ARTICLE IN PRESS

Transportation Research Part A xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Transportation Research Part A

journal homepage: www.elsevier.com/locate/tra

Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach

Bobin Wang *, Chunfu Shao, Xun Ji

MOE Key Laboratory for Urban Transportation Complex Systems Theory and Technology, Beijing Jiaotong University, Beijing 100044, China

ARTICLE INFO

Article history:
Received 1 May 2016
Received in revised form 15 January 2017
Accepted 23 March 2017
Available online xxxx

Keywords:
Dynamic analysis
Holiday travel behaviour
Integrated Multimodal Travel Information (IMTI) usage
Biographical interdependence
Life-oriented approach
State dependence

ABSTRACT

The Integrated Multimodal Travel Information (IMTI) plays an important role in the evolution process of holiday travel behaviour, which is seldom investigated. To fill this gap, this study analyses holiday travel behaviour dynamics with IMTI usage, based on the life-oriented approach. IMTI usage is taken as a separate life domain in this study, and a two-way relationship between holiday travel biography and IMTI usage biography over the life course, is examined after controlling for the effects of residential, household structure, employment/education, and car ownership biographies. Based on the web-based life history survey data, statistical characteristics of mobilities in each life biography are first analysed. Then, different random-effects ordered logistic models are established to investigate the biographical interdependencies from three aspects: intra-domain interdependency, inter-domain interdependency and outer-domain interdependency. The results show that the life biography is not only affected by a personal life course, but also affected by external background of the times. Under the interaction of inner individual factors and outer environment factors, there is an obvious dynamic two-way relationship between holiday travel biography and IMTI usage biography. Meanwhile, residential, household structure, employment/education and car ownership biographies have significant effects on these two life biographies. Especially, the influence of long-term state dependence for different life domains, over the life course, is much more obvious when explaining holiday travel behaviour dynamics and IMTI usage mobilities. Therefore, the life-oriented approach provides a valid method for analysing the dynamics of holiday travel behaviour with IMTI usage.

1. Introduction

With the expansion of transport infrastructure and the improvement of people's living standards in China, holiday travel demand is increasing significantly. According to official statistics, the number of domestic tourists reached 3262 million person-times in 2013, with an average growth rate of 14.3% per year from 2004 to 2013 (Shao, 2014). Gradually, holiday travel has become an inevitable part in people's lives in China, but its spatiotemporal characteristics are more concentrated in time and space. Chinese people have an average paid annual leave of 11 days per year, which is less than many other countries (Dahlgreen, 2015). That makes them prefer to arrange their holiday travel in statutory holidays.

Moreover, most tourist attractions, or commercial centers, locate in big cities or tourism cities, thus holiday traffic congestion becomes more and more serious in large commercial centers and tourist attractions during statutory holidays (China

* Corresponding author.
E-mail addresses: bobinwang@bjtu.edu.cn (B. Wang), cfshao@bjtu.edu.cn (C. Shao), 13114241@bjtu.edu.cn (X. Ji).

http://dx.doi.org/10.1016/j.tra.2017.03.013
0965-8564/

News, 2014). As a large number of travellers pouring into their destinations, people's activities and travel scheduling become more diverse and complex (Liu and Sharma, 2008). Therefore, it is necessary to study the characteristics of holiday travel behaviour and analyse the influencing factors for the dynamic evolution process of holiday tours, in order to make an appropriate travel demand management (TDM) policy and alleviate traffic congestion in holidays.

Holiday travel behaviour has different properties, compared with commuting on workdays. Firstly, holiday travel demand is elastic with more flexibility in time and space, thus the destination, departure time, travel mode and travel route in holidays, are not fixed. Secondly, a holiday travel union is usually a group, rather than an individual, so the holiday travel decision process involves multiple facets or portfolio choices concerning the group needs (Dellaert et al., 1998; Grigolon et al., 2013a). Meanwhile, holiday travel choices may take a longer decision-making process and establish long-term agendas. Thirdly, there are many statutory holidays in a year. Some occur in January, some take place in March, and some are celebrated in December. So different holidays occur at different time points, which are discrete in time. Moreover, the vacation time is usually very short, some holidays only have one day off. Thus, it is difficult to investigate holiday travel behaviour dynamics in the short-term (day to day dynamics for one week or several weeks). Therefore, this study analyses the dynamics of holiday travel behaviour in the long-term (year to year dynamics through one's lifetime after 18 years old), and establishes a dynamic evolution model for holiday travel behaviour considering multiple dimensional choices of elastic travel demand.

The dynamic evolution of holiday travel behaviour is a process of activity and travel scheduling changing over time, which results from the interaction of inner individual factors and outer environment factors. From the perspective of an individual level, individual travel behaviour may change in response to the variation of socio-demographic characteristics and self-selection issues in different life domains (Cosenza and Davis, 1981; Zhang, 2014a). On the social environment level, the dynamic balance of holiday travel choices may be broken by external forces in the long-term, such as transport infrastructure expansion and Intelligent Transportation System (ITS) construction (Wang et al., 2015a). Moreover, inner individual factors and outer environment factors are not independent, but inter-related with each other. However, most studies separate these two factors and focus on the influence of certain, or partial variables. Few studies investigate the interdependences between these influencing factors and analyse their overall effects on holiday travel behaviour. Therefore, the life-oriented approach is proposed to fill this gap.

According to the life-oriented approach, the dynamic travel choice results from dynamic influencing factors covering various life domains (e.g. residence, job, education, family life, leisure and recreation, as well as relevant travel behaviour) (Zhang, 2016). Moreover, with the rapid development of information technology, information usage plays an important role in our daily lives. It influences all aspects of people's work, study, and other life domains, and these life choices also affect their information usage at the same time. Similarly to travel behaviour, information usage results from different life choices and life choices are also affected by information usage too. Therefore, this study takes Integrated Multimodal Travel Information (IMTI) usage as a separate life domain, and investigates the two-way relationship between the holiday travel behaviour domain and the IMTI usage domain, after controlling for the effects of residential, employment/education, household structure, and car ownership domains over the life course.

IMTI is defined as a variety of activity and travel information covering all kinds of the trip modes, which can be divided into qualitative information (e.g. real-time traffic accident location, traffic control section, heavy traffic roads, etc.), quantitative information (e.g. queue length, vehicle speed, bus/metro arrival time, total travel time, etc.) and advisory message (e.g. route choice suggestion, departure time suggestion, alternative transfer information, etc.). IMTI usage mainly refers to the number of IMTI queries, query method and the influence degree of IMTI. There are a variety of ways to disseminate IMTI in holidays in China, including web portals, traffic radio, Variable Message Sign (VMS), call centers, Short Messaging Service (SMS) platforms, mobile communication terminals, electronic information boards, etc. (Wang et al., 2015a).

Many studies focus on the information influence on travel decisions, such as mode choice, destination choice and route choice, and take commuting as the research object (Grotenhuis et al., 2007; Liu et al., 2013; Parvaneh et al., 2012). However, very few studies investigate the two-way relationship between holiday travel behaviour and IMTI usage. Moreover, most studies only consider the influencing factors in one life domain, and neglect the influence of other life domains. In reality, IMTI is a critical factor that may influence and constrain holiday travel behaviour significantly, and holiday travel behaviour also has significant effects on IMTI usage at the same time. Therefore, understanding their two-way relationship will help to provide an effective IMTI service to induce the traveller's behaviour in holidays, and alleviate holiday traffic congestions effectively.

In light of the demonstration above, the contribution of this study is threefold: (1) It makes an initial attempt to apply the life-oriented approach to analyse holiday travel behaviour dynamics in the long-term. (2) Extending the major life domains of Zhang (2015) and taking IMTI usage as a separate life domain. The two-way relationship between holiday travel behaviour biography and IMTI usage biography is investigated after controlling for the effects of the other life biographies. (3) Enriching the life-oriented approach and providing the research framework for analysing holiday travel behaviour dynamics, considering biographical interdependencies among different life domains from three aspects: intra-domain interdependency, inter-domain interdependency and outer-domain interdependency.

This study is organised as follows. Section 2 briefly reviews the literature on holiday travel behaviour dynamics and the life-oriented approach. It also indicates the shortage of existing research and then clarifies the content and object of this study. Section 3 proposes the research framework and describes the modelling approach and model variables used in this study. Section 4 contains the survey and sample, and a statistical analysis for data is then presented in Section 5. Section 6

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

presents model results with detailed discussion, and finally, important findings and related policy suggestions are summarised.

2. Literature review

2.1. Research on travel behaviour dynamics

With the deepening of travel behaviour research, the static activity-travel model exposes its limitations and cannot fulfil the increasing research needs, then the focus shifts from the cross sectional modelling to the dynamic modelling gradually (Sharmen, 2014). Meanwhile, the research perspective is changing from short-term dynamics to long-term dynamics (Srinivasan and Bhargavi, 2007).

The research on travel behaviour dynamics can be divided into micro dynamics research and macro dynamics research. The micro dynamics consider the generation process of daily activity travel scheduling, and explain the formation and allocation of different activities within a day (Arentze et al., 2011; Ettema and Timmermans, 2003; Krygsman et al., 2006; Srinivasan and Athuru, 2005).

On the other hand, the macro dynamics investigate the dynamic evolution process of travel behaviour over time, which can be investigated from the perspective of short-term or long-term. In the short-term, day to day dynamics are investigated between different workdays for different types of activities (Habib and Miller, 2008; Roorda and Ruiz, 2008). The role of household members and space–time constraints can be considered into the day to day dynamic analysis of travel behaviour (Kang and Scott, 2010; Neutens et al., 2012). In the long-term, year to year dynamics of travel behaviour are investigated using panel data between consecutive years. The persistent inertia factor and state dependence are also considered in the long-term dynamic models (Golob, 1990; Roorda and Ruiz, 2008; Srinivasan and Bhargavi, 2007). Besides, there is a group of scholars utilising the process modelling to provide an insight into the dynamic transfer process of travel behaviour choices (Goulias, 1999; Vij et al., 2013; Xiong and Zhang, 2015). However, most of these studies take the commuting as the research object, and very few studies investigate the dynamics of holiday travel behaviour.

Several studies analyse travel behaviour dynamics from the perspective of an individual life course. Representative approaches include the life cycle approach (Fried et al., 1977; Vij et al., 2013; Zimmerman, 1982) and the life course (or life trajectory or life event) approach (Lanzendorf, 2003; Oakil, 2013). Within these theoretical frameworks, travel behaviour is changing over longitudinal trajectories of individual life course, in terms of key events that bring in major changes. Kitamura and Kostyniuk (1986) suggested that life course accounts for as much or more variation, in travel, than socio-demographic characteristics. Ortúzar and Willumsen (2011) also identified the life cycle as an important factor affecting the decision-making of travel behaviour.

The analysis of travel behaviour choices over the life course covers various aspects, including tourism choices (Collins and Tisdell, 2002; Fodness, 1992; Gibson and Yiannakis, 2002), destination choices (Oppermann, 1995, 1998), and transport mode choices (Davison and Ryley, 2013; Huby and Burkitt, 2000). Other studies have focused on a specific life cycle stage, and some take the student's vacation behaviour as the study object (Carr, 2002; Grigolon et al., 2012; Peercy and McCleary, 2011; Ross, 1993; Sung, 2004). However, most studies simply consider certain (age) or partial factors as the explanatory variables to describe the relationship between the travel behaviour choice and life course, and the variation of explanatory variables over time is seldom considered in their models.

The travel behaviour decision process involves multiple facets or portfolio choices for travellers to fulfil their travel needs. The portfolio choices cover all aspects of travel behaviour characteristics, including travel time, travel distance, travel mode, number of companions, activity durations and so on (Chu, 2003; Van Acker et al., 2007). The influencing factors for travel behaviour choices have been studied from various aspects. Some studies explore the relationship between land use and travel behaviour (Maat and Timmermans, 2006; Van Acker and Witlox, 2011; Van Acker et al., 2014), and some researchers think personal preferences, socio-demographic characteristics and the built environment could influence people's activity choices (Grigolon et al., 2013b; Jenelius et al., 2011; LaMondia and Bhat, 2012; Van Acker et al., 2012). Moreover, some investigate how recreation travel is influenced by the family lifecycle (Grigolon et al., 2013a), and some indicate that IMTI has a significant effect on holiday travel behaviour (Wang et al., 2015b).

However, few studies investigate the interdependence among these influencing factors comprehensively and analyse their overall effects on the evolution process of travel behaviour. Moreover, the research framework is lacking with regard to analysing holiday travel behaviour dynamics. Therefore, this study provides the research framework for the dynamic analysis of holiday travel behaviour, based on the life-oriented approach, and analyses the two-way relationship between holiday travel biography and IMTI usage biography, considering the interaction of inner individual factors and outer environment factors.

2.2. The life-oriented approach

The life-oriented approach is proposed by Zhang in 2010, which argues that people's decisions on various life domains are not independent with each other and an understanding of life choices should not be constrained by the boundary of any single discipline (Zhang, 2010, 2012, 2015, 2016).

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

In general, this theory puts forward four main points: (1) People's life choices in various domains, e.g. residence, neighbourhood, health, education, work, family life, leisure and recreation, finance, and travel behaviour, are interdependent with each other (Zhang, 2014a). (2) Travel behaviour results from various life decisions, and any understanding of travel behaviour is secondary to a fundamental understanding of life choice decisions (Zhang, 2014b). (3) There is a two-way relationship between travel behaviour and the other life domains (Zhang et al., 2014). (4) People's life choices are closely related with the quality of life (QOL), which should be improved by the collaboration of different governmental sectors (Zhang et al., 2012; Xiong and Zhang, 2014). Existing research has verified the rationality of this theory, but related empirical studies are very limited.

The essential difference between the activity-based approach and life-oriented approach is that: the former argues that the travel demand is derived from activity participation, and the latter argues that the travel demand is derived from life decisions (Bowman, 1998; Zhang, 2014b). The former takes tours as the study object, while the latter takes life domains as the study object (Primerano et al., 2008). Therefore, the life-oriented approach provides a new method for understanding the dynamics of holiday travel behaviour with IMTI usage.

The life-oriented approach applies a life history analysis to understand people's long-term decisions on travel behaviour, which incorporates interdependences between different life domains (Zhang, 2014b). However, in the current life-oriented approach, Internet usage has only been regarded as an explanatory variable for the leisure and recreation domain (Zhang, 2014a). Actually, the development of ITS influences people's travel habits and changes their travel behaviour choices significantly (Ben-Elia et al., 2013; Bekhor and Albert, 2014; Farag and Lyons, 2012). Especially, IMTI has significant effects on individual activity travel scheduling and decisions under elastic demand (Grotenhuis et al., 2007; Wang et al., 2015b). Therefore, this study takes IMTI usage as a separate life domain, and different random-effects ordered logistic models are built to analyse the long-term dynamics of holiday travel behaviour with IMTI usage based on the research framework.

In this study, "holiday" refers to the statutory holidays in China, and "holiday travel" means a travel or outing for one day, or several days, during this specific period. There are seven statutory holidays for all citizens in China, and this study only considers four statutory holidays, i.e. the Spring Festival in January or February, Tomb-Sweeping Day in April, May Day in May and National Day in October. The reason can be explained as: (1) The Spring Festival, May Day and National Day are the first approved national statutory holidays in China and the Tomb-Sweeping Day was formally executed in 2008. (2) They are called "Major Holidays" in China, which have longer days off compared with the other statutory holidays. From 1999 to 2007, the Spring Festival, May Day and National Day all have seven days off. From 2008 to now, the Spring Festival, and National Day have seven days off, and the Tomb-Sweeping Day and May Day have three days off. (3) The Spring Festival, Tomb-Sweeping Day, May Day and National Day are the first and only approved national statutory holidays, when all of the national highways are free during these periods.

Therefore, holiday travels in these four statutory holidays have similar characteristics, which have strong representativeness among holiday activity and travel scheduling.

3. Methodology

3.1. Research framework

Six life biographies are considered in this study: residential biography, household structure biography, employment/education biography, car ownership biography, holiday travel biography and IMTI usage biography. Biography is defined as a series of mobilities in each life domain over the life course, and mobility indicates a change occurring in each domain, which is similar to a life event that brings major changes. A series of mobilities divide the life course into a sequence of episodes, and the episode duration is the period between two consecutive mobilities (Zhang et al., 2014). It is easy to understand that the episode duration is the lasting time of a state. In the long-term dynamics, the time points of mobilities are recorded in years. Therefore, a life biography is able to demonstrate how the state of a life domain changes year by year, over the life course, and the state of a year is called a scenario.

