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

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[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.

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

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

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

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

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

78   This study is organized as follows. Section 2 briefly reviews the literature on tour-based analysis,
79 holiday travel behavior analysis and the impact analysis of IMTI on travel behavior. It also indicates the
80 shortage of existing research and then clarifies the contribution of this study. Section 3 describes the
81 modeling approaches and explains the meaning of the variables used in the models. Section 4 contains the

82 data and survey, and a discussion of the model results is then presented in Section 5. Finally, the important
83 findings and recommendations for future study are summarized.

84

85 2. Literature review

86 *2.1 Tour-based analysis*

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

102 Tour-related characteristics include trip chain length, total time travelled, number of activity locations,
103 tour frequency, number of transfers, trip mode, etc. (Chu, 2003; McGuckin and Nakamoto, 2004; Li et al.,
104 2013). Some studies use these characteristics as dependent variables to explore the effect of land use on
105 tour characteristics (Limanond and Niemeier, 2004; Maat and Timmermans, 2006; Van Acker et al., 2014).
106 Some consider tour-related characteristics simultaneously with trip-related characteristics (Srinivasan,
107 2002; Frank et al., 2008; Van Acker and Witlox, 2011). Moreover, some researchers think personal
108 preferences, socio-demographic characteristics and the built environment could influence people's activity
109 choice (Chang and Mahmassani, 1988; Kim et al., 1994; Jenelius et al., 2011; Grigolon et al., 2013).
110 However, the influencing factors are usually provided first and most studies verify the relationship between
111 the factors and the tour characteristics based on confirmatory factor analysis. Therefore, few studies have
112 identified the major true influencing factors and considered their influence integrally.

113 *2.2 Holiday travel behavior analysis*

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

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

130   *2.3 Impact of IMTI on travel behavior*

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

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

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

151

3. Methodology

153   *3.1 Research thinking*

154   Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) are different types of
155   factor analysis. The former uses specific criteria to explore the factorial structure from the measurement
156   scales with no information of the influencing factors, while the latter is used to verify whether the
157   measurement scales can measure the factorial structure effectively based on prior analysis results (Brown,
158   2012; Comrey and Lee, 2013). However, although EFA and CFA are different in their basic ideas,
159   theoretical hypotheses and analytical procedures, they interrelate and interact with each other in the
160   practical application of management research. In the development of the factor analysis theory, an EFA is
161   often performed first, and analysis of the results can provide a theoretical basis for the subsequent CFA
162   (Anderson and Gerbin, 1988; Golob, 2003). Generally, if there is no solid theory foundation on which to
163   build the factorial structure, an EFA is usually performed first to generate a theory about the internal

164 structure and, then, a CFA is used to verify this structure. In addition, EFA and CFA should have
165 non-overlapping samples (Anderson and Gerbin, 1988). Therefore, it is reasonable to select a part of the
166 data to perform EFA first and then utilize the remaining data for CFA.

167   CFA is the basis of Structural Equation Modeling (SEM). It is the CFA method that the SEM
168 measurement model uses to verify the factorial structure of measurement scales. SEM is a confirmatory
169 method used to test whether the theoretical model holds and corresponds to real data or not. An SEM with
170 latent variables is composed of two sub-models: (1) A measurement model is used to specify latent
171 (unobserved) variables as the linear functions (weighted averages) of other variables. (2) A structural
172 model is used to capture the causal influences (regression effects) of the exogenous variables on the
173 endogenous variables and the causal influences of endogenous variables upon one another (Bentler, 1980;
174 Bollen, 1998; Golob, 2003). From the methodological point of view, it is recommended that the
175 measurement model should be developed first, followed by the structural model (Anderson and Gerbing,
176 1988; Van Acker et al., 2007; Wang et al., 2011). Moreover, the fruits of EFA can provide a theoretical
177 basis to guide construction of the SEM measurement model. Therefore, this study uses EFA before the
178 SEM analysis.

179 *3.2 Exploratory factor analysis*

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

184 $$x_i = \lambda_{i1}\xi_1 + \lambda_{i2}\xi_2 + \cdots + \lambda_{in}\xi_n + \delta_i, i = 1, 2, \cdots, q, n \leq q \tag{1}$$

185 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

186 variables); λ_{ij} is estimated coefficient, called factor loading. Its statistical significance represents the

187 correlation between the observed variables and common factors (Fabrigar et al., 1999). Since the observed

188 variables and common factors are standardized variables, the correlative coefficient matrix is equal to the

189 covariance matrix, and δ_i is the error term.

190   The key task is to obtain λ_{ij} and the most common method to determine this parameter is Principal

191 Component Analysis (PCA). PCA is a statistical method that uses orthogonal transformation to convert a
192 set of possibly correlated observed variables into linearly uncorrelated principal components, i.e. the
193 common factors in EFA (Jollifee, 2005). The general form of PCA can be expressed as follows:

194
$$\begin{cases} y_1 = r_{11}x_1 + r_{12}x_2 + \cdots + r_{1q}x_q \\ y_2 = r_{21}x_1 + r_{22}x_2 + \cdots + r_{2q}x_q \\ \cdots\cdots \\ y_n = r_{n1}x_1 + r_{n2}x_2 + \cdots + r_{nq}x_q \end{cases} \tag{2}$$

195 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 0.01 in 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

238 between exogenous latent variables and endogenous latent variables; ζ is a $m \times 1$ residual error vector.

239 A full SEM contains eight parameters including Λ_y, Λ_x, B, Γ, Φ, Ψ, Θ_ε, Θ_δ. Here, Φ and Ψ

240 are the covariance matrixes of ξ and ζ. Θ_ε and Θ_δ are the covariance matrixes of ε and δ.

241 There are five steps of the solution of SEM: (1) Specification. Set up the initial hypothesis model,

242 based on the mature theory or previous research results. (2) Identification. This step decides whether the

243 model can obtain the unique solution in estimation. (3) Estimation. Input the sample data into the initial

244 model and estimate the eight parameter matrices. (4) Evaluation. Evaluate the effectiveness of the

245 calculated model, including the significance of the model parameters, the goodness of the fitted values, etc.

