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The Research on Sensitivity of Chinese Urban Elderly Travel Characteristic Parameters

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Abstract

Aimed at the problem that the significant differences in the elderly travel behavior characteristics under different activities can't be explained well by the existing travel-based statistical analysis methods, this paper analyze the elderly travel behavior based on the date of 407 effective elderly travel questionnaire surveys and 54 follow-up interviews in Kunming. The travel behavior characteristics based on activities are analyzed. The sensitivity of travel characteristic parameters is analyzed by using the structural equation model method. The results show that the differences of personal and family attributes, there is no significant sensitivity on the travel behavior of the elderly. In addition to the special restrictions by physical conditions, travel behavior with a strong sensitivity to the activity. Mainly have the following conclusions. Firstly, leisure activities with a strong reliance on the bus, the travel distance and activity duration are longer. Shopping activities with preference on foot, travel distance and activity duration are shorter. Secondly, in addition to going to hospital and picking up children, departure time is not sensitive to travel purpose, but departure time with a strong sensitivity to travel mode. The third, activity duration with a strong sensitivity to travel distance, trip times and travel mode.

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Keywords: activity analysis; travel behavior; structural equation model; relevance

1. Introduction

By the end of 2014, the Chinese elderly population, aged 60 and above, has achieved 212 million, approximately 15.5% of the total population [1]. The current urban transport system mainly for commuter traffic needs and cannot

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satisfy the ever-growing elderly travel needs. On the other hand, with the arrival of the peak of the growth of the elderly population, the increasing numbers of the elderly travel, bring new traffic problems, adding further pressure to an already overtaxed urban traffic system. Thus, an in depth study into urban elderly travel behavior characteristics and its relevance, in helping us to understand the inherent travel rules of the elderly, provide a scientific basis to solve the new problems facing the urban transportation system as well as the relevant decisions.

The countries that first to enter the aging society have developed economy. Due to that most elderly people had have a driver's license, the travel mobility of them is quite strong. However, with increasing age their driving ability is compromised and weakened by their slowly failing health, left home to the outdoor activities, their ability to start gradually weakened. Therefore, the study of the elderly travel problems has as its main focus, the aspect of driving security and security of travel mobility problems. Hjorthol et al. [2] and Alsnih et al. [3] have found that with age, older drivers meet with a variety of symptoms such as episodes of unresponsiveness, vision and hearing loss and other problems. Part of the elderly will no longer suitable for driving, causing their outdoor ability for activities has declined. It has been proposed that this group be divided into smaller groups defined by age ranges to be studied separately. It has been shown that low income on the elderly travel behavior is above to the influence degree of the commuter crowds travel behavior [4]. Giuliano et al. [5] and Su et al. [6] have found that due to the strong dependence on the car, combined with limited public transport services, the elderly less frequently use public transportation to travel. For the elderly will no longer drive, they really require the provision of door to door transport, demanding the creation of a responsive bus service.

After China entered the aging society, the study of the elderly traffic problems is mainly based on the city's comprehensive traffic survey data, statistical analysis of spatial and temporal characteristics of travel and travel choice behavior research. Mao et al. [7], Zhang, Z et al. [8] and Xia et al. [9] analyzed the spatial distribution of the elderly group outings, travel behavior characteristics, as well as the influence of the personal and family attributes on their travel behavior characteristics through the statistics. Chen et al. [10] by constructing disaggregate model, analyzed the influencing factors of the elderly travel choice behavior. Due to the lack of a special investigation, reflects lack of the correlation information on the daily activities features and travel behavior features. With the multi-disciplinary research approach, geography was introduced to the study of the daily activities of the urban elderly, and Chai et al. [11] and Li et al. [12] studied the shopping trip of the older people, including the space-time structure features and the influence of the cognitive evaluation of shopping places to their travel choices; Zhang, C et al. [13] used time geography to study the space-time characteristics differences of the elderly who have different individual and family attributes daily activities path. The introduction of the geography research methods, promotes the urban elderly travel behavior research toward the change of activity analysis.