Analysing the biographical interdependencies among different life domains over the life course, is the key interest of this study, which includes the intra-domain interdependency, inter-domain interdependency and outer-domain interdependency. Intra-domain interdependency considers multiple facets or portfolio choices for a life domain, which describes the dynamic relationships between multiple facet choices of this life domain. For example, the intra-domain interdependency for the holiday travel biography includes multiple choices of holiday travel behaviour, such as travel time, travel distance, number of companions, activity durations and so on. Moreover, the historical experience (state dependency) can be considered in the intra-domain interdependency analysis.

On the other hand, the inter-domain interdependency indicates the two-way relationship between different life domains. A mobility in one life domain may affect the other life biographies over the life course, so the co-occurrence of different life biographies should be analysed through the inter-domain interdependency. Moreover, the state dependence or lag effects can also be considered in the inter-domain interdependency analysis.

Furthermore, the outer-domain interdependency mainly describes the two-way relationship between the external environment and life domains. Obviously, the development of society and economy affects people's self-selection issues in different life domains. At the same time, individual life choices could influence the development process of social environment,

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

such as the relationship between the land use and urban transport system. Therefore, the proposed research framework of this study is shown in Fig. 1.

In order to investigate the dynamic evolution process of holiday travel behaviour with IMTI usage, this study focuses on the inter-domain interdependency between holiday travel biography and IMTI usage biography, after controlling for the effects of residential, household structure, employment/education, and car ownership biographies. In the meantime, the intra-domain interdependency and outer-domain interdependency of these two life biographies are also considered in the models. However, this study only considers the one-way influence of external environment factors on holiday travel and IMTI usage biographies, to prove the existence of the outer-domain interdependency.

3.2. Random-effects ordered logistic model

In order to capture the evolution process of holiday travel behaviour in the long-term, the panel data or longitudinal data is required. Panel data is traditionally obtained through tracking the behaviour of a group of individuals in consecutive periods. It combines the advantages of cross section data and time series data, and can provide more information on individual travel behaviour dynamics. Therefore, this study uses the panel data to analyse the biographical interdependences between different life biographies over the life course.

Qualitative response models have been a growth industry in econometrics, particularly in the area of panel data analysis, which combines probabilities with econometric tools to make probabilistic statements about the occurrence of events (Green, 2011). The advantage of this kind of model is allowing the model builder to learn about economic processes, while accounting for both individual heterogeneity and dynamic effects that are not visible in cross sections.

A random-effects ordered logistic model is such a model, which has two or more ordered responses. The biggest difference between a random-effects ordered logistic model and a standard ordered logistic model is the former considers the individual specific heterogeneity in the dynamic analysis. Individual life choices are discrete choices, because people are usually faced with two or more options. Moreover, the values of some variables follow a certain order. Therefore, this study applies the random-effects ordered logistic model to analyse the dynamic interrelationships among different life biographies.

The random-effects ordered logistic model is a multinomial response model, where the responses are irrelevant and ordered (Wooldridge, 2010). The observed ordered variables y_{it} can be derived from latent continuous variables y_{it}^*, such that

$$y_{it} = \begin{cases} 1, & if \quad y_{it}^* \leqslant \mu_1 \\ 2, & if \quad \mu_1 < y_{it}^* \leqslant \mu_2 \\ \quad \vdots & \\ \mathrm{K}, & if \quad y_{it}^* > \mu_{k-1} \end{cases} \tag{1}$$

where $i = 1, 2, \ldots, N$ for panels, and $t = 1, 2, \ldots, T$ for observed periods. K is the number of possible values of y_{it}, and y_{it}^* is a latent continuous variable. The relationship between y_{it} and y_{it}^* is decided by a set of utility cut points $\mu_1, \mu_2 \ldots \mu_{k-1}$. Assuming the latent variables y_{it}^* is determined by

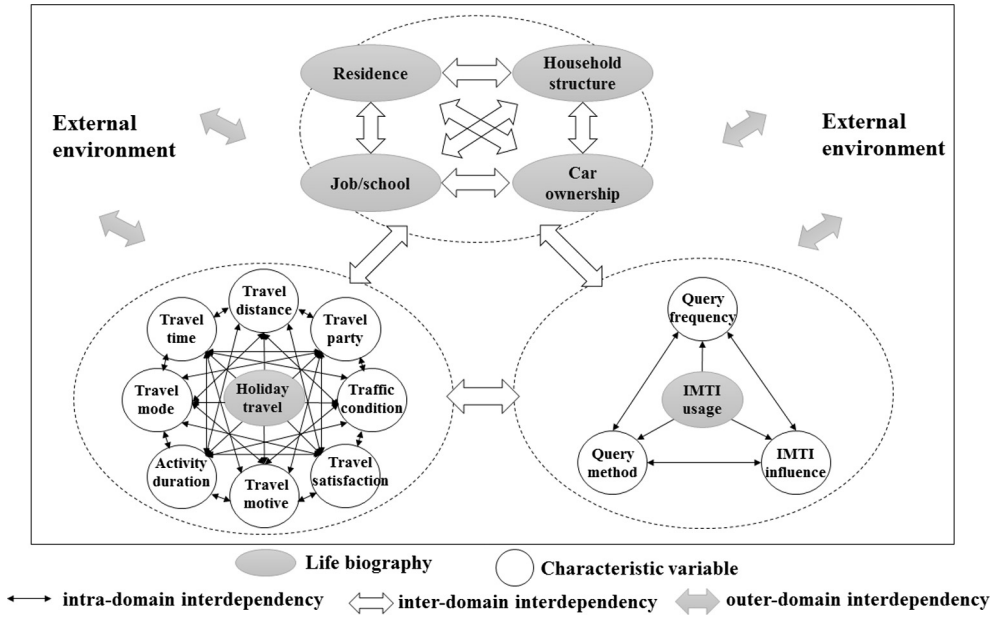

Fig. 1. Research framework.

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

$$y_{it}^{*} = \alpha_i + \beta x_{it} + \varepsilon_{it} \tag{2}$$

where α_i are independent and identically distributed $N(0, \sigma_v^2)$, which represent unobservable individual effects that do not change with time. The error term ε_{it} are distributed as logistic with $E(\varepsilon_{it}) = 0$, $Var(\varepsilon_{it}) = \pi^2/3$, which are independent of α_i. x_{it} is the explanatory variable changed with individual and time, which could be life choice variable or lag variable for different life biographies.

In this study, y_{it}^{*} refers to the holiday travel biography or IMTI usage biography, which has a linear relationship with explanatory variables. Based on the research framework, the latent variable model can be expressed as

$$y_{it}^{*} = \alpha_i + \beta_1 Intra_{it} + \beta_2 Intra_{it-5} + \beta_3 Inter_{it} + \beta_4 Inter_{it-5} + \beta_5 Outer_{it} + \varepsilon_{it} \tag{3}$$

where $Intra_{it}$ refers to the intra-domain independent variable, and $Intra_{it-5}$ refers to the 5th-order lag variable for intra-domain interdependency. Similarly, $Inter_{it}$ and $Inter_{it-5}$ refer to the inter-domain independent variable and 5th-order lag variable for inter-domain interdependency, respectively. $Outer_{it}$ is the outer-domain independent variable.

The parameters are estimated via Maximum Likelihood Estimation (MLE), and the conditional distribution of the dependent variable, given the random effects, is assumed to be multinomial with success probability determined by the logistic cumulative distribution function. Such that

$$\begin{aligned}\Pr(y_{it} = k|\mu, x_{it}, \alpha_i) &= \Pr(\mu_{k-1} < \alpha_i + \beta x_{it} + \varepsilon_{it} \leqslant \mu_k) = \Pr(\mu_{k-1} - \beta x_{it} - \alpha_i < \varepsilon_{it} \leqslant \mu_k - \beta x_{it} - \alpha_i) \\ &= H(\mu_k - \beta x_{it} - \alpha_i) - H(\mu_{k-1} - \beta x_{it} - \alpha_i) = \frac{1}{1+\exp(-\mu_k + \beta x_{it} + \alpha_i)} - \frac{1}{1+\exp(-\mu_{k-1} + \beta x_{it} + \alpha_i)}\end{aligned} \tag{4}$$

where μ_0 is taken as $-\infty$ and μ_k is taken as $+\infty$. $H(\cdot)$ is the logistic cumulative distribution function. The Wald chi-square test is used to estimate the overall significance of the model, with p value of 0 indicating an overall significant model (Zhou et al., 2011). A likelihood-ration test is also applied to compare the random-effects ordered logistic regression with the standard ordered logistic regression.

3.3. Model variables

To eliminate the multicollinearity problem, the significant influencing variables should be screened out from primary indicators for dependent variables. Multicollinearity is a common problem in the regression analysis, which will lead to larger standard deviations of regression coefficients and lower accuracy estimates. In statistics, stepwise regression is one method for elimination multicollinearity, in which the choices of predictive variables are carried out by an automatic procedure (Draper and Smith, 2014; Hocking, 1976). The forward selection is the basic method of stepwise regression, which introduces variables into the model one by one with a sequence of F-tests and t-tests. The detailed procedure is: a simple linear regression is conducted first for all explanatory variables, and the biggest contributed variable is selected out as the basic variable for the model. Then the other variables are introduced into the model one by one, which will be chosen, or not decided, by the significance of the t values. The process is repeated until all of the reserved variables are significant for the simple linear regression equation without multicollinearity (Efroymson, 1960).

In order to select better and fewer variables for the random-effects ordered logistic model, this study uses the forward selection method to remove multi-collinear variables first. The holiday travel time, travel distance, number of IMTI queries and IMTI query method are taken as dependent variables, respectively, and the explanatory variable which is significant for all of these dependent variables will be reserved for the following analysis. Strictly speaking, it is not so appropriate to take ordinal variable as a dependent variable for simple linear regression. However, the stepwise regression provides an effective method for minimisation of the number of explanatory variables for this study. Finally, 24 explanatory variables are selected from primary indicators, which include 8 lag factors and 16 real time factors.

Especially, the travel time, travel mode and traffic condition only record the actual travel situations occurring in Beijing. The options of the "Query method" are sorted by the accuracy of IMTI. The larger the option number is, the more accurate IMTI are provided, and the more advanced the IMTI query method will be. When people's main query method for IMTI is "asking someone else", the IMTI accuracy only depends on the respondent's experience. It may be right or wrong. Even if people have their own reliable travel experience, they cannot know all of the other alternative routes like a map. Moreover, a map cannot provide real-time accurate IMTI like traffic radio and navigation, and navigation is more powerful and advanced than traffic radio.

The detailed explanation of these variables is shown in Table 1.

4. Survey and sample

4.1. Survey implementation

This study conducted a web-based life choice survey, considering the variation of different life domains over the life course. The life history survey can obtain similar data structure like panel survey, which uses a retrospective approach to ask respondents to recall major events, such as their long-term mobility decisions (Belli, 1998; Cervero and Day, 2008;

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

Freedman et al., 1988; Zhang et al., 2014). It is easier to carry out and can save a lot of time, compared with panel surveys (Beige and Axhausen, 2012; Gärling and Axhausen, 2003). However, the reliability of retrospective data is influenced by the accuracy of the memory. Therefore, some authors argue that it is appropriate to let people recall major events better, such as residence moving and household structure changes (Hollingworth and Miller, 1996).

With the above consideration, the web-based life history survey of holiday travel behaviour was carried out in February 2016 in Beijing. The Internet survey can provide a relaxed and comfortable environment for people to recall their life experience. Moreover, the other members in the household could help the respondent to regain his/her memories. It is worth mentioning that the biggest holiday in China, the Spring Festival, was on February 8th, 2016. The memory of the past experience in the holidays would become clearer as relatives and friends reunite in this big holiday.

The survey was implemented with the assistance of a major Chinese Internet survey company, which has more than 2.6 million registered survey panels. After pre-treatment and cleaning for the data, 326 completely valid questionnaires, with

Table 1
Definition of variables.

Independent variables	Variable name (symbol)	Explanation (unit)
Outer environment biography	Year (year)	≥0 integers
Residential biography	Residence type (residencetype)	1 = other; 2 = company/school dormitory; 3 = renting; 4 = self-purchased house
	Residence type 5 years ago (L5. residencetype)	1 = other; 2 = company/school dormitory; 3 = renting; 4 = self-purchased house
Household structure biography	Family size (householdnumb)	≥0 integers
	Family size 5 years ago (L5.householdnumb)	≥0 integers
Car ownership biography	Car possession quantity (carnumb)	≥0 integers
Employment/ education biography	Work/school location (workplace)	1 = urban districts; 2 = suburban districts; 3 = outer suburb districts
	Work/school location 5 years ago (L5.workplace)	1 = urban districts; 2 = suburban districts; 3 = outer suburb districts
	Job/school satisfaction (worksatisf)	>0 integers (10-point scale with 1 being the worst and 10 being the best)
	Job/school satisfaction 5 years ago (L5.worksatisf)	>0 integers (10-point scale with 1 being the worst and 10 being the best)
Holiday travel biography	Number of companions (travelnumb)	≥0 integers
	Activity duration (activityduration)	≥0 integers (hour)
	Activity duration 5 years ago (L5. activityduration)	≥0 integers (hour)
	Travel time within Beijing (traveltime)	≥0 integers (hour)
	Travel distance (traveldis)	1 = intra-city travel; 2 = inter-city travel; 3 = travel to Hong Kong, Macao or Taiwan; 4 = travel abroad
	Travel modes within Beijing (travelmode)	1 = combined modes of public transport/slow traffic; 2 = car; 3 = taxi; 4 = parking and ride (P&R)
	Travel modes within Beijing 5 years ago (L5.travelmode)	1 = combined modes of public transport/slow traffic; 2 = car; 3 = taxi; 4 = parking and ride (P&R)
	Traffic condition within Beijing (trafficcondi)	1 = no congestion; 2 = slight congestion; 3 = part of the ring roads and main roads are congested; 4 = many ring roads and main road are congested; 5 = most of the roads are congested
	Traffic condition within Beijing 5 years ago (L5.trafficcondi)	1 = no congestion; 2 = slight congestion; 3 = part of the ring roads and main roads are congested; 4 = many ring roads and main road are congested; 5 = most of the roads are congested
	Travel satisfaction (travelsatisf)	>0 integers (10-point scale with 1 being the worst and 10 being the best)
IMTI usage biography	Number of queries (querytimes)	≥0 integers
	Query method (querymethod)	1 = asking someone else; 2 = experience; 3 = map; 4 = traffic radio; 5 = navigation (vehicle/mobile)
	IMTI influence (informationinflu)	1 = no effect; 2 = general effect; 3 = great effect
	IMTI influence 5 years ago (L5. informationinflu)	1 = no effect; 2 = general effect; 3 = great effect
Dependent variables		
Holiday travel biography	Travel time within Beijing (traveltime2)	1 = 0–1; 2 = 1–2; 3 = 2–3; 4 = 3–4; 5 = above 4 (hour)
	Travel distance (traveldis)	1 = intra-city travel; 2 = inter-city travel; 3 = travel to Hong Kong, Macao or Taiwan; 4 = travel abroad
IMTI usage biography	Number of queries (querytimes2)	1 = zero time; 2 = one time; 3 = two times; 4 = three times; 5 = four times; 6 = above four times
	Query method (querymethod)	1 = asking someone else; 2 = experience; 3 = map; 4 = traffic radio; 5 = navigation (vehicle/mobile)

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

5424 scenarios, were obtained from respondents aged from 19 to 72 years old, who had settled in Beijing for more than one year. The sample covers 16 districts of Beijing, including 2 central urban districts (Xicheng district and Dongcheng district), 4 suburban districts (Chaoyang district, Fengtai district, Shijingshan district and Haidian district) and 10 outer suburb districts (Fangshan district, Tongzhou district, Shunyi district, Changping district, Daxing district, Mentougou district, Huairou district, Pinggu district, Miyun district and Yanqing district), in which age, gender and residential distribution is consistent with the whole population in Beijing generally.

