2. Exploring Household Structure Effect on Elderly Travel Needs under Variations in Mobility and Accessibility - A Case Study of the Seoul Metropolitan Area, South Korea -

世帯構成およびモビリティとアクセシビリティが高齢者の交通需要に及ぼす影響 ― 韓国ソウル都市圏を対象として ―

Department of Urban Engineering, The University of Tokyo 37-097041 Sang-Eon Seo

Recent official statistics show Korea's soaring elderly households residing without adult children, indicating a need to pay more attention to the effects of household structure on the elderly. In this context, this study aimed to understand the effects of household structure on elderly travel needs under variations in mobility and accessibility. First, the current status of elderly people and future expectations through analyzing 2002/2006 travel survey data and elderly statistics in Korea were analyzed. Second, using the existing survey data, the effects of intra-household interactions and residential accessibility on the going-out tendency of elderly maintenance and leisure activities were analyzed. Third, an original survey was conducted in order to solve the limitations of the previous steps which were mainly caused by the shortcomings of the existing dataset. Using the original survey data, research hypotheses were tested statistically by estimating a structural equations model.

1. Introduction

1.1. Background and Key Issues

Population aging has recently come to the fore as a prevalent social issue all over the world. The case of the Korean Society is not an exception in the world-wide phenomenon. However, there are four distinct differences in Korea as compared with other countries. The first aspect is the intensity of aging as a result of a very low fertility rate (1.23 for Korea in 2010, 1.87 for France, 2.07 for U.S. 1.37 for Japan). According to the official population projections, the elderly population (65 or older) will reach 14% (aged society) of the national population in 2018, only 18 years after it first exceeded 7% (aging society) in 2000. It took France 115 years and the U.S. 73 years to go from an aging society to an aged society; it took Japan 26 years for this change. The second is a striking change in the elderly household structure which has not received much attention from the Korean society. Recently, the trend of living with their old parents has been rapidly decreasing, probably due to a low fertility rate, rapid industrialization, and the influence of Western culture. According to the "2008 Social Survey", 55% of household heads in 1998 were living with their parents when one of their parents was still alive and about 40% in 2008. From these changes, it is clear that elderly singles and couples who cannot receive support from their adult children will proliferate. The third aspect is the rapid increase of elderly auto dependency. The auto ownership of the elderly in Korea almost tripled over the last 10 years from 9% in 1999 to 26% in 2009 while that of the non-elderly increased by 30% from 59% to 77% in the same period. In other words, elderly people's driving need to travel is rapidly increasing, probably due to increasing elderly travel needs: in part, getting less support from adult children. The fourth aspect is lack of household structure consideration in Korean transportation planning models. Accurate travel-demand forecasting is one of key purposes in the transportation planning field, especially in the countries experiencing rapid socio-demographic or socio-economic changes. Korea is also such a country and it is their first priority in transportation planning practice. However, seven major projects (reviewed in this study) considered only zone-level explanatory variables in their trip generation models, without taking into consideration individual or household level variables. This speaks well of the necessity to look at the effects of household structure changes on elderly travel behavior in Korea.

In this context, this study aimed to understand the

effects of household structure changes on elderly travel needs under variations in mobility and accessibility

1.2. Research Goal and Objectives

This study starts from the main research question "What are the effects of rapid population aging and decreasing household size on elderly travel needs in Korea?" To answer this main question, this study aims for understanding elderly travel needs (going out of home) with a focus on household structure, mobility, and accessibility to achieve: 1) more accurate travel-demand forecasting and 2) better transportation planning and policy toward a better quality of life for the elderly. To answer the main research question and achieve the main goal, the following five objectives were set up:

1. To understand the current status of the elderly and the future expectations in Korea
2. To clarify the effects of household structure, mobility, and residential accessibility on elderly travel needs
3. To explore the differences in elderly travel needs by household structure under given conditions of mobility and accessibility
4. To investigate how satisfied the elderly are with their activities
5. To suggest how policy prescriptions should be different for the current and future elderly toward a better quality of life for the elderly

1.3. Research Outline

The first chapter introduces the background of this study and emerging key issues in Korea with the outline of this study. The second chapter reviews the literature related to elderly travel behavior. In terms of data source, to answer the research question and achieve the research goal listed above, this study was first planned to make the best use of existing available data in Korea, and then progress further with original survey data. As a result, the first stage of analysis (Chapter 3 and Chapter 4) works with existing data (zone-based aggregate) and the second stage (Chapter 5) uses data from an original survey data (residential location-based disaggregate). In terms of data analysis work, the first stage is subdivided into two steps. Therefore, it can be divided into three data analysis steps. Finally, this thesis is concluded with the findings from all steps.