Due to differences in lifestyle, the elderly travel behavior research results in the developed countries are not suitable for China. Chinese researches with urban residents travel behavior research ideas and travel survey data, use statistical analysis methods, does not contain the activities information, cannot explain the elderly travel characteristics of different activities. A large number of data analysis of Kunming city in recent years the elderly bus IC card record show that there is no information of travel purpose, so it is hardly to build up the relationship among characteristic parameters and it is hardly to provide reliable basis for source travel behavior mechanism research. Due to the differences of lifestyle between the elderly and the general urban residents, combined with the unique physiological and psychological homogeneity in the elderly, the differences of personal and family attributes, there is no significant impact on the travel behavior of the elderly. The differences of activity characteristics become the important factors that affect the elderly travel behavior.

Based on the above understanding, in this study, the previous research model is abandoned. The basic characteristics of daily activities should be brought into the travel behavior research scope. Activity - travel behavior characteristics are analyzed. Introducing the structural equation model analysis method to explore the correlation among the urban elderly activities and travel behavior characteristics variables.

2. Study area and data sources

The urban elderly travel survey was conducted over a period of three days, from September 13th to the September 15th, 2013. Survey sites were selected in Kunming city center within 3rd ring and in the outlying areas of the city, including parks, hospitals, supermarkets and other gathering places for the elderly. The survey was taken at

different times during the day, including the morning, at noon hour and in the afternoon. The survey was carried out, using a random sampling method to obtain the elderly personal and family attributes, “activity-travel” information for participant on Thursday, Friday and Saturday. 449 questionnaires were distributed, all of which were recovered, providing 407 valid questionnaires, giving the efficient rate of 90.6%. In the statistical analysis, we also have 54 follow-up interviews from 407 valid questionnaires, giving the rate of valid questionnaires is 13.3%.

The elderly travel questionnaire design included four parts: the basic attributes of the individual, the basic attributes of the family, residence properties, investigating the previous day's trip situation. The basic attributes of personal and family includes gender, age, presence or absence of public transport discount cards, person’s education, pre-retirement career, family structure, living state, personal and family monthly income, household ownership, means of transport, hobbies, etc. Residence features includes convenient access of surrounding recreational and shopping facilities within the residence facility. Investigation of the previous day's trip situation includes travel time, trip purpose, trip origins and destinations, travel mode and some other inclusions.

3. Analysis of urban elderly travel behavior characteristics

3.1. Travel rate and the activity type

In the effective sample of this study, the elderly travel is a total of 624 times a day (Regardless of the return), per capita travel is 1.53 times a day. According to the existing research, daily activities can be divided into living activities, to maintain life activities and leisure activities [14]. Data analysis showed that urban elderly’s main daily activities are leisure, maintain life activities. The leisure activities include daily entertainment, visiting relatives and friends et al. Maintain life activities include shopping, going to hospital, picking up children et al. A few old people still have a work travel.

3.2. Travel mode

As shown in Fig. 1, by bus and on foot are the main ways to urban elderly travel. The elderly choose bus to travel more when they participate in leisure activities. When they participate in shopping activities, they obviously choose to travel on foot. Further interview makes us understand something. The elderly have wider choice range when they choose the leisure activities destination. Choosing the way to bus is the inner demand of the leisure travel mobility and convenience. The elderly usually choose the nearby destination when they are shopping, so flexible walking way becomes more appropriate.

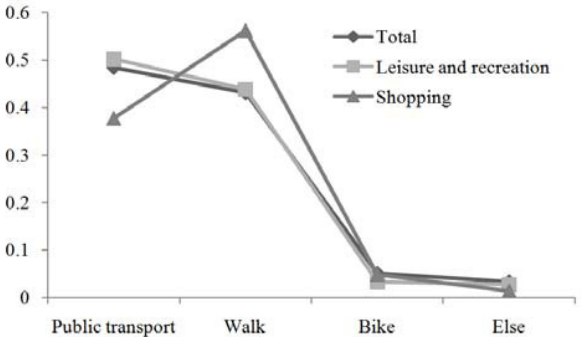

Fig. 1. Distribution of travel mode

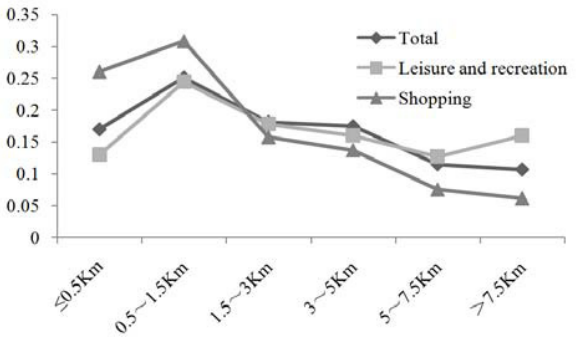

Fig. 2. Distribution of trip distance

3.3. Travel distance

As shown in Fig. 2, urban elderly overall travel distance concentrated in 5 km, the rate of more than 5 km trip has significant decline trend with the increase of distance. Within the scope of 1.5 km trip, the rate of shopping activities