The questionnaire was designed based on the life-oriented approach of Zhang (2014b). In order to obtain the respondent's subjective initiative decisions, the respondent was requested to recall his/her life experience from the year when he/she was 18 years old to 2016. Moreover, if the respondent arrived at Beijing after 18 years old, he/she had to recall from the time of arrival. Therefore, people with different ages have different observed periods in the survey, and the panel data is unbalanced in this study.

Different from the major life domains of Zhang (2015), IMTI usage was added as a separate life domain into the research framework. Therefore, six biographies containing a series of mobilities, over the life course, were included in this survey. For the mobilities of residential biography, household structure biography, employment/education biography and car ownership biography, the number of mobilities and exact time points for every mobility (the year when the mobility occurred) were asked first, then the information related to different types of biographies were investigated in each episode. Considering the complexity and cumbersome items of the questionnaire, the respondent only needed to fill in the last four mobilities at most.

For the holiday travel biography and the IMTI usage biography, there is no definite time points for the changes of holiday travel behaviour or IMTI usage, so the observed period for each respondent was divided into four episodes, and people with different ages had different episode durations. For each episode, respondents were asked to recall one holiday travel experience from the four statutory holidays (the Spring Festival, the Tomb-Sweeping Day, the Labor Day or the National Day). Information related to the spatiotemporal characteristics, travel conditions, and IMTI usage, were then investigated for each holiday travel. Moreover, our questions were not very detailed in order to guarantee the accuracy of the memory. Whenever the questions for each type of biography had been finished, there was a question that "what percentage can you recall from the above content?" If the answers for all life biographies were below 50%, that questionnaire was unqualified.

Detailed information about the six biographies is as follows:

(1) Residential biography: a series of mobilities for residence and surrounding environmental conditions over the life course, including the residence location, residential satisfaction, house-ownership, accessibility (distance to bus stop, railway station and surrounding facilities) and the relationship with the neighbourhood.
(2) Household structure biography: household members were defined as the persons who are living together in Beijing and have economic connections. Household structure biography recorded a series of mobilities for household members and family status over the life course, including the family size, household composition, the number of children, the number of elders, and family happiness. Moreover, the relationships with the head and the other members of the household were also investigated, to verify the accuracy of the questionnaire, as well as the reliability of the retrospective survey.
(3) Employment/education biography: a series of mobilities for working or learning conditions of office staff or students in Beijing. The changes in work/school location and job/school satisfaction were investigated from the year when the respondent was 18 years old to 2016.
(4) Car ownership biography: a series of mobilities for car ownership over the life course. The number of cars and car use frequency were investigated. Moreover, the family car possession quantity at present was asked first, and then the quantity changes of family cars over the life course were recorded one by one. It is also a method to verify the validity of the questionnaire by checking the consistency of the data.
(5) Holiday travel biography: a series of mobilities for holiday travel behaviour over the life course. Respondents were asked to recall one holiday travel experience in each episode. For each recalled holiday travel, the travel distance (intra-city, inter-city, travel to Hong Kong, Macao or Taiwan, or travel abroad), number of companions, activity duration (the time staying at the destination), travel modes used in Beijing, travel time spending in Beijing, traffic condition within Beijing and travel satisfaction were investigated in the survey.
(6) IMTI usage biography: a series of mobilities for IMTI usage over the life course. For each recalled holiday travel, the frequency of querying IMTI, the main query method (asking someone else, by experience, map, traffic radio, or navigation), and the influence degree of IMTI were also investigated in each episode.

4.2. Sample description

The age, gender and residential distribution of the life history survey sample is summarised in Table 2, comparing with the calculated data of the population sampling survey of Beijing in 2014 (Beijing Statistical Yearbook, 2015).

Because the Internet penetration in outer suburb districts is lower than the urban districts or suburban districts in China, the sample proportion of outer suburb districts is slightly lower than its population proportion. Moreover, according to the age structure of Chinese netizens, the number of older netizens is less than the younger netizens (China Internet Network Development Statistical Report, 2016), thus the sample of respondents older than 50 years old are fewer than the number

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

it should be. However, comparing with the existing statistical data of the whole population in Beijing, the life history survey data reasonably conform to the representative sample and can be used for further analysis.

5. Statistical analysis

5.1. Mobility analysis at different ages

The occurrence timings of mobilities in residential, household structure, employment/education, and car ownership biographies are shown in Fig. 2. There is a peak period of mobilities lying between 20 and 30 years old for all these 4 biographies, which is similar like the curve of Zhang et al. (2014). Considering the possibility of mobilities in different domains for a person aged between 20 and 30 years old, they are more likely to change in residential location instead of the other biographies, and the possibility of change in car ownership is the lowest. Moreover, it can be seen that most mobilities fall in the range of 20 and 35 years old for residential, household structure and employment/education biographies, except for the car ownership biography which is in the range of 20 and 40 years old.

Generally, the four curves have the same variation trend, which indicates the co-occurrence of the four life domain biographies over the life course.

5.2. Mobility analysis for different aged cohorts

Next, the average number of mobilities for each aged cohort in the four types of biographies is analysed in Fig. 3. Generally, the average number of mobilities increases with the growth of age. However, the mobility frequency of the people aged above 50 years old is lower than the young aged cohort, especially in the employment/education biography and car ownership biography; that is relevant with their education and social background at that time. In China in the 1970s and 1980s, the economic level was relatively backward and every student could get a stable job after graduation, thus the generation aged above 50 years old are more steady and don't love adventure. Therefore, Fig. 3 shows that the study of holiday travel behaviour dynamics should consider not only the influence of personal life cycle or life course, but also the influence of external background of the times.

5.3. Cross-aggregation analysis between occurrence year and life course

The cross-aggregation between the occurrence year of mobilities and life course is analysed in Fig. 4. The mobility frequency can be identified through the density of these mobility points. If people's life choices are only affected by the life course, the distribution of these mobility points should be the same for different people at the same life stage. Fig. 2 shows the distribution ranges of high frequency points in the four life biographies, which provides a good observation interval to analyse the mobility frequency. Moreover, the samples aged above 50 years old are too small that they can be excluded from the analysis to avoid misunderstanding. Therefore, the area obtained from the intersection of three lines is shown in Fig. 4. It can be seen that the mobility points of household structure biography are distributed uniformly, which means the number of household members is mainly influenced by the life course. However, the mobility frequency increases year by year in the other three biographies, suggesting that life biography is affected by the external background of the times, as well as per-

Table 2
Sample distribution.

Factor	Level	The census of Beijing		The sample	
		N (ten thousand people)	%	N (person)	%
Gender	Male	1106.5	51.43%	172	52.76%
	Female	1045.1	48.57%	154	47.24%
	Sum	2151.6	100.00%	326	100.00%
Residential distribution	Central urban district	221.3	10.29%	24	7.36%
	Suburban districts	1055.0	49.03%	190	58.28%
	Outer suburb district	875.3	40.68%	112	34.36%
	Sum	2151.6	100.00%	326	100.00%
Age	19			15	
	20–24	223.7	13.06%	45	14.56%
	25–29	243.6	14.22%	57	18.45%
	30–39	397.9	23.23%	102	33.01%
	40–49	354.4	20.69%	64	20.71%
	50–59	312.8	18.26%	32	10.36%
	60–69	180.8	10.55%	9	2.91%
	72			2	
	Sum	1713.2	100.00%	309 + 17	100.00%

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

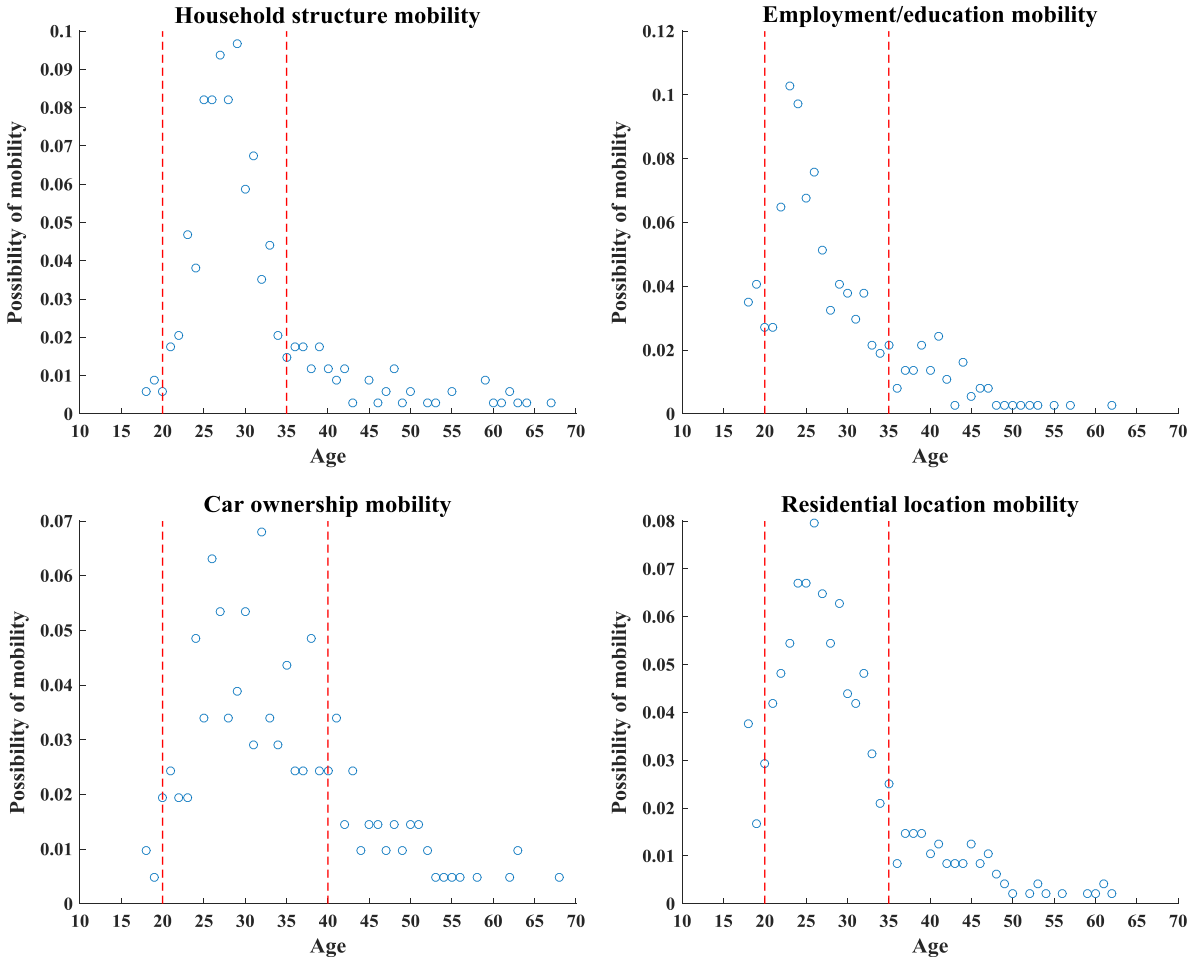

Fig. 2. Possibility of mobility in residential, household structure, employment/education, and car ownership biographies at different ages.

sonal life course. Therefore, the holiday travel biography and IMTI biography should consider the interaction of inner individual factors and outer environment factors.

5.4. Mobility analysis of IMTI usage biography

The frequency distributions of IMTI query times, and its influence over the life course, are shown in Fig. 5. Along with the increase of age, people are less likely to query IMTI with high frequency in holidays, and the proportion of no IMTI usage decreases first and then increases. For the influence degree of IMTI, people were less affected by IMTI when they were young, but the influence became bigger when they got older. This may be related to the development of ITS or their own growth.

The frequency distributions of IMTI usage mobilities over the years are presented in Fig. 6. With the development of the times, there are a more number of IMTI queries with a greater IMTI influence.

5.5. Mobility analysis of holiday travel biography

The frequency distributions of holiday travel time and travel distance over the life course are shown in Fig. 7. The proportion of holiday travel time within Beijing in 0–1 h, increases as people get older, and the proportions of travel time in more than 3 h decrease at the same time. Moreover, elderly people aged above 60 years old mainly have 2–3 h travel time within Beijing in holidays, which is of relevance with their lower movement speed. For the travel distance, people prefer to travel in the city in holidays when they are young, and their travel distance increases when they get into middle-age; that is related to the accumulation of personal wealth and social economic growth. The frequency distributions of holiday travel mobilities over the years are presented in Fig. 8. With the development of the times, the short-term travel reduces and long-term travel increases gradually. At the same time, the intra-city travel reduces and long-distance travel increases over the years.

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

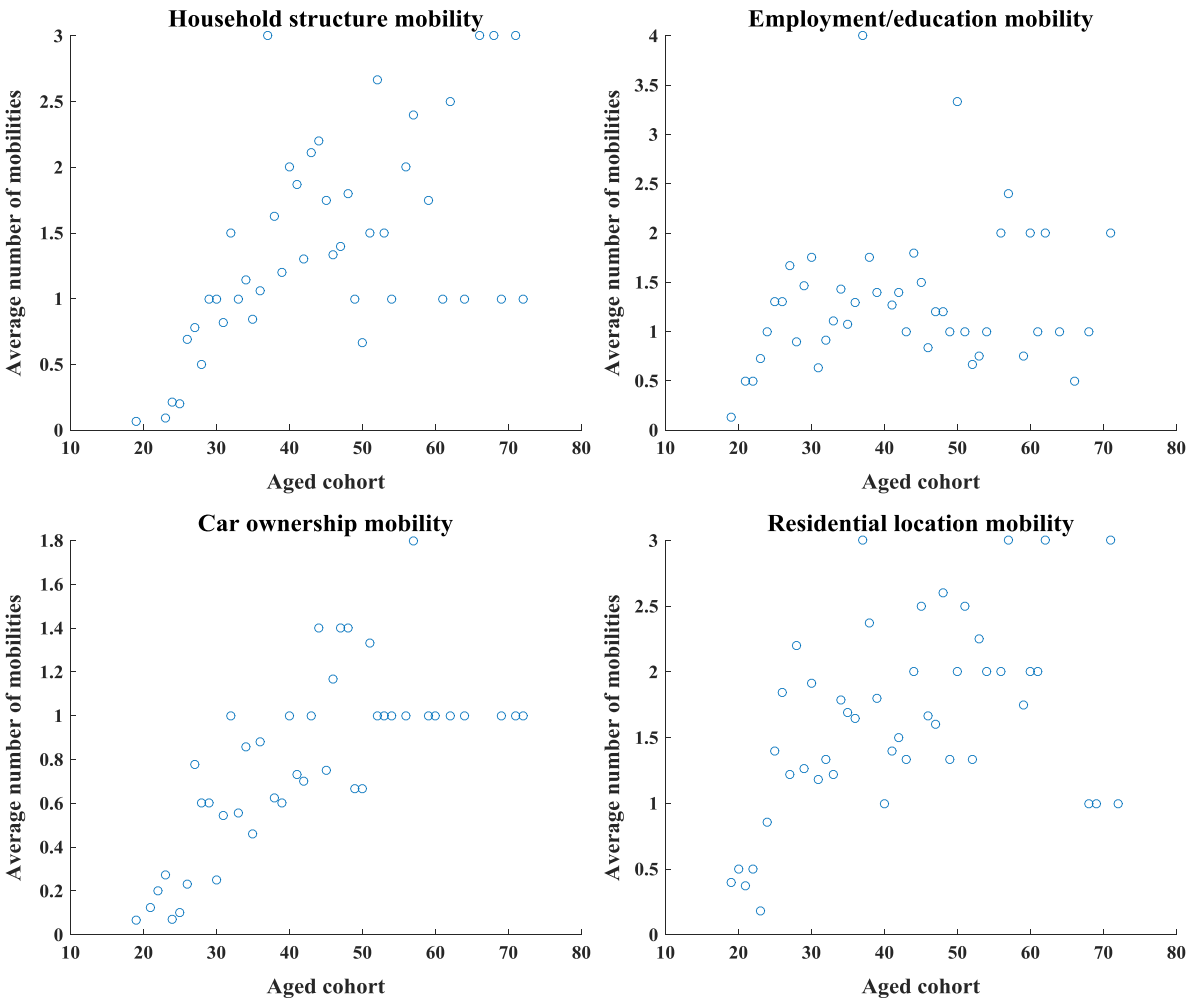

Fig. 3. Average number of mobilities for each aged cohort in residential, household structure, employment/education, and car ownership biographies.

