and travel route changes.

The pre-trip IMTI also has a significant and negative influence on the trip chain's spatiotemporal characteristics. Spatiotemporal characteristics are mainly described by the trip distance and travel time, so the more information received by the traveler, the simpler the trip chain spatiotemporal complexity will be. Moreover, the information about trip mode and travel route catches the traveler's attention to adjust their travel behavior.

The results of this study can provide a reference for policy makers regarding the holiday traffic demand management. There are some recommendations for effectively alleviating the holiday traffic congestions in China. First, policy makers should focus on the construction of an Intelligent Transportation System (ITS) and pay more attention to the pre-trip IMTI. In addition, the en-route IMTI service level needs to be improved as soon as possible. Second, the available information should be mainly about trip mode and travel route, such as route choice, trip mode choice, alternative bus route information and alternative subway line information.

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