is significantly greater than the rate of leisure activities. More than 1.5 km range trip distance has a wide distribution. Leisure travel accounts for a larger proportion, but the rate of shopping travel reduce significantly. The elderly shopping travel is given priority to with 1.5 km range, leisure activities tend to be longer distance travel.

3.4. Departure time

As shown in Fig. 3, urban elderly departure time respectively focused on two period of time, they are 8:15～9:15 in the morning and 13:15～14:15 in the afternoon. Morning peak characteristic is significant, but there is no typical peak characteristic in the afternoon.

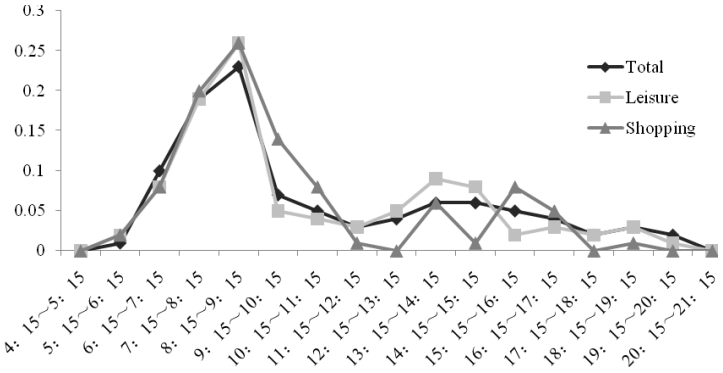

Fig. 3. Distribution of departure time

This survey statistical analysis shows that there are significant differences between urban elderly daily activities travel behavior characteristics and commuter traffic on the whole. The elderly travel behavior characteristics like travel mode and the choice of time and space under the different activities have significant differences. So it is necessary to use quantitative relationship model analysis method for the related research. The related research is that further to explore the influence factors of the elderly travel behavior characteristics and the correlation among the characteristic variables.

4. The correlation analysis of urban elderly travel behavior characteristics

This article analyzed the correlation of urban elderly travel behavior characteristics based on structural equation model (SEM). Structural equation model includes two basic model, they are measurement model and structure model. Measurement model mainly deal with the relationship between the observation indexes and the latent variables. It tests the reliability and validity of the measurement model and dose fitting degree evaluation by confirmatory factor analysis. Structural model is a description about the causal relationships among latent variables [15]. It is benefit for using structural equation model to analyze the quantitative relationship among urban elderly daily activities travel behavior characteristics exogenous variables, endogenous variable and observed variables.

4.1.SEM theoretical assumptions

The construction of a structural equation model is usually need a theory assumes that combined with the existing research results. Get the mechanism of relevance among the variables through observable index and modeling analysis, verifying the hypothesis and data fitting. Based on the existing research results and the understanding of the old-age life basic features, this article assumes that personal and family attributes of the urban elderly as its potential influence factors of activity - travel behavior, affect its daily activities and travel decisions. All kinds of travel choice in travel behavior are affected by daily activities, at the same time, there are mutual influence among the variables. According to the above hypothesis, the theory model was constructed. The correlation among urban

elderly properties, activity factors, travel behavior and characteristic parameters are analyzed through the model computation.

4.2. Characteristic variable selection

According to the theory of structural equation model and related research [16-18], we select model variables. This study selected gender, age, person's education, pre-retirement career, family structure, living state, personal and family monthly income, residential location, household ownership, means of transport, etc as exogenous variables of the structural equation model. As shown in Table 1.

In the study of traffic problems, travel purpose characterize the daily activities characteristics of travelers. Departure time, travel mode and travel intensity are used to characterize travel behavior. In this paper, let these four kinds of variable as the initial preparation endogenous variables for the model. The endogenous variables of the structural equation model included choice of travel purpose, choice of departure time, choice of travel mode and travel intensity of 4 endogenous variable groups, as shown in Table 2. In particular, because of the particularity of the elderly, travel distance and the longest activity duration can often reflect the travel intensity. We choose these two parameters and travel times together to constitute trip intensity observed variables.