6. Model analysis

6.1. Model estimation analysis

In order to analyse the two-way relationship between the holiday travel biography and IMTI usage biography, different models were established to investigate the influence mechanism between them. Moreover, the effects of residential, household structure, employment/education, and car ownership biographies were also considered in the models. Finally, 24 selected variables were taken into the models, and the parameters were estimated by the software Stata. The model results are shown as follows.

6.1.1. The influence mechanism of the IMTI usage biography on the holiday travel biography

The holiday travel time and travel distance were taken as dependent variables, respectively, to describe the holiday travel biography. Therefore, the other observed variables, for the holiday travel biography, belong to intra-domain independent variables. The observed variables for residential, household structure, employment/education, car ownership and IMTI usage biographies belong to inter-domain independent variables. Moreover, the variable "year" is the outer-domain independent variable to describe the influence of outer environment on holiday travel biography. Two random-effects ordered logistic models for the holiday travel biography were established, based on the research framework, and the results are shown in Table 3.

The significance of independent variables can be determined by the p-value, and the higher significance means the higher dependency. The biographical interdependencies for holiday travel biography are analysed from the following four aspects:

(1) Intra-domain interdependency: The activity duration, travel modes used in Beijing, number of companions, traffic condition and travel satisfaction all have significant effects on holiday travel time and travel distance.

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

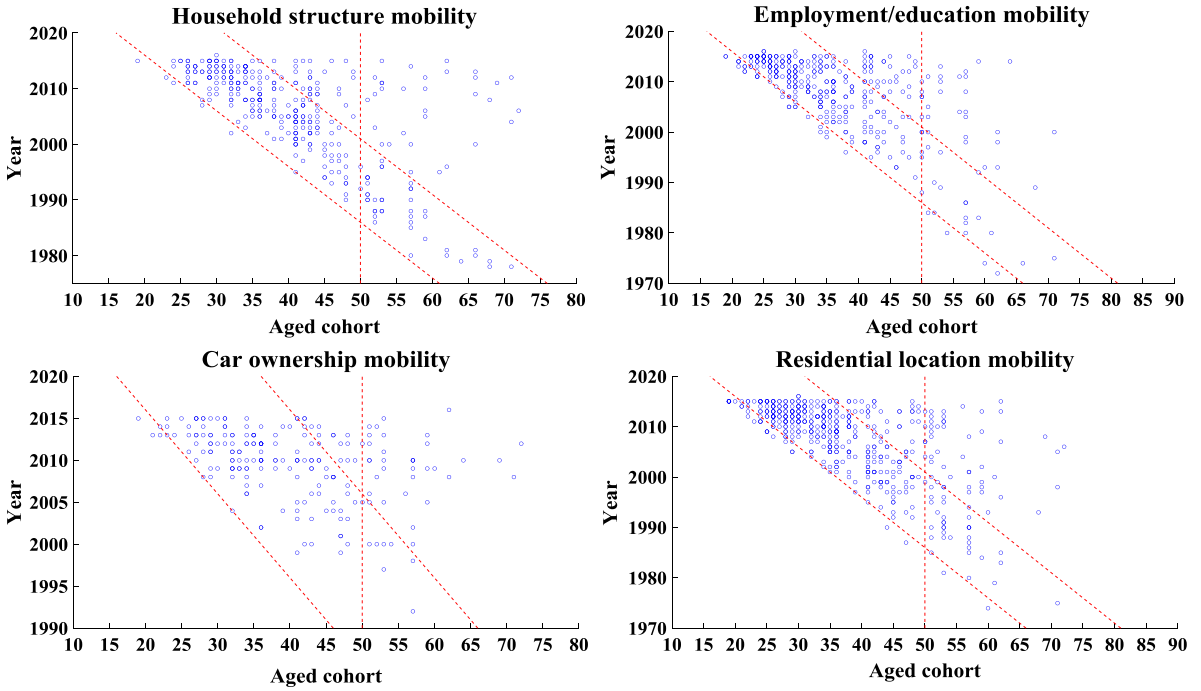

Fig. 4. Occurrence year of mobilities for each aged cohort in residential, household structure, employment/education, and car ownership biographies.

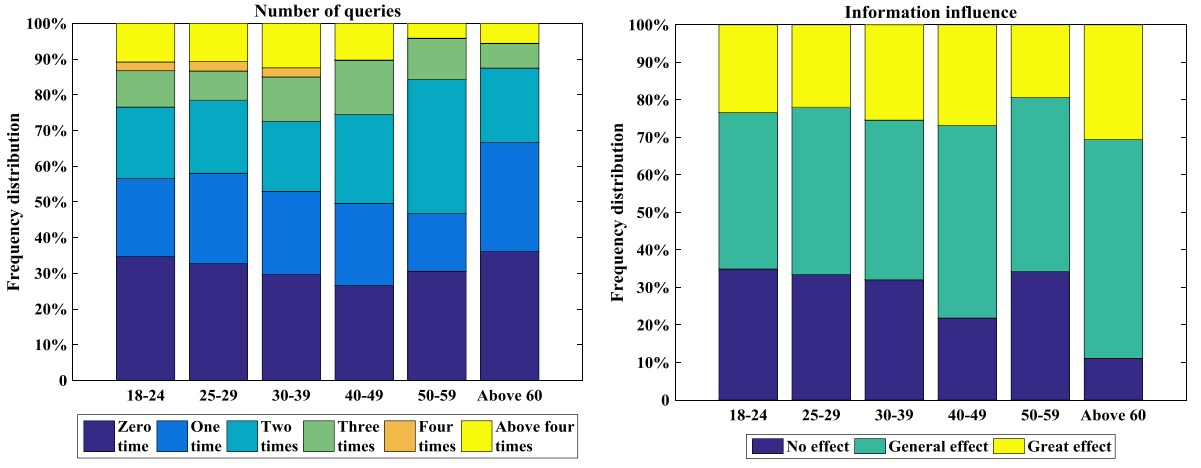

Fig. 5. Frequency distribution of IMTI usage mobilities over the life course.

The activity duration has positive correlations with the travel time and travel distance, which means people with longer activity duration usually have a longer travel time and travel distance in holidays. This reveals the fact that the place people want to stay for a long time in holidays is usually far from their home. However, the number of companions has a negative correlation with holiday travel time and travel distance, and this is related to the inconvenience of the travel with a lot of people. Moreover, traffic congestion also has significant effects on people's travel time and travel distance in their holidays. Compared with public transport or slow traffic, the car or taxi travellers have a shorter travel time and longer travel distance, but P&R travellers have a longer travel time and longer travel distance in holidays. For the lag variables, the past activity duration and traffic conditions impressed on people's hearts, and it has a significant impact on their present travel time and travel distance; beside, different travel modes used in the past have similar effects on travel time and travel distance in holidays.

(2) Interdependency between holiday travel biography and IMTI usage biography: As shown in Table 3, the IMTI usage biography has a significant influence on the holiday travel biography, which confirms the conclusion of Wang et al. (2015b) that IMTI has a significant effect on people's holiday travel behaviour.

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

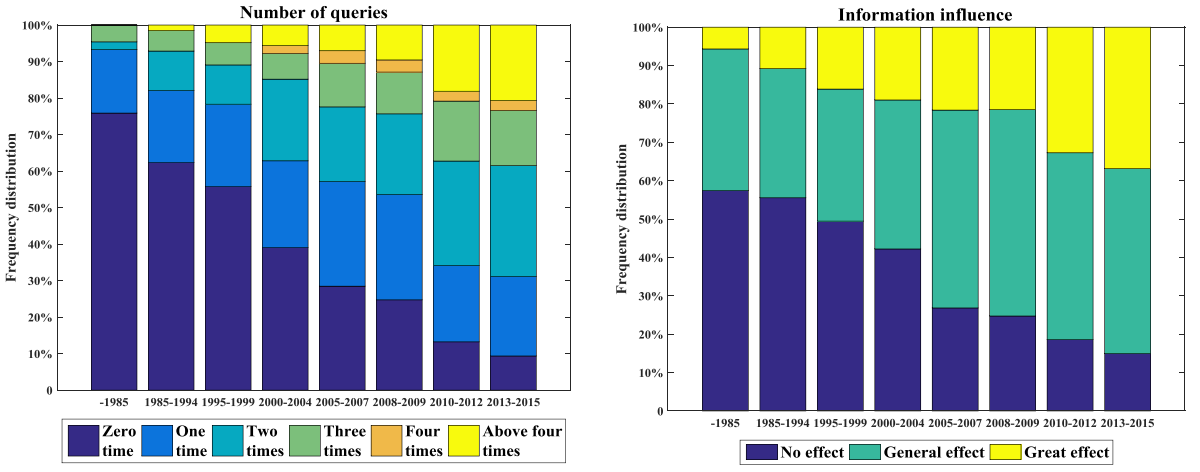

Fig. 6. Frequency distribution of IMTI usage mobilities over the years.

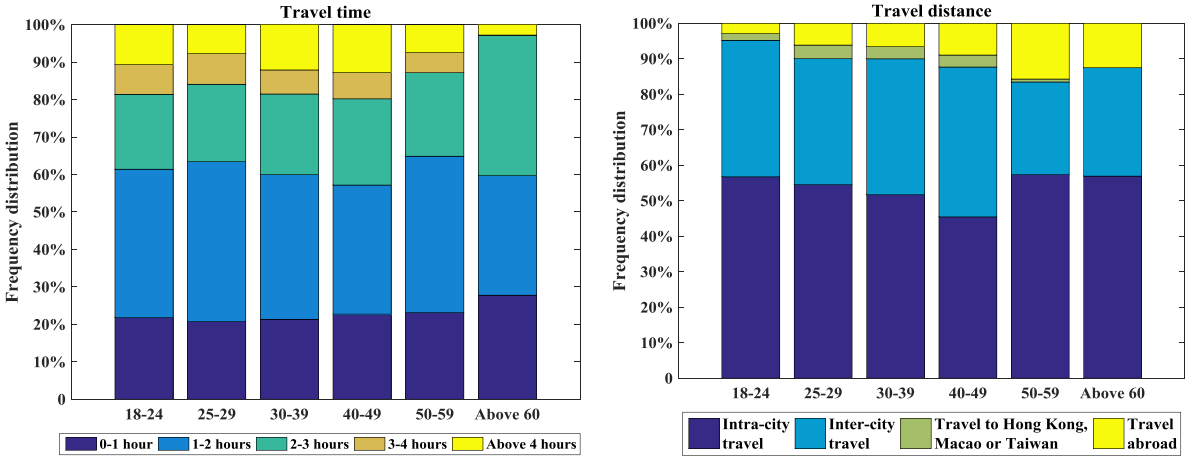

Fig. 7. Frequency distribution of holiday travel mobilities over the life course.

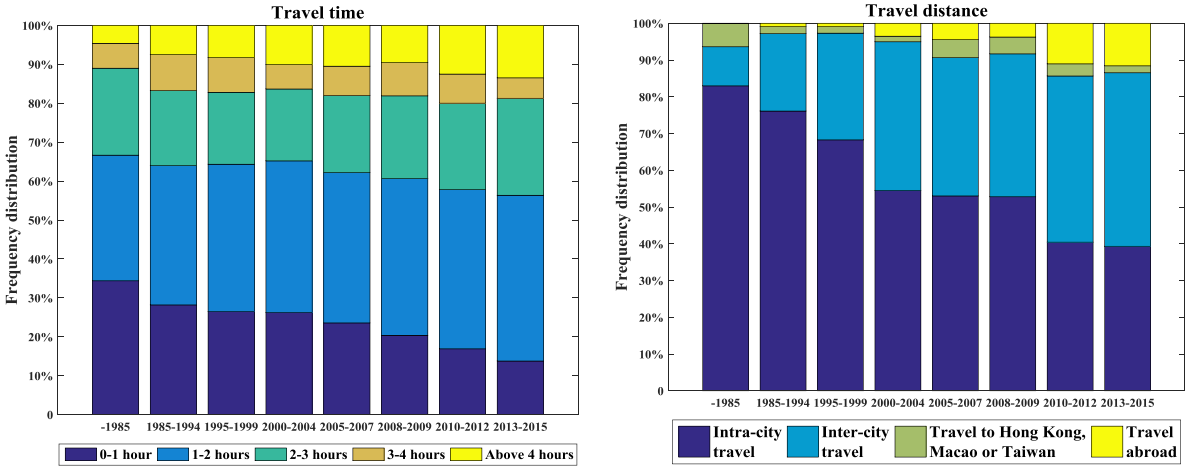

Fig. 8. Frequency distribution of holiday travel mobilities over the years.

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

Table 3
Random-effects ordered logistic model results for holiday travel biography.

Variables	Travel time			Travel distance		
	Coef.	Std. Err.	P > |z|	Coef.	Std. Err.	P > |z|
year	−0.017**	0.008	0.027	0.042***	0.015	0.005
worksatisf	0.066	0.052	0.203	−0.279***	0.091	0.002
L5.worksatisf	−0.204***	0.051	0.000	−0.279***	0.089	0.002
2.workplace	−0.179	0.193	0.355	−1.400***	0.314	0.000
3.workplace	0.120	0.293	0.682	0.386	0.478	0.419
2L5.workplace	−0.666***	0.198	0.001	−0.379	0.311	0.223
3L5.workplace	−0.786**	0.306	0.010	−2.120***	0.519	0.000
2.residencetype	−0.047	0.322	0.883	3.122***	0.597	0.000
3.residencetype	0.614**	0.291	0.035	1.772***	0.527	0.001
4.residencetype	0.144	0.267	0.589	1.535***	0.481	0.001
2L5.residencetype	−1.517***	0.317	0.000	1.447***	0.504	0.004
3L5.residencetype	−1.678***	0.300	0.000	1.157**	0.495	0.019
4L5.residencetype	−1.443***	0.280	0.000	1.259***	0.452	0.005
carnumb	−0.392***	0.105	0.000	0.528***	0.181	0.003
householdnumb	0.027	0.063	0.662	0.217*	0.112	0.052
L5.householdnumb	0.282***	0.064	0.000	0.075	0.120	0.531
activityduration	0.013***	0.002	0.000	0.081***	0.003	0.000
L5.activityduration	0.002*	0.001	0.074	0.008***	0.002	0.000
2.travelmode	−0.625***	0.135	0.000	0.420*	0.250	0.093
3.travelmode	−1.798***	0.242	0.000	3.094***	0.384	0.000
4.travelmode	0.886***	0.259	0.001	1.254***	0.426	0.003
2L5.travelmode	−0.532***	0.140	0.000	0.988***	0.230	0.000
3L5.travelmode	−0.032	0.230	0.889	−0.087	0.367	0.812
4L5.travelmode	0.812**	0.330	0.014	2.038***	0.456	0.000
travelnumb	−0.079***	0.022	0.000	−0.117***	0.037	0.002
trafficcondi	1.020***	0.073	0.000	0.245*	0.132	0.063
L5.trafficcondi	0.554***	0.073	0.000	0.645***	0.124	0.000
travelsatisf	−0.191***	0.056	0.001	0.726***	0.111	0.000
informationinflu	0.350***	0.103	0.001	0.279*	0.170	0.100
L5.informationinflu	−0.348***	0.096	0.000	−0.619***	0.169	0.000
2.traveldis	−0.439**	0.177	0.013			
3.traveldis	−0.953***	0.316	0.003			
4.traveldis	−0.858***	0.281	0.002			
querytimes	0.075**	0.035	0.033	0.328***	0.057	0.000
2.querymethod	0.862***	0.180	0.000	−0.596*	0.344	0.084
3.querymethod	2.018***	0.215	0.000	0.520	0.378	0.169
4.querymethod	0.895***	0.233	0.000	−0.251	0.504	0.619
5.querymethod	1.701***	0.185	0.000	0.083	0.320	0.796
traveltime				−0.217***	0.080	0.006
cut1	−36.289**	15.497	0.019	96.991***	30.249	0.001
cut2	−32.165**	15.494	0.038	106.078***	30.262	0.000
cut3	−29.356*	15.493	0.058	107.346***	30.268	0.000
cut4	−28.000*	15.493	0.071			
sigma2_u	10.859***	1.196		16.218***	2.260	
N	3858			3858		
Wald chi2	777.277			748.241		
Prob > chi2	0.0000			0.0000		
LR test vs. ologit regression						
Prob > = chibar2	0.0000			0.0000		

Standard errors in parentheses.
For categorical variable, the number in front of variable symbol refers to the options.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

The coefficients of IMTI influence, for travel time and travel distance, are all positive, which means the influence degree of IMTI has a positive correlation with holiday travel time and travel distance. This is relevant with the popularity of the Internet. Rich and detailed travel information on the Internet affects people's holiday travel plans significantly, and makes them travel longer and further. Meanwhile, the coefficients of the past IMTI influence on travel time and travel distance are all negative; this means the past IMTI provides precious travel experience for people, and help them to save a lot of travel time and travel distance in holidays. Moreover, the number of queries also has a significant impact on holiday travel time and travel distance. A longer travel time or travel distance usually needs more IMTI queries. For the way of querying IMTI, the query method has significant effects on holiday travel time, but its influence on holiday travel distance is not so significant. Compared with asking someone else, the experience and traffic radio are usually used for longer time and shorter distance

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

travel in holidays, while the map and navigation (vehicle/mobile) are usually used for longer time and longer distance travel in holidays.