246 (5) Modification. If the evaluation result is not satisfactory, modify the model and repeat the previous steps

247 until obtaining the most reasonable and best-fitted model.

248 This paper uses the Maximum Likelihood Estimation (MLE) method and chooses five goodness-of-fit

249 indicators to evaluate the model performance, namely: the ratio of chi-square value to the degrees of

250 freedom (χ^2/df); the goodness of fit index (GFI); the root mean square error of approximation (RMSEA);

251 the Bentler-Bonett normed fit index (NFI); and the comparative fit index (CFI). In practice, the

252 recommended acceptance of a good fit to a model requires that the obtained GFI, NFI and CFI value

253 should have a range from 0 to 1, with higher value indicating better model fit. A cut-off criterion of

254 $CFI \geq 0.95$ is presently recognized as indicative of good fit (Hu and Bentler, 1999), while values of GFI

255 and NFI greater than 0.90 are usually interpreted as indicating an acceptable fit (Hu and Bentler, 1999;

256 Schermelleh-Engel et al., 2003; Sanders et al., 2005). Traditionally, $RMSEA \leq 0.05$ can be considered as a

257 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,

258 whereas $RMSEA > 0.10$ is not acceptable (Browne and Cudeck, 1993; Van Acker and Witlox, 2010).

259 However, a cut-off value close to 0.06, or a stringent upper limit of 0.07, seems to be the recent general

260 consensus amongst authorities (Hu and Bentler, 1999; Steiger, 2007). Moreover, there is no absolute

261 standard for an acceptable of χ^2/df; the recommendation is that $\chi^2/df < 2$ is indicative of a good fit (Byrne,

262 1991; Hooper et al., 2008). However, this value may increase with larger samples (Bollen, 1989).

263 *3.4 Variables*

264 Some researchers have found that personal preferences, socio-demographic characteristics and the

265 built environment could influence people's activity choice. Therefore, the observed variables used in the

266 EFA and SEM models are shown in Table 1.

267 **Table 1**

268 **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

269   Some indicators are explained, especially:

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

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

282   (3) Trip chain structural characteristics: the four indicators are the statistical result of a traveler's
283   one-day trip chain in the holidays. The type of trip mode means the combination of trip modes in one-day
284   travel, and can be divided into single mode and combined mode. The trip chain length refers to the sum of
285   the trips, whose value is equal or greater than 2. The number of activity locations refers to the number of
286   the traveler's main destinations, excluding the starting and end points (i.e. home). The number of transfers
287   is the sum of the number of transfers between different trip modes and the number of transfers between
288   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

331 56 from the Summer Palace. (2) 375 questionnaires were obtained through face-to-face interview, with 329
332 being effective (effective rate of 87.73%). Among the valid questionnaires, 177 were from Xidan and 152
333 from the Summer Palace. Invalid questionnaires were mainly due to the incompleteness of the trip chain or
334 missing data. By comparing the postal survey with face-to-face interview, the efficiency of the latter was
335 higher than the former. Therefore, face-to-face interview is more suitable for an RP-SP survey of holiday
336 travel behavior in terms of sample size, validity rate and survey period.

337 *4.2 Sample difference and questionnaire reliability analysis*

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

343 **Table 2**

344 **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		

345 "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
346 en-route IMTI. "**" means the correlation is significant at the confidence level of 0.01; "*" means the correlation is significant at the
347 confidence level of 0.05.

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

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

358   0.7 is acceptable, whereas $\alpha < 0.6$ is not acceptable (Moss et al., 1998). Table 3 presents the Cronbach's

359   Alpha coefficient of each construct, and is the result of the total sample of postal survey and face-to-face

360   interview.

361   **Table 3**

362   **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

363   In Table 3, each Cronbach's Alpha coefficient is above 0.6, which means the questionnaire is

364   acceptable and can be used for further data analysis.

4.3 Operationalization of variables

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

367   The traveler characteristics: for personal attributes, the majority of the travelers at these two sites

368   were 20-30 years old (Xidan=61.35%, the Summer Palace=61.06%), most of whom were staff (36.87%)

369   and students (35.18%). Additionally, 90% of them had high school certificate or above, which means most

370   of the travelers at the two sites were young and well educated. Moreover, more than 80% travelers had no

371   children and about two-thirds (69.63%) had monthly incomes lower than 4000 RMB. In the household

372   characteristics, most of the travelers (71.5%) in Xidan were married while about half (42.79%) in the

373   Summer Palace were single. Nearly one-third (30.38%) of the families had cars. Among the car owners,

374   more than half (53.47%) were from Xidan. By contrast, the ratio of bicycle owners was much greater

375   than those of car owners, and more than half (56.38%) of the families had bicycles. In addition, the

376   travelers at these two sites were mainly working-class young people, so most individuals and families had

377   traveled by public transportation with lower travel costs.

378   Travel activity: the data of the travel activity variables are statistics for the single trip, the destination

379   of which was Xidan or the Summer Palace. With Xidan and the Summer Palace as the activity locations,

380   the trip origins were evenly distributed in each loop of Beijing (about 20% between each ring road), which

381   indicates the random nature of the sample. The average trip distance was 18.87 km and the average travel

382   time was about one hour. The single mode mainly included bus (18.55%) and metro (28.19%), while the

383   combined mode was in the majority (45.06%). The trip chain's statistical indicators show that 35.18% of

384   the trip chains had more than one activity location and the average trip chain length was 2.49, while the

385   average transfer time was 0.96.

386   IMTI: for the pre-trip information, 63.46% of the Summer Palace travelers needed to obtain the

387   information of traffic conditions in advance, while the number for Xidan was only 41.55%. The precise

388   question was "Do you need to obtain the information regarding traffic conditions before going to Xidan or

389   the Summer Palace: yes/no". This might be relevant to the main trip modes in these two places. There were

390   more travelers in Xidan who took the metro for the trip, which has a fixed frequency and time schedule.