As shown in Table 3, this study use SPSS statistical analysis software for the correlation test of model endogenous variables, exogenous variables and the observed variables. After the inspection, exogenous variables 'gender X1', 'residential location X9' and endogenous variables 'whether to go to the hospital Y4', 'whether to use bike Y13' are low correlation with other variables (The correlation coefficient is less than 0.3). Their function may have been replaced by other variables. In order to simplify the model and according to the relevant requirements of the structural equation model, excluding these 4 observed variables.

Table 1. Exogenous variable explanation

Category	Variable name	Variable symbol
Personal attributes	Gender	X1（Male =1、Female =2)
	Age	X2（Continuous values）
	Education background	X3（Bachelor degree and above =1、College =2、High school and technical secondary school=3、Junior high school =4、Primary school and the following =5）
	Occupation before retirement	X4（Civil servants =1、Business unit worker =2、Company worker =3、Else =4）
	Personal monthly income(¥)	X5（<1000=1、1000～2000=2、2000～3000=3、3000～4000=4、>4000=5）
Family attributes	Family structure	X6（4 generations =1、3 generations =2、2 generations =3、The couple =4、Else =5）
	Living state	X7（4 generations live together =1、3 generations live together =2、2 generations live together =3、The couple live together =4、Else =5）
	Family monthly income(¥)	X8（<2000=1、2000～3000=2、3000～5000=3、5000～10000=4、>10000=5）
	Residential location	X9（Within the first ring =1、Between the first and the second ring =2、Outside the second ring =3）
	With or without a car	X10（Yes=1、No=0）
	With or without a e-bike	X11（Yes =1、No =0）
	With or without a bike	X12（Yes =1、No =0）

4.3. Parameter estimation

Theoretical model is calculated by using the software AMOS20.0, we concluded the standardized parameter estimation of the model, as shown in Figure 4.

4.4. Model evaluation

According to the Fig. 4, after parameter estimation, we obtain adaptation degree index root mean square error of approximation of the model RMSEA=0.065＜0.08, the normed fit index NFI=0.904＞0.90, it is show that the fitting of the data is good.

Table 2. Endogenous variable explanation

Category	Variable name	Variable symbol	Category	Variable name	Variable symbol
Trip purpose	Work	Y1（Yes=1、No=0）			
	Pick up children	Y2（Yes=1、No=0）		Walk	Y12（Yes=1、No=0）
	Shopping	Y3（Yes=1、No=0）		Bike	Y13（Yes=1、No=0）
	Go to hospital	Y4（Yes=1、No=0）	Travel mode	Public transport	Y14（Yes=1、No=0）
	Leisure	Y5（Yes=1、No=0）		Car	Y15（Yes=1、No=0）
	Visiting friends	Y6（Yes=1、No=0）		Else	Y16（Yes=1、No=0）
	Private affairs	Y7（Yes=1、No=0）			
Departure time	6:15~8:15	Y8（Yes=1、No=0）	Travel intensity	Trip times	Y17（Continuous values）
	8:15~11:15	Y9（Yes=1、No=0）		Maximum travel distance	Y18（Continuous values）
	13:15~17:15	Y10（Yes=1、No=0）		The longest activity duration	Y19（Continuous values）
	17:15~21:15	Y11（Yes=1、No=0）			

Table 3. Correlation test of observed variables

	Work	Pick up children	Shopping	Leisure	6:15~8:15	8:15~11:15	13:15~17:15	Walk	Bus	Trip times	Travel distance	Travel duration
Gender (X1)	-0.004	-0.037	0.085*	-0.045	-0.039	-0.029	0.062	-0.040	-0.109	0.104*	-0.061	0.018
Residential location（X9）	-0.063	0.003	-0.016	0.027	0.057	0.044	-0.081*	-0.010	-0.019	-0.039	0.101*	0.010
Go to hospital (Y4)	-0.024	-0.058	-0.110*	-0.113*	-0.005	-0.015	0.020	0.069	-0.037	0.018	0.023	0.003
Bike（Y13）	-0.022	0.059	0.090*	-0.006	0.044	0.001	-0.043	-0.101	0.010	-0.009	-0.108*	-0.044