(3) Interdependencies between holiday travel biography and other biographies: the residential, employment/education and car ownership biographies are found to be more influential on holiday travel biography than household structure biography. Compared with the other two influential biographies, the influence of residential biography on the holiday travel biography seems much more obvious, because the coefficients of its explanatory variables are larger than the other variables. Specially, lag variables of different life domains over the life course have significant effects on holiday travel biography. The past job/school satisfaction have a negative effect on holiday travel time and travel distance, which means people tend to longer travel time and travel distance in holidays when they are not satisfied with their past job or school. This also suggests that longer journey in holidays is another method for people to comfort their discontent on work or study. Meanwhile, people who worked in suburban districts or outer suburban districts before do not prefer longer time or longer distance travel in holidays. This is related to their travel habit of the past. Moreover, people lived in company/school dormitories now, or in the past, have longer travel distance in holidays, which may be due to having less pressure on life and economy. The family owning many cars usually has a shorter travel time and longer travel distance in holidays, and this is consistent with the intra-domain interdependency analysis for the car travellers.
(4) Outer-domain interdependency: the outer-domain independent variable year has significant effects on holiday travel time and travel distance. With the development of the times, people spend less travel time in the city, and more and more people travel to Hong Kong, Macao, Taiwan or foreign countries in holidays. This reveals the gradual improvement of people's living standards, and proves the outer environment biography has a great influence on the holiday travel biography.

The p-values for the two models all equal to 0, indicating that the two models are overall significant. Sigma2_u is the panel-level variance component σ_v^2, which reveals the individual variation. The reported likelihood-ratio test shows that there is enough variability between the random-effects ordered logistic regression over the standard ordered logistic regression.

6.1.2. The influence mechanism of the holiday travel biography on the IMTI usage biography

In order to analyse the two-way relationship between the holiday travel biography and the IMTI usage biography, the IMTI usage biography was taken as latent variable. Its observed variables, number of queries and query method, are taken as dependent variables, respectively. Similarly, the other observed variables for the IMTI usage biography belong to intra-domain independent variables. The observed variables for residential, household structure, employment/education, car ownership and holiday travel biographies belong to inter-domain independent variables. Moreover, the variable "year" is the outer-domain independent variable describing the outer environment influence on IMTI usage biography. Two random-effects ordered logistic models for IMTI usage biography were established, based on the research framework, and the results are shown in Table 4.

The significance of independent variables can be determined by the p-value, and the higher significance means the higher dependency. The biographical interdependencies for the IMTI usage biography are analysed from the following four aspects:

(1) Intra-domain interdependency: the IMTI influence, number of queries and query method are all significant variables for the IMTI usage biography. IMTI influence has positive correlations with the number of queries and query method, which means people affected by IMTI usually have a higher frequency of IMTI queries with a more advanced query method. Similarly, people influenced by historical IMTI also tend to query information in holidays, but they prefer to use traditional methods, such as asking someone else, by experience or map. The number of queries has a positive relationship with the query method, which is related to the convenience and accuracy of the advanced query method. Compared with asking someone else, the use of map, traffic radio or navigation increases the number of IMTI queries in holidays.
(2) Interdependency between the IMTI usage biography and the holiday travel biography: As shown in Table 4, holiday travel biography also has significant influence on the IMTI usage biography, but this relationship has seldom been investigated. Therefore, this study proves that there is a two-way relationship between the holiday travel biography and the IMTI usage biography.

Considering the significance of the predictor variables in the holiday travel biography, the longer activity duration usually needs a higher frequency of IMTI queries. This is relevant with the analysis result of Section 6.1.1, i.e. the place where people want to stay for a long time in holidays is usually far from their home. So IMTI plays an important role in the holiday travel when people stay in a strange place. Moreover, the car, taxi and P&R travellers tend to query IMTI and use an advanced query method in holidays, compared with people who travelled by public transport or slow traffic tools. A congested traffic condition induces people to query more IMTI with advanced query methods. However, travel companions can provide all kinds of information, without need to query IMTI from the other ways. Besides, activity duration and traffic conditions in the past also have significant effects on the number of queries and query method for IMTI, which indicates that holiday travel biography has significant state dependence on IMTI usage biography.

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

Table 4
Random-effects ordered logistic model results for IMTI usage biography.

Variables	Query times			Query method		
	Coef.	Std. Err.	P > |z|	Coef.	Std. Err.	P > |z|
year	0.053***	0.010	0.000	0.080***	0.008	0.000
worksatisf	−0.270***	0.061	0.000	0.008	0.058	0.890
L5.worksatisf	0.299***	0.062	0.000	−0.041	0.056	0.470
2.workplace	0.169	0.215	0.431	1.184***	0.211	0.000
3.workplace	0.378	0.318	0.234	1.127***	0.344	0.001
2L5.workplace	0.205	0.224	0.360	0.510**	0.209	0.015
3L5.workplace	−0.290	0.353	0.412	0.530	0.339	0.118
2.residencetype	−0.516	0.343	0.133	−0.787**	0.318	0.013
3.residencetype	−0.057	0.305	0.851	−1.010***	0.301	0.001
4.residencetype	−0.753***	0.279	0.007	−1.278***	0.275	0.000
2L5.residencetype	0.344	0.328	0.294	1.474***	0.332	0.000
3L5.residencetype	0.301	0.320	0.347	1.989***	0.318	0.000
4L5.residencetype	0.438	0.295	0.138	2.490***	0.309	0.000
carnumb	0.036	0.120	0.763	0.439***	0.124	0.000
householdnumb	0.101	0.071	0.157	−0.130*	0.071	0.066
L5.householdnumb	−0.008	0.072	0.915	−0.349***	0.077	0.000
activityduration	0.007***	0.002	0.000	−0.004**	0.002	0.046
L5.activityduration	−0.002**	0.001	0.027	−0.003**	0.001	0.018
2.travelmode	0.140	0.155	0.365	0.688***	0.141	0.000
3.travelmode	1.297***	0.261	0.000	1.290***	0.312	0.000
4.travelmode	0.547**	0.268	0.041	1.042***	0.335	0.002
2L5.travelmode	0.096	0.150	0.523	0.960***	0.162	0.000
3L5.travelmode	0.235	0.249	0.345	0.270	0.269	0.316
4L5.travelmode	1.590***	0.304	0.000	−0.660*	0.391	0.091
travelnumb	−0.086***	0.024	0.000	−0.074***	0.026	0.004
trafficccondi	0.186**	0.081	0.021	0.738***	0.090	0.000
L5.trafficcondi	−0.228***	0.078	0.004	0.153*	0.089	0.085
travelsatisf	0.252***	0.064	0.000	0.015	0.063	0.808
informationinflu	2.324***	0.121	0.000	1.415***	0.118	0.000
L5.informationinflu	0.247**	0.104	0.017	−0.413***	0.126	0.001
2.traveldis	0.755***	0.192	0.000	−0.455**	0.214	0.033
3.traveldis	0.411	0.326	0.208	1.773***	0.398	0.000
4.traveldis	1.597***	0.289	0.000	−1.005***	0.341	0.003
querytimes				0.632***	0.051	0.000
2.querymethod	−1.678***	0.211	0.000			
3.querymethod	0.951***	0.232	0.000			
4.querymethod	1.379***	0.260	0.000			
5.querymethod	2.785***	0.205	0.000			
traveltime	0.250***	0.049	0.000	0.363***	0.054	0.000
cut1	113.159***	20.785	0.000	162.037***	15.062	0.000
cut2	117.005***	20.797	0.000	165.144***	15.075	0.000
cut3	120.570***	20.800	0.000	166.597***	15.080	0.000
cut4	123.072***	20.799	0.000	167.508***	15.083	0.000
cut5	123.649***	20.800	0.000			
sigma2_u	16.123***	1.840		18.071***	2.365	
N	3858			3858		
Wald chi2	1565.977			1215.825		
Prob > chi2	0.0000			0.0000		
LR test vs. ologit regression						
Prob > = chibar2	0.0000			0.0000		

Standard errors in parentheses.
For categorical variable, the number in front of variable symbol refers to the options.
* p < 0.1.
** p < 0.05.
*** p < 0.01.

(3) Interdependencies between the IMTI usage biography and other biographies: the residential, household structure, employment/education and car ownership biographies are found to have significant influence on IMTI usage biography. Compared with the other two life biographies, the influence of residential and employment/education biographies on the number of queries are much more significant. Meanwhile, the four life biographies all have significant effects on the query method for IMTI in holidays, and the influence of residential biography are much more obvious than the other life biographies.

Compared with people working in urban districts, people working in suburban districts or outer suburban districts prefer to use traffic radio or navigation in holidays; this is relevant with their travel habit on workdays. The present residence type

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

Table 5
Marginal effects for holiday travel time in Beijing.

Variables	Travel time				
	1	2	3	4	5
year	0.0015**	0.0008*	−0.0015**	−0.0005**	−0.0003**
	(0.0007)	(0.0005)	(0.0007)	(0.0002)	(0.0002)
L5.worksatisf	0.0172***	0.0096***	−0.0174***	−0.0053***	−0.0041***
	(0.0046)	(0.0034)	(0.0043)	(0.0014)	(0.0012)
2.workplace	0.0410***	0.0319**	−0.0441***	−0.0154**	−0.0135**
	(0.0139)	(0.0150)	(0.0156)	(0.0061)	(0.0057)
3.workplace	0.0028	0.0009	−0.0030	−0.0007	−0.0000
	(0.0183)	(0.0218)	(0.0227)	(0.0092)	(0.0083)
2L5.workplace	0.0527***	0.0374**	−0.0564***	−0.0186***	−0.0152***
	(0.0156)	(0.0150)	(0.0165)	(0.0062)	(0.0055)
3L5.workplace	0.0638**	0.0414**	−0.0666***	−0.0214**	−0.0173**
	(0.0267)	(0.0175)	(0.0255)	(0.0083)	(0.0071)
2.residencetype	0.0168	0.0143	−0.0189	−0.0063	−0.0059
	(0.0155)	(0.0306)	(0.0215)	(0.0123)	(0.0119)
3.residencetype	−0.0079	−0.0218	0.0104	0.0088	0.0104
	(0.0119)	(0.0287)	(0.0178)	(0.0113)	(0.0118)
4.residencetype	0.0487***	0.0381	−0.0555***	−0.0175*	−0.0137
	(0.0127)	(0.0243)	(0.0168)	(0.0094)	(0.0093)
2L5.residencetype	0.0982***	0.1186***	−0.1206***	−0.0509***	−0.0453***
	(0.0218)	(0.0326)	(0.0244)	(0.0127)	(0.0136)
3L5.residencetype	0.1131***	0.1242***	−0.1347***	−0.0546***	−0.0480***
	(0.0203)	(0.0331)	(0.0218)	(0.0127)	(0.0137)
4L5.residencetype	0.0917***	0.1155***	−0.1141***	−0.0491***	−0.0439***
	(0.0171)	(0.0315)	(0.0201)	(0.0122)	(0.0133)
carnumb	0.0332***	0.0184***	−0.0335***	−0.0103***	−0.0079***
	(0.0094)	(0.0070)	(0.0089)	(0.0030)	(0.0025)
L5.householdnumb	−0.0239***	−0.0132***	0.0240***	0.0074***	0.0057***
	(0.0058)	(0.0048)	(0.0056)	(0.0019)	(0.0016)
activityduration	−0.0011***	−0.0006***	0.0011***	0.0003***	0.0003***
	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0001)
L5.activityduration	−0.0001*	−0.0001	0.0001*	0.0000*	0.0000*
	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0000)
2.travelmode	0.0641***	0.0419***	−0.0702***	−0.0207***	−0.0152***
	(0.0133)	(0.0119)	(0.0122)	(0.0043)	(0.0037)
3.travelmode	0.1813***	0.0375	−0.1560***	−0.0377***	−0.0250***
	(0.0320)	(0.0259)	(0.0188)	(0.0061)	(0.0051)
4.travelmode	−0.0492***	−0.0875***	0.0699***	0.0352***	0.0317***
	(0.0129)	(0.0294)	(0.0188)	(0.0117)	(0.0117)
2L5.travelmode	0.0479***	0.0211**	−0.0465***	−0.0129***	−0.0095***
	(0.0139)	(0.0082)	(0.0120)	(0.0035)	(0.0028)
3L5.travelmode	0.0026	0.0017	−0.0028	−0.0009	−0.0007
	(0.0187)	(0.0124)	(0.0200)	(0.0063)	(0.0048)
4L5.travelmode	−0.0540***	−0.0618*	0.0663***	0.0267**	0.0227*
	(0.0189)	(0.0319)	(0.0250)	(0.0127)	(0.0120)
travelnumb	0.0067***	0.0037**	−0.0067***	−0.0021***	−0.0016***
	(0.0019)	(0.0014)	(0.0019)	(0.0006)	(0.0005)
trafficcondi	−0.0864***	−0.0479***	0.0870***	0.0267***	0.0206***
	(0.0100)	(0.0133)	(0.0067)	(0.0034)	(0.0036)
L5.trafficcondi	−0.0469***	−0.0260***	0.0473***	0.0145***	0.0112***
	(0.0075)	(0.0078)	(0.0063)	(0.0025)	(0.0024)
travelsatisf	0.0162***	0.0090***	−0.0163***	−0.0050***	−0.0039***
	(0.0050)	(0.0035)	(0.0046)	(0.0016)	(0.0013)
informationinflu	−0.0297***	−0.0165**	0.0299***	0.0092***	0.0071***
	(0.0091)	(0.0066)	(0.0088)	(0.0029)	(0.0024)
L5.informationinflu	0.0295***	0.0163**	−0.0297***	−0.0091***	−0.0070***
	(0.0085)	(0.0064)	(0.0084)	(0.0027)	(0.0022)
2.traveldis	0.0375**	0.0191**	−0.0349***	−0.0120**	−0.0097**
	(0.0157)	(0.0084)	(0.0132)	(0.0050)	(0.0044)
3.traveldis	0.0892***	0.0280**	−0.0759***	−0.0232***	−0.0181***
	(0.0335)	(0.0119)	(0.0239)	(0.0072)	(0.0060)
4.traveldis	0.0790***	0.0274**	−0.0684***	−0.0213***	−0.0167***
	(0.0288)	(0.0111)	(0.0210)	(0.0068)	(0.0059)
querytimes	−0.0064**	−0.0035*	0.0064**	0.0020**	0.0015**
	(0.0031)	(0.0019)	(0.0030)	(0.0009)	(0.0008)
2.querymethod	−0.0984***	0.0035	0.0710***	0.0143***	0.0096***
	(0.0215)	(0.0147)	(0.0151)	(0.0036)	(0.0028)

(*continued on next page*)

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

Table 5 (*continued*)

Variables	Travel time				
	1	2	3	4	5
3.querymethod	−0.1848***	−0.0747**	0.1785***	0.0456***	0.0355***
	(0.0250)	(0.0342)	(0.0198)	(0.0078)	(0.0077)
4.querymethod	−0.1015***	0.0025	0.0740***	0.0150***	0.0101***
	(0.0260)	(0.0157)	(0.0203)	(0.0047)	(0.0036)
5.querymethod	−0.1662***	−0.0451*	0.1495***	0.0354***	0.0264***
	(0.0238)	(0.0269)	(0.0169)	(0.0055)	(0.0050)
Observations	3858	3858	3858	3858	3858

Standard errors in parentheses.
For categorical variable, the number in front of variable symbol refers to the options.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

has negative effects on the IMTI query method, while the past residence type has positive effects on the IMTI query method. Moreover, family owning many cars usually uses more advanced IMTI query methods, such as traffic radio or navigation on vehicles. Besides, the present or past family size all have negative effects on query method, which means the query method for a big family is usually based on their own travel experience. That is consistent with the analysis for travel companions.