391   This study also investigated travelers at Xidan who didn't need to obtain information about traffic

392   conditions in advance, and most of them said that the metro was reliable and punctual. In addition,

393   respondents had to choose the information they needed before going to Xidan or the Summer Palace from

394   the information list, and order it by importance. According to the ranking of the pre-trip IMTI, travelers at

395 Xidan cared more about traffic congestion while travelers at the Summer Palace cared more about travel
396 time. Compared with pre-trip IMTI, the demand of the en-route IMTI was lower. Only 35.75% of the
397 Xidan travelers took the travel information guidance during the trip, while 51.92% of the Summer Palace
398 travelers did likewise. The precise question was: "Do you accept the travel information guidance during
399 the trip to Xidan or the Summer Palace: yes/no". As for the content of en-route information, travelers at
400 both sites cared more about traffic congestion and public transport schedules.
401   In order to demonstrate the influence of IMTI on the travel activity, Table 4 presents a comparison of
402 statistical indicators between the actual trip chain and the trip chain affected by pre-trip and en-route IMTI.
403 **Table4**
404 **Comparison between the actual trip chain and the trip chain affected by the integrated multimodal**
405 **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	

406   It can be seen from Table 4 that:

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

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

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

419

420 # 5. Result analysis

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

424 *5.1 Exploratory factor analysis*

425   According to the basic principles and data type requirements of EFA, 20 variables were selected from

426 the questionnaire under the pre-trip and en-route IMTI service, respectively. First, the KMO and Bartlett

427 testing results show that the KMO values are 0.749 and 0.717 and Bartlett testing statistic Sig. are both

428 equal to 0.00. Therefore, there is a significant correlation between the variables and it is necessary to carry

429 out factor analysis. Next, the study uses principal component and maximum variance method to estimate

430 the factor loading matrix and extract the common factors. The results are shown in Tables 5-6.

431 **Table 5**

432 **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

433

434 **Table 6**

435 **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

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

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

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

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

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

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

456   (6) Trip chain structural characteristics: the number of activity locations, trip chain length, trip chain
457 complexity and the number of transfers are statistical indicators of the trip chain. In the activity system,
458 these indicators portray the traveler's travel choice and reflect the complexity of the trip chain.
459 Furthermore, a trip chain is actually a combination of multiple activities, which reflect the connection form
460 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.
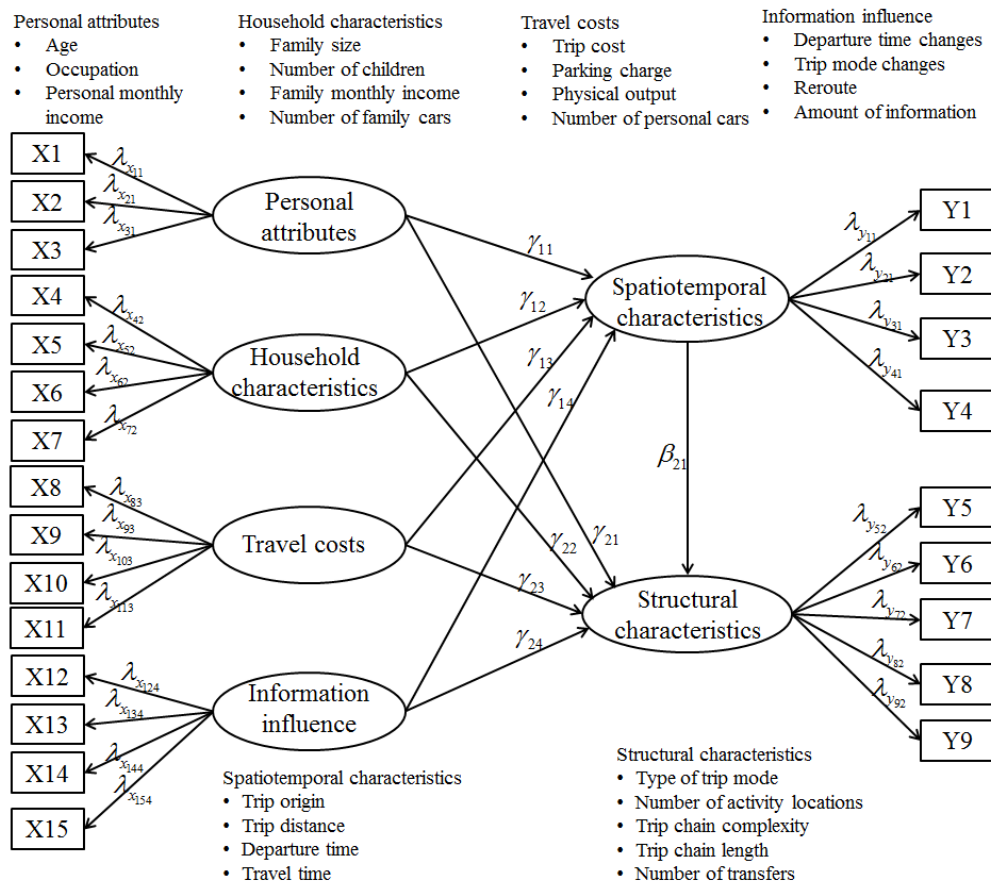
Fig.1. Initial path diagram of the holiday trip chain influencing factors