2. Literature Review

In 2000, the elderly population reached 7% of the national population (aging society) and the entrance into aging society brought about Korean society's attention to aging population. For the legal support for Korea's population aging policy, "Framework Act on Low Birth Rate in an Aging Society" was enacted in September 2005. Based on this Act, two five-year basic plans "The First Basic Plan on Aging Society and Population of Korea, 2006-2010" and "The Second Basic Plan on Aging Society and Population of Korea, 2011-2015" were established in 2006 and 2010, sequentially. These basic plans mainly look at the negative impact of the falling fertility rates and population aging on the labor market, thus they aim to maintain the economically active population through boosting low fertility rate and job creation for the elderly and females. In terms of transportation policy, "The Mobility Enhancement for the Mobility Impaired Act" was enacted in January, 2005 in order to provide safe and comfortable mobility for the mobility-impaired persons through providing mobility-assisting facilities rather than focusing on elderly travel behavior and household structure changes. As a result, majority of research focused on traffic safety of elderly drivers or elderly pedestrians: probably, motivated by the above Act. Among reviewed studies, only two studies considered household structure-related variables such as the presence of preschool children (Seo et al. 2006) and household size (Choo et al. 2011), meaning a lack of studies on household structure effects in Korea. In other words, the majority of Korean studies have overlooked the effects of household structure effects on elderly travel behavior although very rapid decrease of household size is expected in Korea.

Unlike Korea, many foreign studies consistently argued that household structure (intra-household interaction) and employment status (time budget) are important determinants of going-out behavior. Another important determinant is accessibility: although there are many definitions, in this study accessibility is limited to built-environment such as land use and transportation service quality and mobility is limited to individual physical mobility and auto availability. In the literature, there are four types of major accessibility measures: cumulative measures, gravity-type, utility-based, and space-time measures. The most widely used measure is

gravity-type measure and the most theoretically sound one is utility-based measure. As the definitions of accessibility suggest, accessibility measures have been widely used to probe into the relationship between land use and activity participation with a common hypothesis "greater accessibility leads to more travel" (Crane 1996). However, interestingly, some studies showed inconsistent findings with the common hypothesis. For example, Handy (1993) showed that accessibility does not affect the frequency of shopping trips and Kitamura et al. (2001) showed that accessibility is not significantly or positively related to total number of trips and tours. In the case of aggregate-level modeling applications, many researchers and practitioners have attempted to incorporate a measure of accessibility into trip generation models, generally in order to consider changes to the network/land-use and induced travel demand. However, Ortúzar and Willumsen (2011) pointed out that empirical aggregate applications commonly produce either non-significant or negative relationships between accessibility and trip frequency which, in a sense, violates the basic economic theory, that is, lower travel cost leads to more travel. In other words, the fundamental relationship between accessibility and trip/tour frequency is not consistent across studies.

3. Understanding the Current Status of Elderly and Future Expectations in Korea using 2002 and 2006 Travel Survey Data

In the literature review chapter, previous findings on travel behaviors were reviewed, but most of the studies were from the other countries besides Korea due to the few amounts of published studies on this field in Korea, especially in regards to the effects of household structure on travel behavior. Therefore, based on the previous findings, this chapter explores the current status of the elderly and future expectations through comparing two cross-sectional travel survey data (2002 vs. 2006).

3.1. Data Source and Study Area

The Korea Transport Database Center (KTDC) conducts a household travel survey every 5 years on weekdays (autumn) in the Seoul Metropolitan Area (SMA), which is composed of Seoul City, Incheon City, and Gyeonggi Province. In 2002 and 2006, respectively, KTDC carried out a one-day diary survey including three types of data: personal, household, and travel data by stratified sampling method based on the previous population census data (2000 and 2005). Considering data availability, the SMA was determined as the study area. Fig.1 shows the SMA; the central area is Seoul City surrounded by Incheon City and Gyeonggi Province. In addition, the area can be divided into urban and suburban areas based on the names of administrative units, such as Dong, Eup, and Myeon in Korean; these are the subdivisions of a city in Korea which correspond to town level in other countries. In this classification, the place of residence is critical because the residential locations can be used as an indicator for the level of transportation accessibility. The suburban areas of the SMA consist mostly of mountainous regions and have very poor public transit services.

