



# 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.

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## 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).<sup>1</sup> 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 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 et al., 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 et al., 2012). As the core element of the Intelligent Transport Systems (ITS), ATIS provides the traveler with Integrated Multimodal Travel

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<sup>1</sup> 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.

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 and Schuler, 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 et al., 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 and Sharma, 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.

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