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

482 under the pre-trip and en-route IMTI service are shown in Figs. 2-3, respectively. The coefficients are
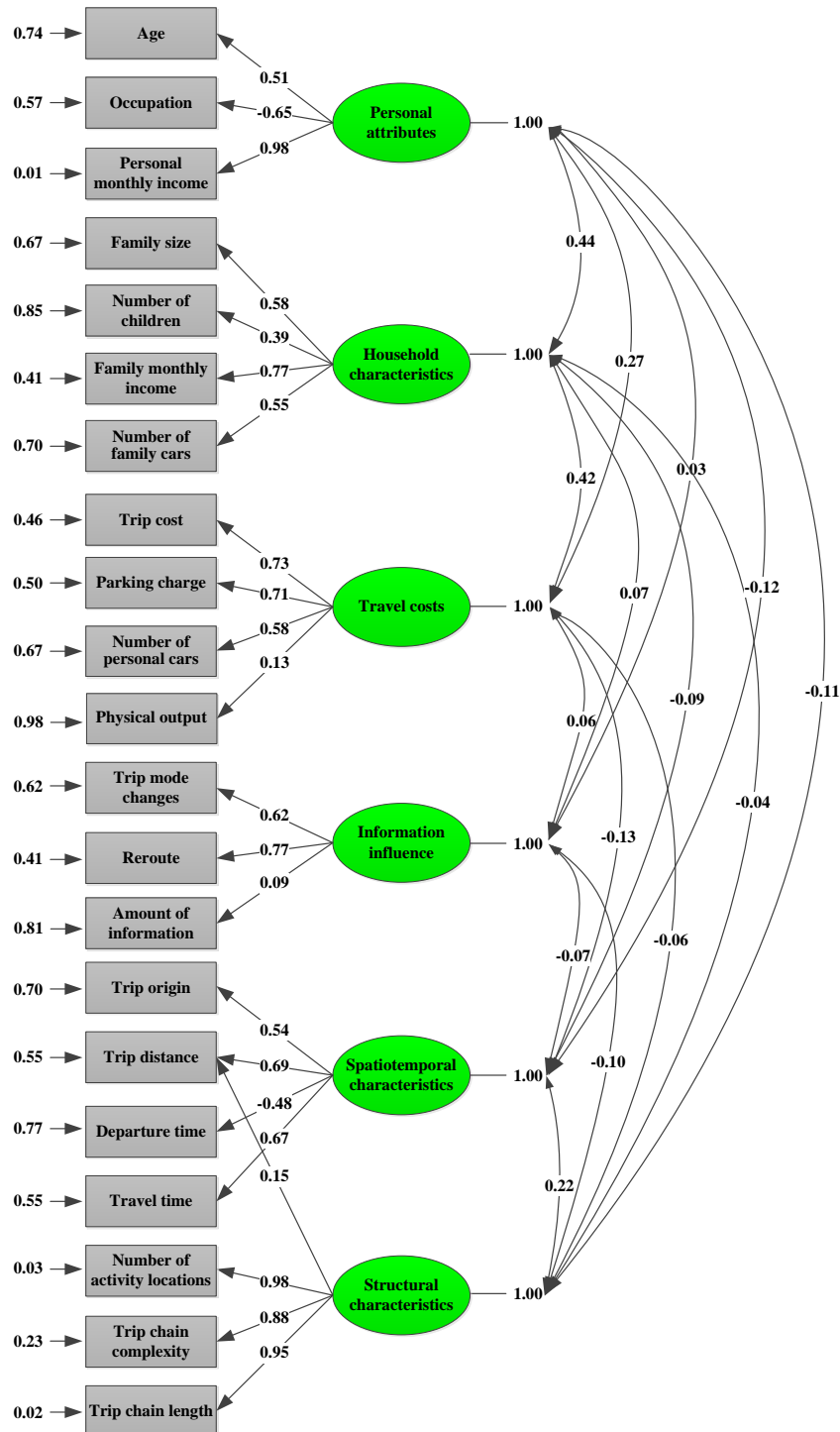483 standardized.
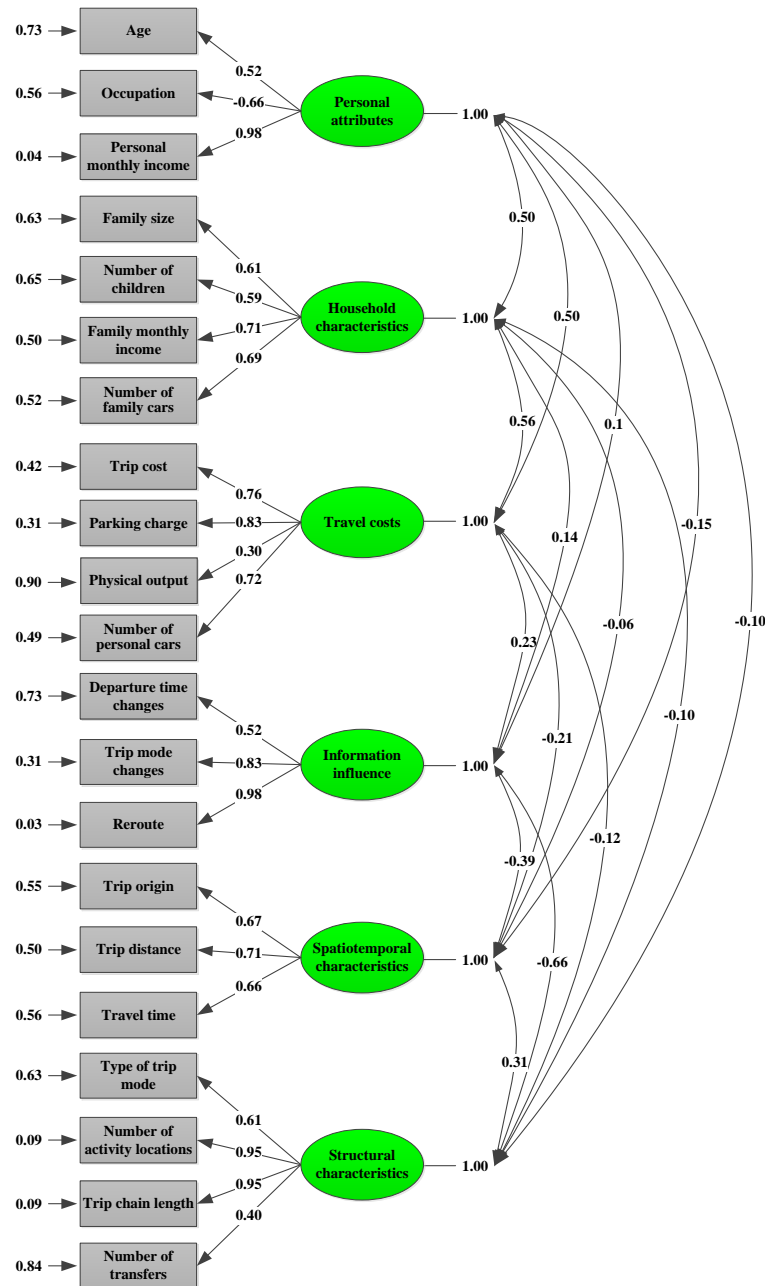
484
485 **Fig.2. Path diagram for the measurement model under the pre-trip IMTI service**