4.5. The relevance analysis of elderly travel behavior characteristics

The effect value in Fig. 4 show that the personal attributes of the elderly like age, education, occupation before retirement, personal monthly income and the family attributes like family structure, living status, family monthly income have no significant influence on the choice of travel purpose, choice of departure time, choice of travel mode and travel intensity. The elderly daily activities such as shopping, leisure, visiting friends have the significant influence to the corresponding choice of travel mode and travel intensity. Urban elderly travel like leisure, shopping are the associated behavior of their daily activities. Differences in activity have different influence on their travel behavior. This obtained the same conclusion with the overall characteristics analysis.

As shown in Fig. 4, it is clear that the travel behavior influence factors and characteristics of elderly and commuter crowds are not same. The proportion of the urban elderly people to use public transport is very high in China, differences in personal and family attributes of the elderly have little effect on their travel behavior. The retired life makes most of the elderly have a lot of discretionary time, their travel is not sensitive to time, and daily activities mainly affected by individual preferences and physical condition. At a certain age their physiological and psychological characteristic has strong homogeneity feature, weakening the influence of personal and family attributes. On the other hand, in Kunming, carrying out a policy that the elderly to take the bus is free, and each kind of leisure places in the city area such as park, square for free or the low charge for the elderly. These make the elderly leisure travel basically is not restricted by the expenses that individual pays.

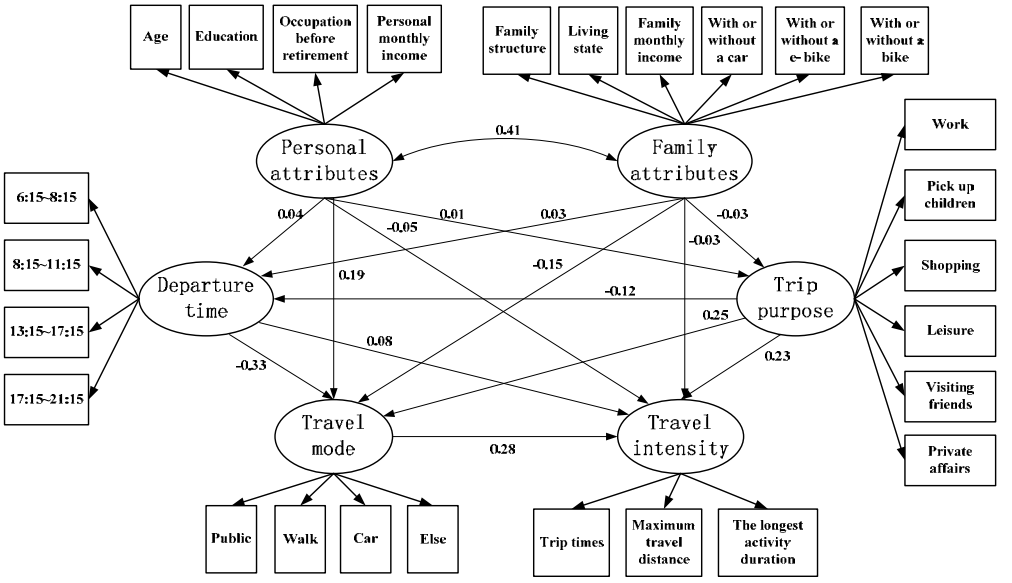

Fig. 4. Standardized parameter estimation of SEM model

Also can be seen from the Figure 4, there is a significant reciprocal influence among the endogenous latent variables in this model. In order to understand the reciprocal influence among the observed variables of endogenous latent variable more intuitive and clear, show the interaction from all kinds of travel choice behavior, it can analyze that through the direct effect path graph of the endogenous variable group.

4.5.1. Travel purpose effect analysis

The direct effect path of the travel purpose endogenous variable group in Fig. 5, the effect less than 0.15 is not to show (Do the same with below).

As shown in Fig. 5, the direct effects of the work variables on shopping and leisure variables are -0.256 and 0.239, it is show that the elderly work purpose will restrain their shopping purpose and promote their leisure purpose.