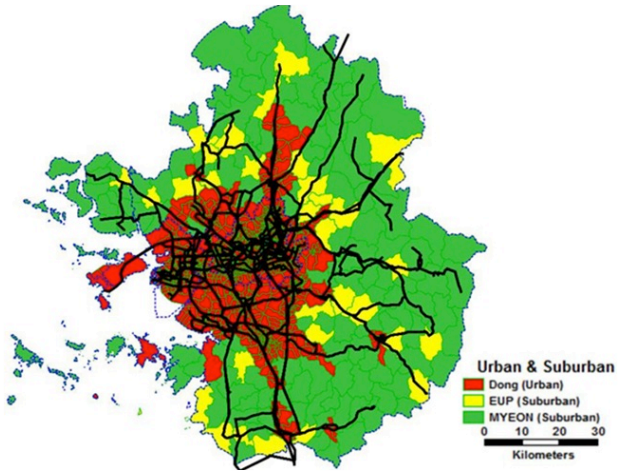

Fig.1 Seoul Metropolitan Area: Urban vs. Suburban

3.2. Estimation of Going-Out Models and Discussions

Based on the findings of the basic analysis and previous studies, going-out models were separately estimated for the elderly and non-elderly by three purposes (shopping, leisure, and personal business) using a binary logit model because the majority of respondents made at most one trip for each activity purpose in the survey day. In order to consider regional effects (different accessibility) on going-out behavior, the auto availability variables (different mobility) were divided into two regions (urban vs. suburban). The household structure variables of the elderly were also divided into young and old elderly groups using the age threshold of 75 to examine age effects (a proxy of mobility). In the going-out models, positive and significant coefficients

indicate the variables have positive effects on going-out behavior and vice versa.

Many findings correspond to those of the previous studies in Chapter 2, but some interesting findings were also observed. First, as previous studies found, singles tend to go out the most and the old-elderly are less likely to go out than young-elderly, however, t-tests showed that there is no significant difference in going-out behavior between young and old elderly in single households. In other words, the absence of other members forces old-elderly to go out regardless of age and level of mobility. Second, auto availability of the elderly in suburban area has significantly stronger effects on shopping trip generation than in urban areas while it was not significant for the non-elderly. In other words, relatively mobile non-elderly can cope with the poor transit service and a wide spread of activity locations while the elderly cannot.

3.3. Applicability of 2002 Models to 2006 Year

In general, transportation planners or researchers tend to test their models' ability to replicate base year travel behavior with hope of forecasting future years adequately. The underlying main assumptions might be that the base year travel behavior is consistent with the future year and the base year models are capable of capturing major determinants of travel behavior. Hence, the applicability of the estimated elderly models to future years (2002 vs. 2006) was tested using both likelihood ratio test and asymptotic t-test. A likelihood ratio test can be used to test whether overall models are equivalent or not rather than particular parameters. This means that a likelihood ratio test does not indicate which parameters of variables caused the difference. To this end, asymptotic t-test was also used.

The equivalence of the overall models was tested after allowing for differences in variance using a grid search method proposed by Swait and Louviere (1993). The test statistic for the null hypothesis of a likelihood ratio test is given by

$$-2[L_{2002+2006} - (L_{2002} + L_{2006}) : \chi^2 \quad (1)$$

The test statistics were calculated for three activity purposes as shown in Table 1. The null hypotheses of elderly Leisure and Personal Business models were rejected, meaning that the models are not equivalent overall except for the Shopping model and the models estimated from 2002 travel survey data cannot be applied in 2006 although the year difference is only 4 years.

Table 1 Comparison of Elderly Overall Models

Model	Test Statistic	Critical Value	Degree of Freedom
Shopping	23.2		
Leisure	43.0	26.3	16
Personal Business	168.5		

In order to identify the causal variables of the overall differences, asymptotic t-test was conducted. First, the 2002 and 2006 data set were combined into a single data set and each explanatory variable was divided into two variables (e.g., 2002 male variable and 2006 male variable) in order to compare the parameters which have the same unit of utility scale. The test statistics of t-tests are reported in Table 2.