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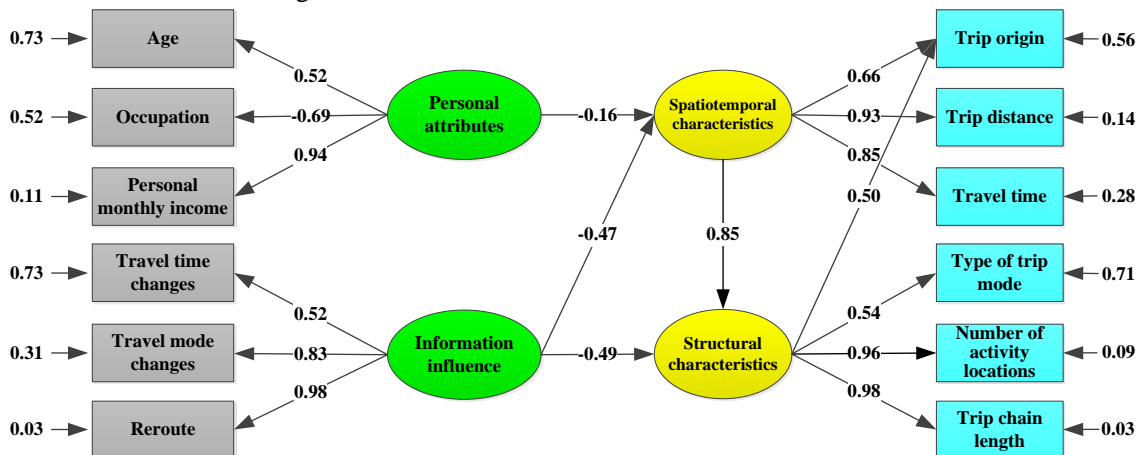487 personal monthly income, but lower standardized coefficient for age, which means the personal attributes
488 mainly represent the traveler's social status and economic strength. Similarly, the household characteristics
489 describe the traveler's family structure and economic strength (i.e. family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

496   It is important to note the positive standardized coefficient between the spatiotemporal characteristics
497 and structural characteristics. This means there is a strong interaction between them.
498   The model has a χ^2 / df value of 1.98, suggesting that the model has a good fit. The RMSEA value of
499 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
500 are considered within the acceptable range of 0 to 1. In addition, the model relationship between the factors
501 can be explained reasonably. Hence, it can be inferred that the CFA result could provide the basis for SEM
502 analysis.

503
504   **Fig.3. Path diagrams for the measurement model under the en-route IMTI service**
505   A similar result was obtained while examining the trip chain under the en-route IMTI service. The

18

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

538 Lyons (2012) that travel behavior and personal attributes have the strongest effects on the pre-trip PT
539 information use.
540   The standardized coefficient between the personal attributes and the spatiotemporal characteristics is
541 -0.16, suggesting that the personal characteristics have limited effect on the trip chain spatiotemporal
542 characteristics. On the other hand, the standardized coefficient between the information influence and the
543 spatiotemporal characteristics is -0.47, while the standardized coefficient between the information
544 influence and structural characteristics is -0.49. This indicates that pre-trip IMTI has negative influence on
545 trip chain characteristics in the holidays. Hence, the more information received by the traveler, the greater
546 the possibility of changing the trip mode and travel route, and the simpler the trip chain spatiotemporal and
547 structural complexity will be. Similar results have been found in previous research (Grotenhuis et al.,
548 2007). Therefore, it is important to investigate the effect of IMTI during holiday periods.
549   In addition, the standardized coefficient between the two endogenous latent variables is 0.85, which
550 indicates that the holiday trip chain spatiotemporal characteristics are closely related to the structural
551 characteristics. Namely, the diversity of the spatiotemporal characteristics will lead to the complexity of
552 the trip chain structure.
553   SEM offers the opportunity to model complex relationships wherein one variable can be the
554 dependent variable in one equation and an independent variable in another equation, resulting in indirect
555 effects. The standardized coefficient between the personal attributes and structural characteristics is -0.14,
556 which is calculated by multiplying the direct effects. This means that personal attributes have a negative
557 effect on trip chain characteristics. Moreover, among the measurement indicators of spatiotemporal
558 characteristics, trip distance and travel time have a strong measurement capability, indicating that the
559 traveler's travel time and trip distance have influence on the trip chain structure complexity. Similarly,
560 older people tend to choose a simple trip chain in the holidays, while low-income people may have transit
561 trips which have more combined mode and number of transfers. In addition, information about trip mode
562 and travel route could influence the traveler's trip chain structure and spatiotemporal characteristics, such
563 as route choice suggestion, trip mode choice suggestion, alternative bus route information or alternative
564 subway line information.
565   Among the fitting indicators of the correction model, the χ^2 / df value is 1.72, the GFI value is 0.93,
566 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
567 that all of the correction model fitting indicators are within the recommended data range and the model has
568 a good fit.