The effects of the picking up children variables on shopping and leisure variables are 0.274 and -0.256, it is show that the picking up children purpose will promote their shopping purpose and restrain their leisure purpose. While the direct effect of shopping variables on leisure variables is -0.691, it is show that their shopping purpose will strongly restrain their leisure purpose. In real life, the elderly who still have a work after retirement are often less housework class responsibility, performance is less shopping trip. The elderly who live with three generations often have more responsibility for family life such as pick up children and shopping, the leisure trip thus reducing. Leisure and shopping is two main types of the elderly activities, is account for more than 95% from the surveyed elderly. In time use these two types of activity with strong exclusiveness.

The elderly daily shopping trip, prefer to choose walking (the direct effect is 0.225) rather than taking a bus (the direct effect is -0.190). Statistical analysis showed that the elderly shopping trip space most focused on home centered 1.5 km range, suitable for old people to choose walking. At the same time, the effects of the shopping trip on travel times, maximum travel distance and the longest activity duration are -0.193, -0.261, and -0.262, it is show that the elderly shopping travel times are low, distance and duration are short.

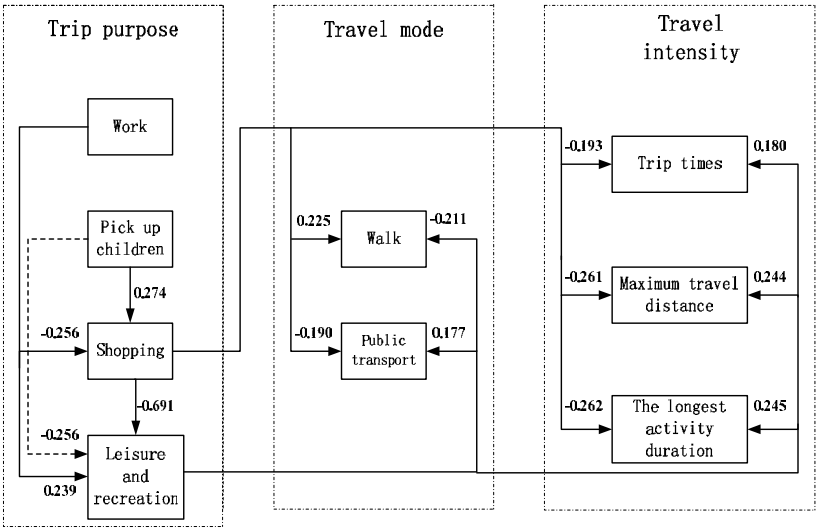

Fig. 5. The direct effect of travel purpose.

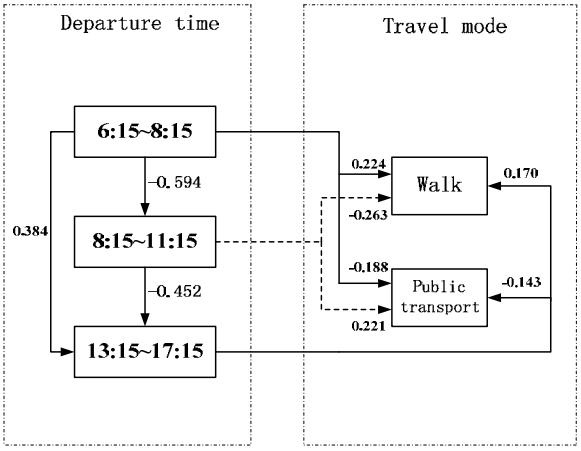

Fig. 6. The direct effect of departure time

The effects of the elderly leisure trip on bus and walk are 0.177 and -0.211, it is show that the leisure activities of old people tend to use the bus, indirect illustrates leisure destination far away from home. From the angle of travel

intensity, the effects of the leisure trip on travel times, maximum travel distance and the longest activity duration are 0.180, 0.244 and 0.245, compared with shopping activities, the elderly leisure travel times are more, travel distance and activity duration are longer. This is a significant characteristic of the elderly leisure travel.

4.5.2. Departure time effect analysis

As shown in Fig. 6, we can see that departure time has more significant effect on travel mode. Specific performance as follows: the effects of 6:15~8:15 time variables on bus and walk are -0.188 and 0.224, it is show that the elderly traveled in this time are likely to choose walking. In real life, the morning exercise behavior occurred more frequently in this time (Kunming summer sunrise time after 6:00 AM), so the elderly like walking to neighborhood parks, green space and square to participate the activities. The effects of 8:15~11:15 time variables on bus and walk are 0.221 and -0.263, it is show that older people prefer to choose public transit at forenoon time, also reflects the elderly long-distance travel most occurred in this time. The effects of 13:15~17:15 time variables on bus and walk are -0.143 and 0.170, it is show that older people prefer to choose walking at afternoon time.