(4) Outer-domain interdependency: the outer-domain independent variable has significant effects on the number of queries and query method for IMTI. With the development of the times, people have more queries for IMTI during the journey in holidays, and their query methods become more accurate and more advanced; that is down to the development of science and technology and the improvement of ITS. At the same time, the rapidly growing IMTI demand encourages government policy makers to strengthen the construction of ITS. Therefore, there is a two-way relationship between external environment and life domains, which can be analysed in the further study.

The p-values for the two models all equal to 0, indicating that the two models are overall significant. The reported likelihood-ratio test shows that there is enough variability between the random-effects ordered logistic regression over the standard ordered logistic regression.

6.2. Model sensitivity analysis

The analysis above mainly focuses on the significance of explanatory variables and their positive or negative effects on dependent variables. The average marginal effects for these predictors will be analysed in detail in this section, to further explore the biographical interdependencies of the holiday travel biography and the IMTI usage biography. Marginal effects show the average change in probability when the predictor or independent variable increases by one unit (Green, 2011). For continuous variables, marginal effects represent the instantaneous change given that the 'unit' may be very small, i.e. derivative. For classified variables, the marginal effect calculates the discrete first-difference from the base category. The average marginal effects of these 24 selected variables for holiday travel biography and IMTI usage biography were estimated by the software Stata, and only the variables having significant marginal effects are shown in Tables 5–8.

6.2.1. Marginal effects for holiday travel biography

Holiday travel biography was described from two aspects of time and space. The marginal effects for different alternatives of holiday travel time within Beijing are shown in Table 5, and the marginal effects for different alternatives of holiday travel distance are shown in Table 6. The results are analysed as follows:

(1) Marginal effects for holiday travel time within Beijing: As shown in Table 5, the marginal effect's changing point for different alternatives of holiday travel time within Beijing lies in the "two hours".

For the outer-domain independent variable "year", its marginal effects for the choice of holiday travel time in 0–1 h, 1–2 h, 2–3 h, 3–4 h and above 4 h are 0.0015, 0.0008, −0.0015, −0.0005 and −0.0003, which means for one instant increase of year, the probability increases 0.15 percentage points for choosing 0–1 h, increases 0.08 percentage points for choosing 1–2 h, decreases 0.15 percentage points for choosing 2–3 h, decreases 0.05 percentage points for choosing 3–4 h, and decreases 0.03 percentage points for choosing more than 4 h. This confirms the conclusion that people spend shorter travel time in the city with the development of the times.

For the interdependency with the IMTI usage biography, people affected by IMTI usually prefer 2–3 h travel time in holidays. When the query method shifts from "asking someone else" to "experience", "map", "traffic radio" or "navigation", the probability of holiday travel for 0–1 h decreases by 9.84, 18.48, 10.15 and 16.62 percentage points, respectively.

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

Table 6
Marginal effects for holiday travel distance.

Variables	Travel distance			
	1	2	3	4
year	−0.0014***	0.0002	0.0002***	0.0010***
	(0.0005)	(0.0001)	(0.0001)	(0.0004)
worksatisf	0.0091***	−0.0012	−0.0016***	−0.0063***
	(0.0030)	(0.0008)	(0.0006)	(0.0021)
L5.worksatisf	0.0092***	−0.0012	−0.0016***	−0.0063***
	(0.0030)	(0.0008)	(0.0006)	(0.0020)
2.workplace	0.0536***	−0.0046	−0.0084***	−0.0406***
	(0.0122)	(0.0036)	(0.0020)	(0.0093)
3.workplace	0.0001	−0.0035**	−0.0013	0.0047
	(0.0165)	(0.0017)	(0.0024)	(0.0130)
2L5.workplace	0.0136	−0.0017	−0.0023	−0.0096
	(0.0113)	(0.0016)	(0.0019)	(0.0080)
3L5.workplace	0.0723***	−0.0143**	−0.0133***	−0.0447***
	(0.0189)	(0.0072)	(0.0037)	(0.0107)
2.residencetype	−0.1047***	0.0283**	0.0182***	0.0583***
	(0.0200)	(0.0116)	(0.0038)	(0.0122)
3.residencetype	−0.0645***	0.0222**	0.0102***	0.0322***
	(0.0172)	(0.0100)	(0.0028)	(0.0075)
4.residencetype	−0.0721***	0.0267***	0.0100***	0.0354***
	(0.0160)	(0.0100)	(0.0026)	(0.0058)
2L5.residencetype	−0.0453***	0.0071	0.0081***	0.0300***
	(0.0158)	(0.0046)	(0.0030)	(0.0101)
3L5.residencetype	−0.0361**	0.0064	0.0064**	0.0233**
	(0.0155)	(0.0044)	(0.0029)	(0.0094)
4L5.residencetype	−0.0393***	0.0067	0.0070***	0.0256***
	(0.0141)	(0.0044)	(0.0027)	(0.0085)
carnumb	−0.0173***	0.0023	0.0030***	0.0120***
	(0.0060)	(0.0015)	(0.0012)	(0.0041)
householdnumb	−0.0071*	0.0009	0.0012*	0.0049*
	(0.0037)	(0.0007)	(0.0007)	(0.0026)
activityduration	−0.0027***	0.0004*	0.0005***	0.0018***
	(0.0001)	(0.0002)	(0.0001)	(0.0001)
L5.activityduration	−0.0003***	0.0000*	0.0000***	0.0002***
	(0.0001)	(0.0000)	(0.0000)	(0.0000)
2.travelmode	−0.0245***	0.0029	0.0053**	0.0163***
	(0.0084)	(0.0018)	(0.0021)	(0.0056)
3.travelmode	−0.1164***	0.0093	0.0198***	0.0874***
	(0.0184)	(0.0064)	(0.0033)	(0.0139)
4.travelmode	−0.0454***	0.0044	0.0094***	0.0316***
	(0.0146)	(0.0032)	(0.0035)	(0.0110)
2L5.travelmode	−0.0330***	0.0031	0.0061***	0.0238***
	(0.0079)	(0.0022)	(0.0016)	(0.0060)
3L5.travelmode	0.0028	−0.0004	−0.0006	−0.0019
	(0.0118)	(0.0017)	(0.0023)	(0.0078)
4L5.travelmode	−0.0726***	0.0063	0.0118***	0.0545***
	(0.0186)	(0.0045)	(0.0028)	(0.0144)
travelnumb	0.0039***	−0.0005	−0.0007***	−0.0027***
	(0.0012)	(0.0003)	(0.0002)	(0.0009)
trafficcondi	−0.0080*	0.0011	0.0014*	0.0056*
	(0.0044)	(0.0009)	(0.0008)	(0.0030)
L5.trafficcondi	−0.0211***	0.0028*	0.0037***	0.0147***
	(0.0041)	(0.0017)	(0.0008)	(0.0029)
travelsatisf	−0.0238***	0.0031	0.0042***	0.0165***
	(0.0042)	(0.0020)	(0.0007)	(0.0027)
L5.informationinflu	0.0203***	−0.0027*	−0.0035***	−0.0141***
	(0.0053)	(0.0015)	(0.0010)	(0.0040)
traveltime	0.0071***	−0.0009	−0.0012***	−0.0049***
	(0.0026)	(0.0006)	(0.0005)	(0.0019)
querytimes	−0.0107***	0.0014	0.0019***	0.0074***
	(0.0020)	(0.0009)	(0.0004)	(0.0013)
2.querymethod	0.0192*	−0.0029	−0.0035*	−0.0129*
	(0.0111)	(0.0022)	(0.0021)	(0.0075)
3.querymethod	−0.0171	0.0015	0.0031	0.0125
	(0.0125)	(0.0017)	(0.0022)	(0.0092)
4.querymethod	0.0081	−0.0010	−0.0015	−0.0056
	(0.0163)	(0.0023)	(0.0030)	(0.0111)

(*continued on next page*)

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

Table 6 (*continued*)

Variables	Travel distance			
	1	2	3	4
5.querymethod	−0.0027	0.0003	0.0005	0.0019
	(0.0104)	(0.0011)	(0.0019)	(0.0074)
Observations	3858	3858	3858	3858

Standard errors in parentheses.
For categorical variable, the number in front of variable symbol refers to the options.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

For the interdependency with the other life domain biographies, people who worked in suburban districts or outer suburban districts in the past, give priority to travel less than two hours in holidays.

For the intra-domain interdependency, when the travel modes used in Beijing shifts from "combined modes of public transport/slow traffic" to "car" or "taxi", the probability increases for the travel in less than 2 h, and decreases for the travel in more than two hours. Moreover, the marginal effects of traffic conditions for holiday travel in 0–1 h, 1–2 h, 2–3 h, 3–4 h and above 4 h are −0.0864, −0.0479, 0.0870, 0.0267 and 0.0206.

(2) Marginal effects for holiday travel distance: As shown in Table 6, the marginal effect's changing point for different alternatives of holiday travel distance lies between the "Intra-city travel" and "Inter-city travel".

For the outer-domain independent variable year, its marginal effects for choosing intra-city travel, inter-city travel, travel to Hong Kong, Macao or Taiwan, and travel abroad are −0.0014, 0.0002, 0.0002 and 0.001, which also confirms the conclusion that more and more people travel to Hong Kong, Macao, Taiwan or foreign countries in holidays with the development of the times.

For the interdependency with the IMTI usage biography, for one instant increase of the number of IMTI queries, the probability decreases 1.07 percentage points for choosing intra-city travel, increases 0.14 percentage points for choosing inter-city travel, increases 0.19 percentage points for choosing travel to Hong Kong, Macao or Taiwan, and increases 0.74 percentage points for choosing travel abroad. This confirms the conclusion that a longer travel distance usually need more IMTI queries.

For the interdependency with the other life domain biographies, when the residence type shifts from "other" to "company/school dormitory", "renting", or "self-purchased house", the probability of having an intra-city travel decreases by 10.47, 6.45 and 7.21 percentage points, respectively. Moreover, people will have longer travel distance in holidays, when they are not satisfied with their job or school.

For the intra-domain interdependency, when the travel modes used in Beijing shifts from "combined modes of public transport/slow traffic" to "car", "taxi" or "P&R", the probability decreases for intra-city travel in holidays, but the probability increases for inter-city travel or travel to Hong Kong, Macao, Taiwan or foreign countries in holidays. Moreover, bad traffic conditions make people reduce their intra-city travels in Beijing and stimulate them to travel to Hong Kong, Macao, Taiwan or foreign countries in holidays.

6.2.2. Marginal effects for the IMTI usage biography

IMTI usage biography was described from two aspects: the number of IMTI queries and query method for IMTI during the holiday journey. Marginal effects for different alternatives of the number of IMTI queries are shown in Table 7, and marginal effects for different alternatives of the query method for IMTI are shown in Table 8. The results are analysed as follows:

(1) Marginal effects for the number of IMTI queries: As shown in Table 7, the marginal effect's changing point for different alternatives of the number of IMTI queries occurs in the "two times".

For the outer-domain independent variable "year", more and more people would query IMTI more than two times during their holiday journeys, with the development of the times.

For the interdependency with the holiday travel biography, for one instant increase of the number of companions, the probability will decrease 0.65 percentage points for querying IMTI two or more times, and this confirms the conclusion that more travel companions need less IMTI queries from others. Similarly, for one instant of bad traffic conditions, the probability for zero time query and one time query will decrease 1.29 and 0.12 percentage points, respectively.

For the interdependency with the other life domain biographies, the present job/school satisfaction and past job/school satisfaction have different marginal effects for the number of IMTI queries. The marginal effects of present job/school satisfaction for zero time query and one time query are 0.0187 and 0.0017, while the marginal effects of past job/school satisfaction for zero time query and one time query are −0.0207 and −0.0019.

For the intra-domain interdependency, people affected by IMTI usually query IMTI more than two times during their holiday journeys.

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

Table 7
Marginal effects for the number of IMTI queries.

Variables	Number of queries					
	1	2	3	4	5	6
year	−0.0037***	−0.0003**	0.0002	0.0020***	0.0004***	0.0014***
	(0.0007)	(0.0001)	(0.0002)	(0.0004)	(0.0001)	(0.0003)
worksatisf	0.0187***	0.0017**	−0.0012	−0.0102***	−0.0021***	−0.0070***
	(0.0042)	(0.0007)	(0.0012)	(0.0024)	(0.0005)	(0.0018)
L5.worksatisf	−0.0207***	−0.0019***	0.0013	0.0113***	0.0023***	0.0077***
	(0.0043)	(0.0007)	(0.0013)	(0.0023)	(0.0006)	(0.0019)
2.residencetype	0.0331	0.0030	−0.0021	−0.0180	−0.0037	−0.0123
	(0.0231)	(0.0024)	(0.0035)	(0.0124)	(0.0025)	(0.0084)
3.residencetype	−0.0006	−0.0011	−0.0006	0.0017	0.0003	0.0003
	(0.0199)	(0.0017)	(0.0011)	(0.0101)	(0.0023)	(0.0081)
4.residencetype	0.0371**	0.0038**	−0.0068	−0.0189**	−0.0036*	−0.0116
	(0.0173)	(0.0018)	(0.0044)	(0.0089)	(0.0021)	(0.0076)
activityduration	−0.0005***	−0.0000**	0.0000	0.0003***	0.0001***	0.0002***
	(0.0001)	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0000)
L5.activityduration	0.0002**	0.0000*	−0.0000	−0.0001**	−0.0000**	−0.0001**
	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
2.travelmode	−0.0110	−0.0023	0.0008	0.0072	0.0014	0.0039
	(0.0109)	(0.0023)	(0.0016)	(0.0066)	(0.0013)	(0.0036)
3.travelmode	−0.0888***	−0.0118***	0.0014	0.0467***	0.0120***	0.0405***
	(0.0173)	(0.0039)	(0.0047)	(0.0096)	(0.0029)	(0.0110)
4.travelmode	−0.0408**	−0.0071***	0.0043	0.0223**	0.0048**	0.0164**
	(0.0184)	(0.0026)	(0.0027)	(0.0103)	(0.0025)	(0.0078)
2L5.travelmode	−0.0066	−0.0007	0.0006	0.0036	0.0007	0.0024
	(0.0104)	(0.0012)	(0.0010)	(0.0056)	(0.0012)	(0.0038)
3L5.travelmode	−0.0162	−0.0018	0.0012	0.0087	0.0019	0.0062
	(0.0172)	(0.0019)	(0.0013)	(0.0092)	(0.0020)	(0.0069)
4L5.travelmode	−0.1066***	−0.0122***	−0.0028	0.0502***	0.0140***	0.0573***
	(0.0193)	(0.0045)	(0.0053)	(0.0092)	(0.0033)	(0.0154)
travelnumb	0.0060***	0.0005**	−0.0004	−0.0032***	−0.0007***	−0.0022***
	(0.0017)	(0.0002)	(0.0004)	(0.0010)	(0.0002)	(0.0007)
trafficcondi	−0.0129**	−0.0012**	0.0008	0.0070**	0.0014**	0.0048**
	(0.0056)	(0.0006)	(0.0009)	(0.0031)	(0.0007)	(0.0022)
L5.trafficcondi	0.0158***	0.0014**	−0.0010	−0.0086***	−0.0018***	−0.0059***
	(0.0054)	(0.0007)	(0.0010)	(0.0030)	(0.0006)	(0.0022)
travelsatisf	−0.0175***	−0.0016***	0.0011	0.0095***	0.0019***	0.0065***
	(0.0045)	(0.0006)	(0.0011)	(0.0024)	(0.0006)	(0.0019)
informationinflu	−0.1614***	−0.0147***	0.0103	0.0879***	0.0180***	0.0599***
	(0.0081)	(0.0047)	(0.0101)	(0.0060)	(0.0025)	(0.0087)
L5.informationinflu	−0.0171**	−0.0016*	0.0011	0.0093**	0.0019**	0.0064**
	(0.0071)	(0.0009)	(0.0012)	(0.0038)	(0.0008)	(0.0029)
traveltime	−0.0174***	−0.0016***	0.0011	0.0095***	0.0019***	0.0064***
	(0.0035)	(0.0005)	(0.0011)	(0.0019)	(0.0004)	(0.0015)
2.traveldis	−0.0550***	−0.0050**	0.0064*	0.0296***	0.0065***	0.0174***
	(0.0144)	(0.0020)	(0.0039)	(0.0079)	(0.0019)	(0.0051)
3.traveldis	−0.0302	−0.0027	0.0045	0.0165	0.0034	0.0085
	(0.0240)	(0.0023)	(0.0037)	(0.0130)	(0.0029)	(0.0074)
4.traveldis	−0.1131***	−0.0119**	0.0054	0.0574***	0.0149***	0.0472***
	(0.0202)	(0.0047)	(0.0062)	(0.0108)	(0.0035)	(0.0121)
2.querymethod	0.1794***	−0.0154	−0.1218***	−0.0348***	−0.0029***	−0.0045***
	(0.0239)	(0.0138)	(0.0160)	(0.0069)	(0.0008)	(0.0014)
3.querymethod	−0.0835***	−0.0233**	0.0605***	0.0353***	0.0038***	0.0072***
	(0.0207)	(0.0096)	(0.0161)	(0.0096)	(0.0012)	(0.0025)
4.querymethod	−0.1150***	−0.0410***	0.0820***	0.0552***	0.0063***	0.0125***
	(0.0217)	(0.0136)	(0.0169)	(0.0125)	(0.0018)	(0.0042)
5.querymethod	−0.1884***	−0.1275***	0.1212***	0.1317***	0.0185***	0.0445***
	(0.0218)	(0.0229)	(0.0223)	(0.0120)	(0.0031)	(0.0080)
Observations	3858	3858	3858	3858	3858	3858

Standard errors in parentheses.
For categorical variable, the number in front of variable symbol refers to the options.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

(2) Marginal effects for the query method for IMTI: As shown in Table 8, the marginal effect's changing point for different alternatives of the query method for IMTI lies between the "map" and "traffic radio".