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

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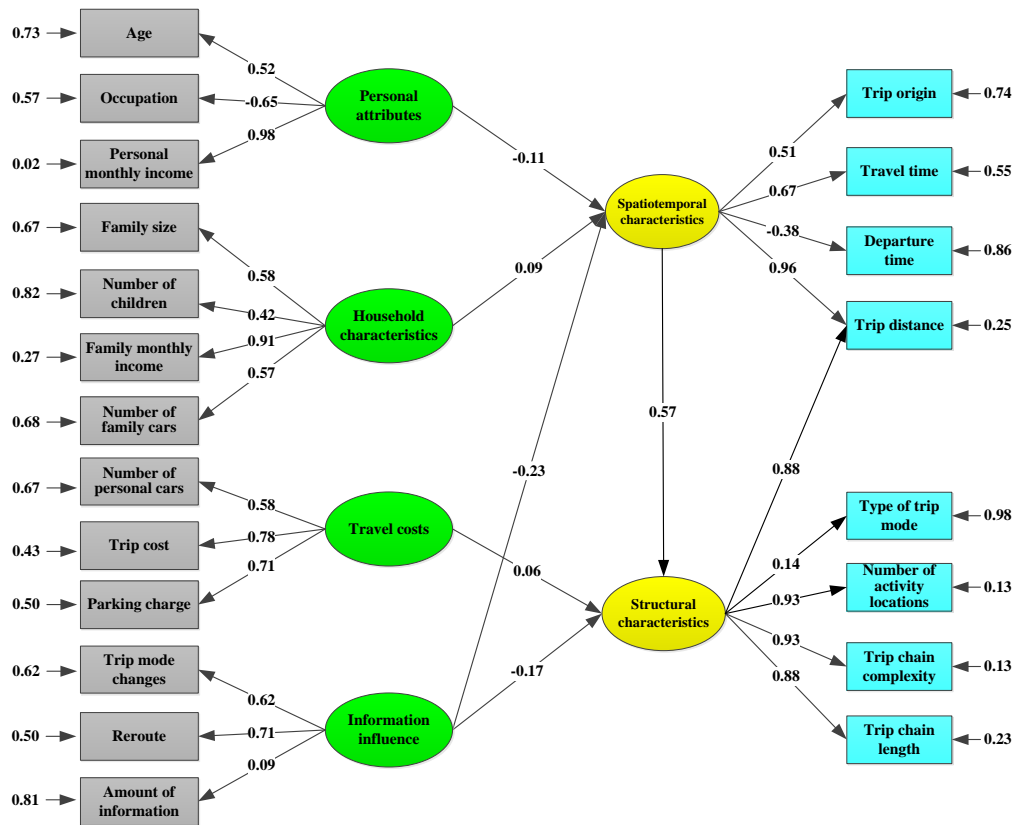
Fig.5. Final path diagram of the en-route information influenced model structure relationship

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.

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

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References

653　Anderson, J. C., Gerbing, D. W. (1988) 'Structural equation modeling in practice: A review and
654　　　　recommended two-step approach', Psychological bulletin, 103(3), pp.411.
655　Anowar, S., Yasmin, S., and Tay, R. (2013) 'Comparison of crashes during public holidays and regular
656　　　　weekends', Accident Analysis and Prevention, 51, 93-97.
657　Asakura, Y., Iryo, T. (2007) 'Analysis of tourist behavior based on the tracking data collected using a
658　　　　mobile communication instrument', Transportation Research Part A, 41(7), pp. 684-690.
659　Baumol, W. J., Ide, E. A. (1956) 'Variety in retailing', Management Science, 3(1), pp. 93–101.
660　Bekhor, S., and Albert, G. (2014) 'Accounting for sensation seeking in route choice behavior with travel
661　　　　time information', Transportation research part F: traffic psychology and behaviour, 22, pp. 39-49.
662　Ben-Elia, E., Di Pace, R., Bifulco, G. N., and Shiftan, Y. (2013) 'The impact of travel information's
663　　　　accuracy on route-choice', Transportation Research Part C: Emerging Technologies, 26, pp. 146-159.
664　Bentler, P. M. (1980) 'Multivariate analysis with latent variables: Causal modeling', Annual review of
665　　　　psychology, 31(1), pp.419-456.
666　Berry, B. J. L., Barnum, H. G., Tennant R. J. (1962) 'Retail location and consumer behavior', Papers and
667　　　　Proceedings of the Regional Science Association, 9(1), pp. 65-106.
668　Bollen, K. A. (1989) Structural equations with latent variables. New York: Wiley.
669　Bollen, K. A. (1998). Structural equation models. John Wiley and Sons, Ltd.
670　Brown, T. A. (2012). Confirmatory factor analysis for applied research. Guilford Press.
671　Browne, M., Cudeck, R., (1993) Alternative ways of assessing model fit. In: Bollen, K., Long, J. (Eds.),
672　　　　Testing Structural Equation Models. Sage, New Park, CA, pp. 136-162.
673　Byrne, B.M., (1991) 'The Maslach burnout inventory: validating factorial structure and invariance across
674　　　　intermediate, secondary, and university educators', Multivariate Behavioral Research 26, pp. 583-605.
675　Carrion, C., Levinson, D. (2012) 'Value of travel time reliability: A review of current evidence',
676　　　　Transportation research part A, 46(4), pp. 720-741.
677　Chang, G. L., Mahmassani, H. S. (1988) 'Travel time prediction and departure time adjustment behavior
678　　　　dynamics in a congested traffic system', Transportation Research B, 22(3), pp. 217-232.
679　Choo, S., Lee, H. and Hong, D. (2012) 'Exploring Weekend Travel Behavior in a Developing Country: An
680　　　　Empirical Study of Seoul', In Transportation Research Board 91st Annual Meeting, Washington DC,
681　　　　2012.

682   Chu, Y. L. (2003) 'Empirical analysis of commute stop-making behavior', Transportation Research Record:
683   Journal of the Transportation Research Board, 1831(1), pp. 106-113.

684   Comrey, A. L., and Lee, H. B. (2013). A first course in factor analysis. Psychology Press.

685   Cools, M., Moons, E., and Wets, G. (2007) 'Investigating effect of holidays on daily traffic counts: time
686   series approach', Transportation Research Record: Journal of the Transportation Research Board,
687   2019(1), pp. 22-31.

688   Cools, M., Moons, E., and Wets, G. (2010) 'Assessing the impact of public holidays on travel time
689   expenditure', Transportation Research Record: Journal of the Transportation Research Board, 2157(1),
690   pp. 29-37.

691   Costello, A. B., Osborne, J. W. (2005) 'Best practices in exploratory factor analysis: Four
692   recommendations for getting the most from your analysis', Practical Assessment Research and
693   Evaluation, 10(7), pp. 1-9.

694   Ding, C., Lin, Y., and Liu, C. (2014) 'Exploring the influence of built environment on tour-based
695   commuter mode choice: A cross-classified multilevel modeling approach'. Transportation Research
696   Part D: Transport and Environment, 32, pp.230-238.