We can also see that there is a significant effect among 3 observation variables within the departure time variable group. The direct effect of 6:15~8:15 time variables on 8:15~11:15 time variables is -0.594. The effect of 8:15~11:15 time variables on 13:15~17:15 time variables is -0.452. It is show that these 3 consecutive travel time have repellency.

4.5.3. Travel mode effect analysis

Fig. 7 shows the direct effect of travel mode. It can be seen that choose bus travel has obvious inhibitory effect for walking, the direct effect is -0.669, it is say that due to factors such as travel distance is long, then the elderly choose bus travel rather than walking. Secondly, the direct effects of the 'BUS' variables on travel times, maximum travel distance and the longest activity duration are 0.174, 0.236, and 0.236. It is show that when the older people choose bus travel, they prefer to travel frequently, and their travel has long distance and longtime characteristics. The direct effects of the 'WALK' variables on maximum travel distance and the longest activity duration are -0.281 and -0.281. It is show that the older people tend to short distance and short time travel when they choose walking.

4.5.4. Trip intensity effect analysis

Fig. 8 shows the direct effect of travel intensity. It can be seen that travel times, maximum travel distance and the longest activity duration, these 3 variables from travel intensity variable group have a strong positive correlation. In the case of a suitable condition, travel active older people have the big probability of long distance and long time travel. At the same time, long distance travel means that travel duration of old people has improved. The interview survey shows that the activity site away from the center of the city tends to better environment and larger scale. The corresponding elderly activities duration is also longer.

5. Conclusion

This paper analyzes the overall characteristics of the urban elderly daily activities travel behavior by statistical methods. This study utilized structural equation modeling, set up a model to analyze the relevance among personal and family attributes, daily activity characteristics, travel behavior characteristic variables of the urban elderly, based on the quantitative analysis, we verify that there are significant differences among the elderly travel behavior characteristic parameters under different activities. There is significant correlation among the activity characteristics and the travel behavior characteristic variables which are closely related to the activities. Structural equation model analysis results further show the following main conclusions:

(1) The differences of personal and family attributes have no significant influence on the elderly travel behavior. But the influence of the activity characteristics on the elderly travel behavior is significant. Activities have significant effect on travel mode and travel intensity. (2) There is a significant correlation among urban elderly

travel behavior characteristic variables. On the one hand, departure time has more significant effect on travel mode. On the other hand, for the elderly, choice of travel mode and travel intensity is highly correlated.

This study on the travel behavior of elderly people based on the Kunming city survey data, and it can also use more urban survey data to be verified.

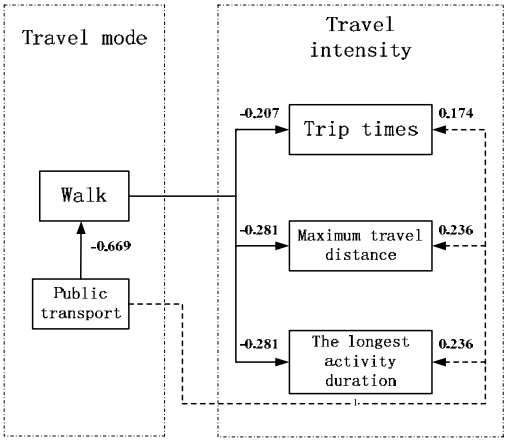

Fig. 7. The direct effect of travel mode.

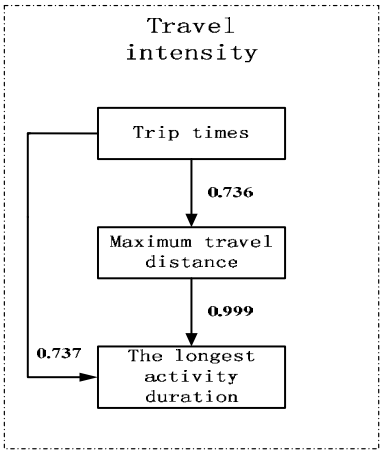

Fig. 8. The direct effect of travel intensity.

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