Table 2 Individual Parameter Differences by Year

Variables		Test Statistic		
		Shopping	Leisure	Personal Business
Urban	Auto	0.92	2.22	5.94
	No Auto	4.02	3.58	10.91
Suburban	Auto	0.69	0.99	2.48
	No Auto	*Reference*		
Low Income		*Reference*		
Medium Income		2.48	0.28	0.43
High Income		0.07	-0.69	0.96
Male		-0.95	1.90	-3.06
Non-Worker		*Reference*		
Part-Time Worker		1.74	-1.18	-2.25
Full-Time Worker		-0.15	-0.79	-3.48
Preschool Children		0.73	-0.10	-1.05
Young -Elderly	Single	-1.61	-0.90	-0.09
	Couple	-1.72	0.96	1.21
	Multi	0.00	2.51	4.30
Old -Elderly	Single	-1.38	-1.93	-1.17
	Couple	-1.06	2.04	-1.41
	Multi	*Reference*		

Note: Shading indicates a significant coefficient at a 95% level of confidence

Most of auto availability related parameters (combined

with regional dummy variables) significantly changed over the last 4 years, meaning that the main cause of the overall model differences might be the large-scale bus system reform in 2004 which was implemented only in urban areas (Seoul city). In other words, the effects of transportation service should be considered in the travel-demand forecasting models to forecast future years adequately.

4. Effects of Household Structure and Residential Accessibility on Elderly Going-Out Behavior

Previous findings on the impact of accessibility on trip/tour frequency were not consistent with each other, indicating a need to clarify this relationship. Therefore, this chapter aimed to understand the effects of household structure and transportation accessibility on elderly travel patterns using the Seoul Metropolitan 2006 household travel survey data. In addition, only elderly households were selected for analyses which include at least one elderly member in the household in order to compare elderly and non-elderly members in the same household.

4.1. Definition of Home-Based Tours

The data set used in this study was collected by using traditional self-reporting method which tends to under-report short trips. In addition, the majority of respondents in the analysis data made simple tours (simple tours accounted for 91%) which do not include additional trips on the way to the workplace and home. Therefore, this study used tours rather than trips as analysis unit by assuming that the main purpose of a tour is determined by the activity type with the longest duration within the tour.

4.2. Auto and Transit Accessibility Measures

The accessibility measures (utility-based) in this study are based on multinomial logit destination choice models developed by using the 2006 household survey data along with zone-based employment and network data. The full set of the alternatives for destination choice can be defined as the set of 1,187 traffic zones in the SMA. Hence, considering computational limitations, it was decided to include 100 randomly drawn alternatives from the full set, and then the destination choice models were estimated using only the respondents' data which chose one of the 100 destinations. Finally, the so-called logsum from the destination choice models was used as accessibility measures. In addition, the alternative specific constants were not included in order to ensure the applicability to the full set of traffic zones for accessibility calculations.

4.3. Residential Location and Tour Frequency

It is generally considered that people travel more frequently when they live in urban areas with higher-density environments and transportation facilities because opportunities can be reached at a lower cost. However, the frequencies of maintenance tours in urban areas were lower than in suburban areas (except for singles) while the frequencies of discretionary tours in urban areas were higher than in suburban areas as shown in Fig.2. One might speculate that if they live in urban areas, there is a greater possibility to make more complex tours reducing the needs to travel for household maintenance tasks or the number of maintenance tours; but, there was no significant difference in the number of trips per maintenance tour between suburban areas and urban areas in the SMA (e.g. trips per maintenance tour: 1.16 in suburban areas, 1.20 in urban areas). A possible reason might be the problem of traditional self-reporting method which tends to under-report short trips.

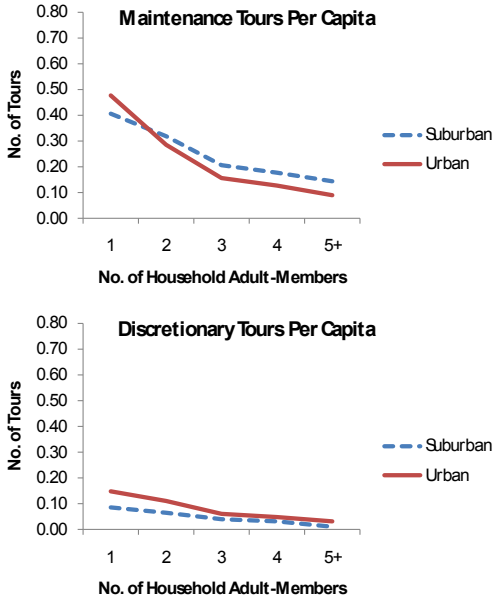

Fig.2 Tour Frequency and Residential Location

4.4. Estimation Results and Discussions

Travel engagement models were developed for maintenance and discretionary tours of elderly

households respectively, to understand the effects of intra-household interactions and transportation accessibility on elderly travel patterns using the SMA 2006 household travel survey data. The models were estimated separately by auto availability at the household level and by age group at the individual level. In other words, there are eight types of models. Due to space limitations, only the estimation results of maintenance engagement models for households with no vehicle were presented in Table 3 as an example.