697   Fabrigar, L. R., Wegener, D. T., MacCallum, R. C., and Strahan, E. J. (1999) 'Evaluating the use of
698   exploratory factor analysis in psychological research', Psychological methods, 4(3), pp. 272–299.

699   Farag, S., Lyons, G. (2008) 'What affects use of pre-trip public transport information? empirical results of
700   a qualitative study', Transportation Research Record, 2069(1), pp. 85-92.

701   Farag, S., Lyons, G. (2012) 'To use or not to use? An empirical study of pre-trip public transport
702   information for business and leisure trips and comparison with car travel', Transport Policy, 20, pp.
703   82-92.

704   Frank, L., Bradley, M., Kavage, S., Chapman, J., Lawton, K. (2008) 'Urban form, travel time, and cost
705   relationships with tour complexity and mode choice', Transportation, 35, pp. 37-54.

706   Golob, T. F. (2003) 'Structural equation modeling for travel behavior research', Transportation Research
707   Part B, 37(1), pp. 1-25.

708   Grigolon, A. B., Kemperman, A. D., and Timmermans, H. J. (2013) 'Mixed multinomial logit model for
709   out-of-home leisure activity choice', Transportation Research Record: Journal of the Transportation
710   Research Board, 2343(1), pp. 10-16.

711   Grotenhuis, J. W., Wiegmans, B. W. and Rietveld, P. (2007) 'The desired quality of integrated multimodal
712   travel information in public transport: Customer needs for time and effort savings', Transport Policy,
713   14(1), pp. 27-38.

714   Guo, J. F. (2012) Beijing Transport Annual Report 2011. Beijing Transportation Research Center.

715   Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E. and Tatham, R. L. (2010) Multivariate data analysis
716   (Vol. 7), Prentice Hall Press, NJ.

717   Hine, J., Scott, J., (2000) 'Seamless, accessible travel: users' views of the public transport journey and
718   interchange', Transport Policy, 7, pp. 217-226.

719   Ho, C. Q., & Mulley, C. (2013) 'Multiple purposes at single destination: A key to a better understanding of
720   the relationship between tour complexity and mode choice', Transportation Research Part A: Policy
721   and Practice, 49, pp. 206-219.

722   Hooper, D., Coughlan, J., and Mullen, M. R. (2008) 'Structural equation modelling: Guidelines for
723   determining model fit', Electronic Journal of Business Research Methods, 6(1).

724   Hu, L. T., and Bentler, P. M. (1999) 'Cutoff criteria for fit indexes in covariance structure analysis:
725   Conventional criteria versus new alternatives', Structural Equation Modeling: A Multidisciplinary

726   Journal, 6(1), pp. 1-55.

727   Jenelius, E., Mattsson, L. G., Levinson, D. (2011) 'Traveler delay costs and value of time with trip chains,
728   flexible activity scheduling and information', Transportation Research Part B, 45(5), pp.789-807.

729   Jolliffe, I. (2005) Principal component analysis. John Wiley and Sons, Ltd.

730   Kaiser, H.F. (1960) 'The application of electronic computers to factor analysis', Educational and
731   Psychological Measurement 20, pp. 141-151.

732   Kaplan, S., Manca, F., Nielsen, T. A. S., and Prato, C. G. (2015) 'Intentions to use bike-sharing for holiday
733   cycling: an application of the Theory of Planned Behavior', Tourism Management, 47, 34-46.

734   Kattan, L., de Barros, A. G., and Saleemi, H. (2013) 'Travel behavior changes and responses to advanced
735   traveler information in prolonged and large-scale network disruptions: A case study of west LRT line
736   construction in the city of Calgary', Transportation Research Part F: Traffic Psychology and
737   Behaviour, 21, pp.90-102.

738   Kenyon, S., and Lyons, G. (2003) 'The value of integrated multimodal traveler information and its
739   potential contribution to modal change', Transportation Research Part F: Traffic Psychology and
740   Behaviour, 6(1), pp. 1-21.

741   Kim, H., Sen, A., Soot S., Christopher E. (1994) 'Shopping trip chains: current patterns and changes Since
742   1970', Transportation Research Record, 1443, pp. 38-44.

743   Kraan, M., Mahmassani, H. S., and Huynh, N. (2000) 'Interactive survey approach to study traveler
744   responses to ATIS for shopping trips'. Paper presented at 79th Annual Meeting in Transportation
745   Research Board, Washington DC, 2000.

746   Krizek, K. J. (2003) 'Neighborhood services, trip purpose, and tour-based travel', Transportation, 30(4),
747   pp.387-410.

748   Lee, Y., Hickman, M., and Washington, S. (2007) 'Household type and structure, time-use pattern, and
749   trip-chaining behavior'. Transportation Research Part A: Policy and Practice, 41(10), pp. 1004-1020.

750   Li, Z., Wang, W., Yang, C., and Jiang, G. (2013) 'Exploring the causal relationship between bicycle choice
751   and trip chain pattern', Transport Policy, 29, pp. 170-177.

752   Limanond, T., Niemeier, D.A. (2004) 'Effect of land use on decisions of shopping tour generation: A case
753   study of three traditional neighbourhoods in WA', Transportation, 31, pp. 153-181.

754   Liu, T., Zhang, C., Wang, T., and Wu, G. (2013) 'Effects of friends' information interaction on travel
755   decisions', Journal of Transportation Systems Engineering and Information Technology, 13(6), pp.
756   86-93.

757   Liu, Z., and Sharma, S. (2006) 'Statistical investigations of statutory holiday effects on traffic volumes',
758   Transportation Research Record: Journal of the Transportation Research Board, 1945(1), pp. 40-48.

759   Liu, Z., and Sharma, S. (2008) 'Nonparametric method to examine changes in traffic volume pattern
760   during holiday periods', Transportation Research Record: Journal of the Transportation Research
761   Board, 2049(1), pp. 45-53.

762   Lo, H. K., Yip, C. W., and Wan, Q. K. (2004) 'Modeling competitive multi-modal transit services: a nested
763   logit approach' Transportation Research Part C: Emerging Technologies, 12(3), pp. 251-272.