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

Table 8
Marginal effects for query method for IMTI.

Variables	Query method				
	1	2	3	4	5
year	−0.0039***	−0.0036***	−0.0006**	0.0002	0.0079***
	(0.0006)	(0.0004)	(0.0002)	(0.0001)	(0.0007)
2.workplace	−0.0813***	−0.0648***	−0.0026	0.0060***	0.1428***
	(0.0156)	(0.0109)	(0.0038)	(0.0022)	(0.0197)
3.workplace	−0.0699***	−0.0547***	−0.0014	0.0062***	0.1199***
	(0.0194)	(0.0164)	(0.0036)	(0.0023)	(0.0324)
2L5.workplace	−0.0256**	−0.0236**	−0.0027	0.0014	0.0505**
	(0.0111)	(0.0099)	(0.0018)	(0.0010)	(0.0207)
3L5.workplace	−0.0265	−0.0246	−0.0028	0.0015	0.0524
	(0.0166)	(0.0164)	(0.0025)	(0.0011)	(0.0337)
2.residencetype	0.0429*	0.0182*	−0.0005	−0.0041	−0.0564**
	(0.0222)	(0.0097)	(0.0024)	(0.0027)	(0.0280)
3.residencetype	0.0450**	0.0136	−0.0063*	−0.0075***	−0.0448*
	(0.0201)	(0.0096)	(0.0033)	(0.0025)	(0.0259)
4.residencetype	0.0183	−0.0192*	−0.0100***	−0.0055***	0.0164
	(0.0164)	(0.0104)	(0.0026)	(0.0020)	(0.0248)
2L5.residencetype	−0.1058***	−0.0457***	0.0045	0.0120***	0.1351***
	(0.0262)	(0.0117)	(0.0049)	(0.0037)	(0.0297)
3L5.residencetype	−0.1332***	−0.0688***	0.0016	0.0135***	0.1870***
	(0.0260)	(0.0132)	(0.0059)	(0.0043)	(0.0285)
4L5.residencetype	−0.1548***	−0.0942***	−0.0032	0.0135***	0.2386***
	(0.0264)	(0.0155)	(0.0069)	(0.0049)	(0.0280)
carnumb	−0.0214***	−0.0197***	−0.0030**	0.0010	0.0432***
	(0.0064)	(0.0061)	(0.0015)	(0.0008)	(0.0123)
householdnumb	0.0064*	0.0059*	0.0009	−0.0003	−0.0129*
	(0.0035)	(0.0033)	(0.0006)	(0.0003)	(0.0070)
L5.householdnumb	0.0170***	0.0157***	0.0024**	−0.0008	−0.0344***
	(0.0043)	(0.0035)	(0.0012)	(0.0006)	(0.0076)
activityduration	0.0002*	0.0002**	0.0000	−0.0000	−0.0003**
	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0002)
L5.activityduration	0.0001**	0.0001**	0.0000	−0.0000	−0.0003**
	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0001)
2.travelmode	−0.0401***	−0.0484***	−0.0118***	−0.0007	0.1009***
	(0.0080)	(0.0090)	(0.0030)	(0.0020)	(0.0156)
3.travelmode	−0.0570***	−0.0729***	−0.0128**	0.0027	0.1400***
	(0.0129)	(0.0194)	(0.0063)	(0.0030)	(0.0342)
4.travelmode	−0.0476***	−0.0557***	−0.0082	0.0034	0.1082***
	(0.0141)	(0.0205)	(0.0054)	(0.0023)	(0.0369)
2L5.travelmode	−0.0405***	−0.0496***	−0.0102***	0.0007	0.0996***
	(0.0079)	(0.0100)	(0.0035)	(0.0019)	(0.0175)
3L5.travelmode	−0.0131	−0.0132	−0.0020	0.0008	0.0276
	(0.0126)	(0.0136)	(0.0025)	(0.0008)	(0.0278)
4L5.travelmode	0.0379	0.0290*	0.0018	−0.0037	−0.0652*
	(0.0251)	(0.0158)	(0.0021)	(0.0029)	(0.0375)
travelnumb	0.0036***	0.0034***	0.0005*	−0.0002	−0.0073***
	(0.0013)	(0.0012)	(0.0003)	(0.0001)	(0.0026)
trafficcondi	−0.0360***	−0.0332***	−0.0051**	0.0017	0.0727***
	(0.0061)	(0.0047)	(0.0022)	(0.0012)	(0.0086)
L5.trafficcondi	−0.0075*	−0.0069*	−0.0011	0.0003	0.0151*
	(0.0044)	(0.0040)	(0.0008)	(0.0003)	(0.0087)
informationinflu	−0.0690***	−0.0637***	−0.0098**	0.0032	0.1394***
	(0.0099)	(0.0072)	(0.0041)	(0.0023)	(0.0112)
L5.informationinflu	0.0201***	0.0186***	0.0029*	−0.0009	−0.0407***
	(0.0064)	(0.0062)	(0.0015)	(0.0007)	(0.0126)
traveltime	−0.0177***	−0.0163***	−0.0025**	0.0008	0.0358***
	(0.0033)	(0.0028)	(0.0011)	(0.0006)	(0.0052)
2.traveldis	0.0233**	0.0186**	0.0023*	−0.0007	−0.0435**
	(0.0114)	(0.0085)	(0.0013)	(0.0006)	(0.0200)
3.traveldis	−0.0566***	−0.0876***	−0.0219***	−0.0052	0.1712***
	(0.0125)	(0.0212)	(0.0078)	(0.0036)	(0.0387)
4.traveldis	0.0563***	0.0378***	0.0033	−0.0025*	−0.0949***
	(0.0216)	(0.0118)	(0.0022)	(0.0015)	(0.0310)
querytimes	−0.0308***	−0.0284***	−0.0044**	0.0014	0.0622***
	(0.0045)	(0.0033)	(0.0017)	(0.0010)	(0.0046)
Observations	3858	3858	3858	3858	3858

Standard errors in parentheses.
For categorical variable, the number in front of variable symbol refers to the options.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

For the outer-domain independent variable ‘‘year”, with one instant increase of year, the probability for ‘‘asking someone else”, ‘‘experience” and ‘‘map” decrease 0.39, 0.36, 0.06 percentage points, while the probability for ‘‘traffic radio” and ‘‘navigation” will increase 0.02 and 0.79 percentage points; this confirms the conclusion that people's query methods for IMTI become more and more advanced with the development of the times.

For the interdependency with the holiday travel biography, when the travel modes used in Beijing shifts from ‘‘combined modes of public transport/slow traffic” to ‘‘car”, ‘‘taxi” or ‘‘P&R”, the probability for ‘‘asking someone else”, ‘‘experience” and ‘‘map” decrease to some extent, and the probability for ‘‘navigation” will increase 10.09, 14.00 and 10.82 percentage points, respectively. Moreover, travel with more companions is usually based on the traditional query method, such as asking someone else, by experience or map. Bad traffic conditions in Beijing stimulate the use of navigation in holidays.

For the interdependency with the other life domain biographies, when the work/school location changes from urban districts to suburban districts or outer suburban districts, the probability decreases for choosing ‘‘asking someone else”, ‘‘experience” or ‘‘map”, but increases for choosing ‘‘traffic radio” or ‘‘navigation”. This proves the conclusion that people who work in suburban districts or outer suburban districts prefer to use traffic radio or navigation in holidays. Moreover, one instant increase of the number of cars, the probability decreases 2.14 percentage points for choosing ‘‘asking someone else”, decreases 1.97 percentage points for choosing ‘‘experience”, decreases 0.30 percentage points for choosing ‘‘map”, increases 0.10 percentage points for choosing ‘‘traffic radio”, and increases 4.32 percentage points for choosing ‘‘navigation”. This confirms the conclusion that a family owning many cars usually use more advanced IMTI query methods.

For the intra-domain interdependency, people affected by IMTI usually use more advanced query methods in holidays.

7. Conclusions

In the current life-oriented approach, Internet usage has only been regarded as an explanatory variable for the leisure and recreation domain, and the two-way relationship between holiday travel behaviour and IMTI usage is seldom investigated. To fill this gap, this study took IMTI usage as a separate life domain, and investigated holiday travel behaviour dynamics with IMTI usage, based on the life-oriented approach. The two-way relationship between holiday travel behaviour biography and IMTI usage biography was examined after controlling for the effects of residential, household structure, employment/education, and car ownership biographies.

In order to support the analysis, a web-based life choice survey, considering the variation of different life domains over the life course, was carried out in February 2016 in Beijing, and 326 completely valid questionnaires with 5425 scenarios were obtained from the respondents aged from 19 to 72 years old. Based on the panel data, statistical characteristics of mobilities in each biography over the life course were first analysed. Then, the random-effects ordered logistic model was applied to investigate biographical interdependencies among different life domains from three aspects: intra-domain interdependency, inter-domain interdependency and outer-domain interdependency. The findings are summarised below.

In a person's life, most of the life mobilities fall within the range of 20 and 35 years old for residential, household structure and employment/education biographies, except for the car ownership biography having a longer range of 20 and 40 years old. Considering the peak period of mobilities for these four biographies, the possibility of changing residential location is the highest, while the possibility of changing car ownership is the lowest. Moreover, there is a synergic relationship between these four biographies, which means a mobility occurring in one biography may drive mobilities in other biographies. Therefore, the policy making related to housing, employment and education should focus on the needs of 20–35 aged cohorts, and the automobile industry policy makers should consider the buying demand for 20–40 aged cohorts.

However, the above conclusion is not unchanging with the development of the times. The analysis results show that life biographies are not only affected by a personal life course, but also affected by the external background of the times. People are not as conservative as the past, and their mobilities are more frequent and complex. Now the generation aged above 50 years old are more stable than the young, but when the young live to 50 years old, their activities and energy may not be weaker than the young at that time; therefore, the formulation of long-term policy making should keep pace with the times.

Similarly, holiday travel biography and IMTI usage biography should consider the influence of personal life course and external background of the times at the same time. For holiday travel biography, as people get older, their travel time in the city become shorter, but their holiday travel distance become longer. When people get into the middle-aged, the proportion of inter-city travel and travel to Hong Kong, Macao, Taiwan or foreign countries increase greatly. With the development of the times, intra-city and short-term travels decrease and long-distance and long-term travels increase over the years. Therefore, the inter-city travel and travel abroad will become a mainstream in holidays, and the middle-aged people are the main consuming group for holiday tourism consumption.

For IMTI usage biography, the number of IMTI queries decreases when people get older, but the IMTI influence on them becomes bigger and bigger. IMTI is the product of the times, the number of queries and its influence increase greatly with the construction of ITS, and that is a positive feedback for the investment of ITS, which also brings much profit for the society.

There is a two-way relationship between the holiday travel biography and the IMTI usage biography, therefore, the hypothesis that the IMTI usage is a separate life domain and should not be treated as an explanatory variable for other life biographies only, is confirmed. The influence degree of IMTI has positive correlations with holiday travel time and travel dis-

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

tance. At the same time, the past IMTI provides precious travel experience for people and saves a lot of travel time and travel distance for them. This indicates that IMTI usage biography has significant influence on people's holiday travel behaviour, which helps people to have a convenient and comfortable travel in holidays.

On the other hand, holiday travel biography also has significant effects on IMTI usage biography. Congested traffic conditions induce people to query IMTI more frequently, and more rely on the advanced query method. Moreover, the car, taxi and P&R travellers prefer to query IMTI and use traffic radio or navigation in holidays, compared with people who travelled by public transport or slow traffic tools. Therefore, the radio station and navigation platform for traffic information should continue to provide good service for the car, taxi and P&R travellers. Moreover, they should consider providing a characteristic service for the public transport or slow traffic travellers.

Residential, household structure, employment/education and car ownership biographies have significant effects on holiday travel biography and IMTI usage biography. Though the residential biography was found to be more influential on these two biographies, mobilities in the other three biographies also play important roles in explaining the decisions for the holiday travel biography and the IMTI usage biography. Therefore, analysis of holiday travel biography and the IMTI usage biography should consider biographical interdependences between various life domains over the life course (e.g., residential, employment/education and car ownership biographies), and the life-oriented approach can provide a comprehensive analysis and a valid forecasting method.

Moreover, the influence of state dependence for different life domains over the life course is much more obvious when explaining holiday travel behaviour dynamics and IMTI usage mobilities. The results confirm the necessity for incorporating the state dependence into the dynamic models, and the research framework of this study can be applied to different life domains.

Intra-domain interdependency could describe the dynamic relationships between multiple facets or portfolio choices of a life domain. For the holiday travel biography, activity duration, travel mode, number of companions, traffic conditions and travel satisfaction, all have significant influence on travel time and travel distance in holidays. Moreover, activity duration and traffic conditions in the past have left a deep impression on people's hearts, and have significant impacts on their travel time and travel distance. For the IMTI usage biography, the influence degree of IMTI has significant effects on the number of queries and the query method. People affected by IMTI usually have a higher frequency of IMTI queries with more advanced query method. Moreover, people influenced by the past IMTI deeply will query IMTI more frequently, but they prefer to use a traditional query method. Therefore, the results can be applied into the study of portfolio decision-making processes for holiday travel behaviour.

The outer-domain independent variable has significant effects on the holiday travel biography and the IMTI usage biography. With the development of the times, people spend less travel time in the city, and more and more people travel to Hong Kong, Macao, Taiwan or foreign countries in holidays. At the same time, people have more queries for IMTI during the journey, with more advanced query methods. The model results are consistent with the statistical analysis results, which proves that the random-effects ordered logistic model is appropriate for the dynamic analysis of holiday travel behaviour with IMTI usage.

Besides, there is a two-way relationship between external environment and life domains. Under the stimulation of the external environment, people's life self-selection issues will change at the same time. If the change makes more profit for the society and economy, government policy makers will strengthen this stimulation, and then a positive feedback loop is formed. This study only proves the influence of the external environment on life domain biographies, but the reverse relationship has not been investigated; this can be analysed in the further study.