764   Ma, J., Mitchell, G., and Heppenstall, A. (2014) 'Daily travel behaviour in Beijing, China: An analysis of
765   workers' trip chains, and the role of socio-demographics and urban form', Habitat International, 43,
766   pp. 263-273.

767   Maat, K., and Timmermans, H. (2006) 'Influence of land use on tour complexity: a Dutch case',
768   Transportation Research Record: Journal of the Transportation Research Board, 1977(1), pp. 234-241.

769   Manaugh, K., Miranda-Moreno, L.F., EI-Geneidy, A.M., (2010) 'The effect of neighbourhood

770   characteristics, accessibility, home-work location, and demographics on commuting distances',
771   Transportation, 37 (4), pp. 627–646.

772   McGuckin, N., Nakamoto, Y. (2004) 'Trips, chains, and tours-using an operational definition'. Paper
773   presented at the National Household Travel Survey Conference, Washington D.C, November, 2004.

774   Moss, S., Prosser, H., Costello, H., Simpson, N., Patel, P., Rowe, S., ... and Hatton, C. (1998) 'Reliability
775   and validity of the PAS‐ADD Checklist for detecting psychiatric disorders in adults with intellectual
776   disability', Journal of Intellectual Disability Research, 42(2), pp. 173-183.

777   Nurul Habib, K. M., Morency, C., Trépanier, M. (2012) 'Integrating parking behaviour in activity-based
778   travel demand modelling: investigation of the relationship between parking type choice and activity
779   scheduling process', Transportation Research Part A: Policy and Practice, 46(1), pp. 154-166.

780   Parvaneh, Z., Arentze, T., and Timmermans, H. J. (2012) Understanding travelers' behavior in provision of
781   travel information: A Bayesian belief approach. Procedia-Social and Behavioral Sciences, 54, pp.
782   251-260.

783   Primerano, F., Taylor, M.A.P., Pitaksringkarn, L., and Tisato, P. (2008) 'Defining and understanding trip
784   chaining behavior', Transportation, 35, pp. 55-72.

785   Recker, W. W., McNally, M. G., and Root, G. S. (1986) 'A model of complex travel behavior: Part
786   I—Theoretical development', Transportation Research Part A: General, 20(4), pp. 307-318.

787   Recker, W.W., Schuler, H.J. (1981) 'Spatial choice and information processing: A comparison of modeling
788   approaches', Economic Geography, 57, 4, pp. 373-383.

789   Ripplinger, D., Mattson, J. and Peterson, D. (2012) 'An Application of Attitudinal Structural Equation
790   Modeling to Intercity Transportation Market Segmentation'. Paper presented at the Transportation
791   Research Board 91st Annual Meeting, Washington DC, 2012.

792   Ruotoistenmäki, A., Seppälä, T. (2007) 'Road condition rating based on factor analysis of road condition
793   measurements', Transport policy, 14(5), pp. 410-420.

794   Sanders, R. D., Allen, D. N., D Forman, S., Tarpey, T., Keshavan, M. S., and Goldstein, G. (2005)
795   'Confirmatory factor analysis of the Neurological Evaluation Scale in unmedicated schizophrenia',
796   Psychiatry research, 133(1), pp. 65-71.

797   Schermelleh-Engel, K., Moosbrugger, H., and Müller, H. (2003) 'Evaluating the fit of structural equation
798   models: Tests of significance and descriptive goodness-of-fit measures', Methods of psychological
799   research online, 8(2), pp. 23-74.

800   Shailes, A., Senior, M. L., and Andrew, B. P. (2001) 'Tourists' travel behaviour in response to congestion:
801   the case of car trips to Cornwall, United Kingdom', Journal of Transport Geography, 9(1), pp. 49-60.

802   Srinivasan, S. (2002) 'Quantifying spatial characteristics of cities', Urban Studies, 39, pp. 2005-2028.

803   Steiger, J.H. (2007) 'Understanding the limitations of global fit assessment in structural equation
804   modeling', Personality and Individual Differences, 42 (5), pp. 893-98.

805   Van Acker, V., Mokhtarian, P. L., and Witlox, F. (2014) 'Car availability explained by the structural
806   relationships between lifestyles, residential location, and underlying residential and travel attitudes',
807   Transport Policy, 35, pp.88-99.

808   Van Acker, V., Witlox, F. (2010). 'Car ownership as a mediating variable in car travel behaviour research
809   using a structural equation modelling approach to identify its dual relationship', Journal of Transport
810   Geography, 18(1), pp. 65-74.

811   Van Acker, V., Witlox, F. (2011) 'Commuting trips within tours: how is commuting related to land use?',
812   Transportation, 38, pp.465-486.

813   Van Acker, V., Witlox, F., and van Wee, B. (2007) 'The effects of the land use system on travel behavior: a

814   structural equation modelling approach', Transportation Planning and Technology, 30 (4), pp.331-353.

815   Van Cranenburgh, S., Chorus, C. G., and Van Wee, B. (2014) 'Vacation behaviour under high travel cost

816   conditions - A stated preference of revealed preference approach', Tourism Management, 43, 105-118.

817   Wang, J. C., Wang, X.Q. and Jiang, B. F. (2011) Structural equation models: methods and applications.

818   High education press.

819   Wang, W.D. (2010) Theory and Application of Structural Equation Modeling. China Renmin University

820   Press, Beijing.

821   Zhang, J., Arentze, T. A., and Timmermans, H. J. (2012) 'A multimodal transport network model for

822   advanced traveler information system', JUSPN, 4(1), pp. 21-27.

823   Zhao, D., Shao, C. F., Sun, G. Z. (2010) 'Travel Behavior Analysis Model of Suburban Railway Based on

824   Combination of RP and SP Data', Journal of Transportation Systems Engineering and Information

825   Technology, 10(6), pp. 156-162.

826   Zinbarg, R. E., Revelle, W., Yovel, I., and Li, W. (2005) 'Cronbach's α, Revelle's β, and McDonald's ω H:

827   Their relations with each other and two alternative conceptualizations of reliability', psychometrika,

828   70(1), pp. 123-133.

829