Overall, this study is an initial attempt to apply the life-oriented approach to analyse holiday travel behaviour dynamics in the long-term. By extending the current major life domains, this study enriches the life-oriented approach and provides a research framework for analysing holiday travel behaviour dynamics. Beijing is working on the construction of a smart city, and travel behaviour mechanism research under the technology of ITS is a key scientific problem for this innovative governance systems. In order to improve the urban traffic system efficiency, and achieve the balance of traffic supply and travel demand, dynamic analysis of holiday travel behaviour with IMTI usage cannot be ignored. Moreover, policy makers are required to take the whole situation into account over a longer period of time, to predict whether policies could achieve the expected result or not. Thus, the results of this study can provide useful information for policy makers understanding the evolution mechanism of holiday travel behaviour in the long-term, and supporting the policy making for holiday traffic demand management.

Acknowledgments

The authors sincerely thank the editor and anonymous reviewers for their helpful comments and valuable suggestions, which considerably improved the exposition of this work. Special thanks are given to Prof. Junyi Zhang from Hiroshima University for his advices in improving the paper quality. This work was supported by the National Natural Science Foundation of China (Grant Number 51338008), the Science Fund for Creative Research Groups of the National Natural Science Foundation of China (Grant Number 71621001), and the Fundamental Research Funds for the Central Universities (Grant Number 2016YJS089).

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

References

Arentze, T.A., Ettema, D., Timmermans, H.J., 2011. Estimating a model of dynamic activity generation based on one-day observations: method and results. Transp. Res. Part B: Methodol. 45 (2), 447–460.
Bekhor, S., Albert, G., 2014. Accounting for sensation seeking in route choice behavior with travel time information. Transp. Res. Part F: Traffic Psychol. Behav. 22, 39–49.
Ben-Elia, E., Di Pace, R., Bifulco, G.N., Shiftan, Y., 2013. The impact of travel information's accuracy on route-choice. Transp. Res. Part C: Emerg. Technol. 26, 146–159.
Beijing Municipal Bureau of Statistics, 2015. Beijing Statistical Yearbook. China Statistics Press, Beijing.
Beige, S., Axhausen, K., 2012. Interdependencies between turning points in life and long-term mobility decisions. Transportation 39, 857–872.
Belli, R.F., 1998. The structure of autobiographical memory and the event history calendar: potential improvements in the quality of retrospective reports in surveys. Memory 6 (4), 383–406.
Bowman, J.L., 1998. The Day Activity Schedule Approach to Travel Demand Analysis (Ph.D. Dissertation). Massachusetts Institute of Technology, USA.
Carr, N., 2002. A comparative analysis of the behaviour of domestic and international young tourists. Tourism Manage. 23 (3), 321–325.
Cervero, R., Day, J., 2008. Suburbanization and transit-oriented development in China. Transp. Policy 15 (5), 315–323.
Chu, Y.L., 2003. Empirical analysis of commute stop-making behavior. Transp. Res. Rec.: J. Transp. Res. Board 1831 (1), 106–113.
China Internet Network Information Center, 2016. China Internet Network Development Statistical Report in January, 2016. <http://www.cnnic.com.cn/hlwfzyj/hlwxzbg/201601/P020160122469130059846.pdf>.
China News, 2014. Serious Traffic Jams During the May Day and the Solution for Solving Traffic Congestion in Holidays. China News. <http://www.shangc.net/news/n/22478.html> (accessed May 2, 2014).
Collins, D., Tisdell, C., 2002. Gender and differences in travel life cycles. J. Travel Res. 41 (2), 133–143.
Cosenza, R.M., Davis, D.L., 1981. Family vacation decision making over the family life cycle: a decision and influence structure analysis. J. Travel Res. 20 (2), 17–23.
Dahlgreen, W., 2015. British Workers Take More of Their Holiday Days than Anyone Else in the World. YouGov. <https://yougov.co.uk/news/2015/11/06/british-workers-holiday-takers-world/> (accessed November 6, 2015).
Davison, L., Ryley, T., 2013. The relationship between air travel behaviour and the key life stages of having children and entering retirement. J. Transp. Geogr. 26, 78–86.
Dellaert, B.G., Ettema, D.F., Lindh, C., 1998. Multifaceted tourist travel decisions: a constraint-based conceptual framework to describe tourist's sequential choices of travel components. Tourism Manage. 19 (4), 313–320.
Draper, N.R., Smith, H., 2014. Applied Regression Analysis. John Wiley & Sons, New York. http://dx.doi.org/10.1002/9781118625590.
Efroymson, M.A., 1960. Multiple regression analysis. In: Ralston, A., Wilf, H. (Eds.), Mathematical Methods for Digital Computers. John Wiley & Sons, New York.
Ettema, D., Timmermans, H., 2003. Modelling departure time choice in the context of activity scheduling behavior. In: The 82th Annual Meeting of the Transportation Research Board, Washington D.C. http://dx.doi.org/10.3141/1831-05.
Farag, S., Lyons, G., 2012. To use or not to use? An empirical study of pre-trip public transport information for business and leisure trips and comparison with car travel. Transp. Policy 20, 82–92.
Freedman, D., Thornton, A., Camburn, D., Alwin, D., Young-DeMarco, L., 1988. The life history calendar: a technique for collecting retrospective data. Sociol. Methodol. 18, 37–68.
Fried, M., Havens, J., Thall, M., 1977. Travel Behavior – A Synthesized Theory. National Cooperative Highway Research Program. Transportation Research Board, National Research Council, Project 8-14 Final Report, 145. <https://trid.trb.org/view.aspx?id=55954>.
Fodness, D., 1992. The impact of family life cycle on the vacation decision-making process. J. Travel Res. 31 (2), 8–13.
Gärling, T., Axhausen, K.W., 2003. Introduction: habitual travel choice. Transportation 30 (1), 1–11.
Gibson, H., Yiannakis, A., 2002. Tourist roles: needs and the life course. Ann. Tourism Res. 29 (2), 358–383.
Golob, T.F., 1990. The dynamics of household travel time expenditures and car ownership decisions. Transp. Res. Part A: Gen. 24, 443–463.
Goulias, K.G., 1999. Longitudinal analysis of activity and travel pattern dynamics using generalized mixed Markov latent class models. Transp. Res. Part B: Methodol. 33 (8), 535–558.
Green, W.H., 2011. Econometric Analysis. Pearson Education, Inc., USA, Prentice Hall.
Grigolon, A., Kemperman, A., Timmermans, H., 2012. The influence of low-fare airlines on vacation choices of students: results of a stated portfolio choice experiment. Tourism Manage. 33 (5), 1174–1184.
Grigolon, A., Kemperman, A., Timmermans, H., 2013a. Facet-based analysis of vacation planning processes a binary Mixed Logit Panel Model. J. Travel Res. 52 (2), 192–201.
Grigolon, A., Kemperman, A., Timmermans, H., 2013b. Mixed multinomial logit model for out-of-home leisure activity choice. Transp. Res. Rec.: J. Transp. Res. Board 2343 (1), 10–16.
Grotenhuis, J.W., Wiegmans, B.W., Rietveld, P., 2007. The desired quality of integrated multimodal travel information in public transport: customer needs for time and effort savings. Transp. Policy 14 (1), 27–38.
Habib, K.M., Miller, E.J., 2008. Modelling daily activity program generation considering within-day and day-to-day dynamics in activity-travel behaviour. Transportation 35, 467–484.
Hocking, R.R., 1976. The analysis and selection of variables in linear regression. Biometrics 32 (1), 1–49.
Hollingworth, B., Miller, E., 1996. Retrospective interviewing and its application in study of residential mobility. Transp. Res. Rec.: J. Transp. Res. Board 1551, 74–81.
Huby, M., Burkitt, N., 2000. Is the new deal for transport really better for everyone? The social policy implications of the UK 1998 white paper on transport. Environ. Plann. C: Gov. Policy 18 (4), 379–392.
Jenelius, E., Mattsson, L.G., Levinson, D., 2011. Traveler delay costs and value of time with trip chains, flexible activity scheduling and information. Transp. Res. Part B 45 (5), 789–807.
Kang, H., Scott, D.M., 2010. Exploring day-to-day variability in time use for household members. Transp. Res. Part A: Policy Pract. 44, 609–619.
Kitamura, R., Kostyniuk, L.P., 1986. Maturing motorization and household travel: the case of nuclear-family households. Transp. Res. Part A: Gen. 20 (3), 245–260.
Krygsman, S., Arentze, T., Timmermans, H., 2006. Capturing tour mode and activity choice interdependencies: a co-evolutionary logit modeling approach. Transp. Res. Part A: Policy Pract. 41 (10), 913–933.
LaMondia, J.J., Bhat, C.R., 2012. A conceptual and methodological framework of leisure activity loyalty accommodation the travel context. Transportation 39 (2), 321–349.
Lanzendorf, M., 2003. Mobility biographies: a new perspective for understanding travel behaviour. In: The 10th International Conference on Travel Behaviour Research, Lucerne, August 10–15. <http://archiv.ivt.ethz.ch/news/archive/20030810_IATBR/lanzendorf.pdf>.
Liu, T., Zhang, C., Wang, T., Wu, G., 2013. Effects of friends' information interaction on travel decisions. J. Transp. Syst. Eng. Inform. Technol. 13 (6), 86–93.
Liu, Z., Sharma, S., 2008. Nonparametric method to examine changes in traffic volume pattern during holiday periods. Transp. Res. Rec.: J. Transp. Res. Board 2049 (1), 45–53.
Maat, K., Timmermans, H., 2006. Influence of land use on tour complexity: a Dutch case. Transp. Res. Rec.: J. Transp. Res. Board 1977 (1), 234–241.
Neutens, T., Delafontaine, M., Scott, D.M., De Maeyer, P., 2012. An analysis of day-to-day variations in individual space–time accessibility. J. Transp. Geogr. 23, 81–91.

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013

Oakil, A.T., 2013. Temporal Dependence in Life Trajectories and Mobility Decisions (Ph.D. Dissertation). Utrecht University, the Netherlands.
Ortúzar, J.D., Willumsen, L.G., 2011. Modelling Transport. John Wiley & Sons Ltd, Chichester, UK.
Oppermann, M., 1995. Travel life cycle. Ann. Tourism Res. 22 (3), 535–552.
Oppermann, M., 1998. Travel horizon: a valuable analysis tool? Tourism Manage. 19 (4), 321–329.
Parvaneh, Z., Arentze, T., Timmermans, H.J., 2012. Understanding travelers' behavior in provision of travel information: a Bayesian belief approach. Procedia-Soc. Behav. Sci. 54, 251–260.
Peercy, M.A., McCleary, K.W., 2011. The impact of the year-round school calendar on the family vacation: an exploratory case study. J. Hospitality Tourism Res. 35 (2), 147–170.
Primerano, F., Taylor, M.A.P., Pitaksringkarn, L., Tisato, P., 2008. Defining and understanding trip chaining behavior. Transportation 35, 55–72.
Roorda, M.J., Ruiz, T., 2008. Long- and short-term dynamics in activity scheduling: a structural equations approach. Transp. Res. Part A: Policy Pract. 42, 545–562.
Ross, G.F., 1993. Destination evaluation and vacation preferences. Ann. Tourism Res. 20 (3), 477–489.
Shao, Q., 2014. The Yearbook of China-Tourism Statistics. China Tourism Press, Beijing.
Sharmen, F., 2014. An analysis of the dynamics of activity and travel needs in response to social network evolution and life-cycle events: a structural equation model. Transp. Res. Part A: Policy Pract. 59, 159–171.
Srinivasan, K.K., Athuru, S.R., 2005. Analysis of within-household effects and between-household differences in maintenance activity allocation. Transportation 32, 495–521.
Srinivasan, K.K., Bhargavi, P., 2007. Long-term changes in mode choice decisions in Chennai: a comparison between cross-sectional and dynamic models. Transportation 34, 355–374.
Sung, H.H., 2004. Classification of adventure travelers: behavior, decision making, and target markets. J. Travel Res. 42 (4), 343–356.
Van Acker, V., Witlox, F., Van Wee, B., 2007. The effects of the land use system on travel behavior: a structural equation modeling approach. Transp. Plann. Technol. 30 (4), 331–353.
Van Acker, V., Witlox, F., 2011. Commuting trips within tours: how is commuting related to land use? Transportation 38, 465–486.
Van Acker, V., Boussauw, K., Derudder, B., Witlox, F., 2012. The causal influence of the built environment questioned: self-selection, underlying attitudes and feedback mechanisms. In: 91st Annual Meeting of the Transportation Research Board. Washington, D.C., January 22–26. <https://trid.trb.org/view.aspx?id=1128739>.
Van Acker, V., Mokhtarian, P.L., Witlox, F., 2014. Car availability explained by the structural relationships between lifestyles, residential location, and underlying residential and travel attitudes. Transp. Policy 35, 88–99.
Vij, A., Carrel, A., Walker, J.L., 2013. Incorporating the influence of latent modal preferences on travel mode choice behavior. Transp. Res. Part A 54, 164–178.
Wang, B., Shao, C., Ji, X., Zhuge, C., Yang, T., 2015a. Reconstruction mechanisms of holiday tour under integrated multimodal travel information service. J. Transp. Syst. Eng. Inform. Technol. 4, 99–105.
Wang, B., Shao, C., Li, J., Weng, J., Ji, X., 2015b. Holiday travel behavior analysis and empirical study under integrated multimodal travel information service. Transp. Policy 39, 21–36.
Wooldridge, J.M., 2010. Econometric Analysis of Cross Section and Panel Data. MIT press, London, England.
Xiong, C., Zhang, L., 2015. Dynamic travel mode searching and switching analysis considering hidden model preference and behavioral decision processes. Transportation, 1–22. http://dx.doi.org/10.1007/s11116-015-9665-3.
Xiong, Y., Zhang, J., 2014. How residential environment and travel behavior influence people's life satisfaction?–a Bayesian network analysis. In: Compendium of Papers CD-ROM. The 93rd Annual Meeting of Transportation Research Board. Washington, D.C., January 12–16.
Zhang, J., 2010. Modeling inter-personal interactions in activity-travel behavior. In: Keynote Speech at the 7th International Conference on Traffic and Transportation Studies, Kunming, China, August 3–5.
Zhang, J, 2012. From Activity-based to Life-oriented Approach: Interdisciplinary Challenges. Invited Speech at the International Seminar on Applications of Activity-based Transportation Modeling in Simulation and ICT Impacts, Korea Research Institute for Human Settlements (KRIHS) and TOD-based Engineering Research Center (TODERC), Seoul, South Korea, October 19.
Zhang, J., 2014a. Revisiting residential self-selection issues: a life-oriented approach. J. Transp. Land Use 7 (3), 29–45.
Zhang, J., 2014b. Necessity of developing a life-oriented approach for representing residential self-selection. In: The 93rd Annual Meeting of the Transportation Research Board, Washington, DC, January 12–16.
Zhang, J., 2015. The life-oriented approach and travel behavior research. In: A discussion paper for the Workshop "Life-Oriented Approach for Transportation Studies" at the 14th International Conference on Travel Behavior Research (IATBR 2015), Windsor, UK, July 19–23.
Zhang, J., 2016. Life-Oriented Behavioral Research for Urban Policy. Springer, Japan. http://dx.doi.org/10.1007/978-4-431-56472-0.
Zhang, J., Yu, B., Chikaraishi, M., 2014. Interdependences between household residential and car ownership behavior: a life history analysis. J. Transp. Geogr. 34, 165–174.
Zhang, J., Tsuchiya, Y., Hinohara, H., Chikaraishi, M., 2012. Citizens' life behavior and quality of life: survey and modeling. Paper presented at the 34th International Association for Time Use Research (IATUR), Matsue City, Japan, August 22–24.
Zhou, G., Liang, R., Tian, J., 2011. Statistical Analysis and Application With STATA. China Machine Press, Beijing.
Zimmerman, C.A., 1982. The life cycle concept as a tool for travel research. Transportation 11, 51–69.

Please cite this article in press as: Wang, B., et al. Dynamic analysis of holiday travel behaviour with integrated multimodal travel information usage: A life-oriented approach. Transport. Res. Part A (2017), http://dx.doi.org/10.1016/j.tra.2017.03.013