Table 3 Estimation Results of Maintenance Engagement Models: Households with No Vehicle

Variables	Elderly Coeff.	Non-Elderly Coeff.
Common Variables		
Urban Areas		
Single: Transit Acc (non-driver)	0.125	*N/A*
Multi-Member: Transit Acc (non-driver)	-0.041	
Suburban Areas		
Single: Transit Acc (non-driver)	0.091	*N/A*
Multi-Member: Transit Acc (non-driver)	-0.133	
No. of Preschool Children	-0.384	-0.202
Individual Variables		
Age20	*N/A*	-0.518
Age65	0.893	*N/A*
Age75	0.745	*N/A*
Worker	0.374	
Available Time Window	0.679	0.269
Discretionary Tour Duration	-0.479	-0.214
Other-member Variables		
Urban Employment Density at Work		
Suburban Employment Density at Work		
Elderly Commuted Workers' Time		
Elderly Day-Off Workers' Time		
Elderly Non-Workers' Time		
Non-Elderly Commuted Workers' Time	-0.529	
Non-Elderly Day-Off Workers' Time	-0.162	
Non-Elderly Non-Workers' Time	-0.209	
Constant	-7.229	-2.934
Threshold	2.109	1.568
Observations	3,790	1,899
1-LL(B)/LL(0)	0.354	0.576
1-LL(B)/LL(C)	0.208	0.216
-2*[LL(C)-LL(0)]	1,065	357

Note: Shading indicates a significant coefficient at a 95% level of confidence

Transit accessibility of the elderly in multi-member HHs is negatively related, but that of the non-elderly is not significant and that of single elderly is positive. A possible explanation is that higher accessibility tend to reduce the travel need of people in multi-member HHs because they can fulfill more tasks in the same place than their counterparts in lower accessibility areas and maintenance tasks tend to be assigned to more mobile people (non-elderly and drivers), probably due to the need of carrying groceries or bags.

The major finding of this chapter is that higher density of land use and better quality of transportation service do not always lead to more tours despite the easiness of reaching destinations due to the problem of under-reported short trips in traditional self-reporting questionnaire survey, lack of internal movements/ trip-chaining consideration in accessibility measures, the impacts of intra-household interactions and different travel needs by activity type.

5. Effects of Household Structure, Mobility, and Accessibility on Elderly Grocery Shopping Behavior

This chapter includes the final step of this study based on the findings and limitations of the previous steps. First of all, an original survey was conducted in order to solve the limitations of the previous steps which were mainly caused by the shortcomings of the existing dataset. Using the original survey data, research hypotheses were tested statistically by estimating structural equation models (using AMOS 20.0).

5.1. Research Hypotheses

In the previous steps, many conclusions tend to rely on subjective interpretations rather than explicit explanations. Therefore, the main reason of this step is to verify the following hypotheses:

Hypothesis 1: Each household has their own total needs of groceries which are relatively fixed, thus there is interactions (trade-offs) among destinations (shopping places in this study).

Hypothesis 2: Each shopping place offers different degrees of product variety and requires different levels of mobility, thus their preferred shopping places or needs also vary according to household type and mobility.

Hypothesis 3: The need of companions and accompanying behavior vary according to shopping places under a given condition such as their companions' mobility and available time budget during opening hours of each shopping place.

Hypothesis 4: Grocery shopping has been seen as an unpleasing activity which individuals do not receive positive utility, but some elderly people could receive positive utility from grocery shopping under certain conditions.

Hypothesis 5: Grocery shopping is basically a means to prepare for meals, thus they can obtain utility not only while shopping but also after shopping such as from eating meals, additionally depending on with whom they have meals including their closeness with family members.

5.2. Methodology

Descriptive analysis showed that the impacts of many variables are strongly interrelated, thus their different impacts cannot meaningfully be interpreted separately. This means that structural equation modeling might be more appropriate for this kind of analysis rather than logit/probit model, thus this chapter used structural equation modeling instead of logit/probit model which was used in the previous steps. First of all, a hypothesized single population model (using an entire survey dataset conducted in this study) was statistically tested by estimating a full structural equation model. Second, the entire survey dataset was segmented into four comparison groups by four dichotomous segmentation variables: co-residence with adult children, auto availability, presence of companions, and presence of daughters-in-law in the household.

5.3. Estimation Results

The initial hypothesized model structure was repetitively modified and tested considering statistics of individual direct parameters and also overall model fit. The final model specification is represented in Fig.3 using SEM path diagram. This single population model confirmed a number of general findings and verified the five hypotheses. For example, first, it shows that there is clear trade-offs between shopping frequencies due to the

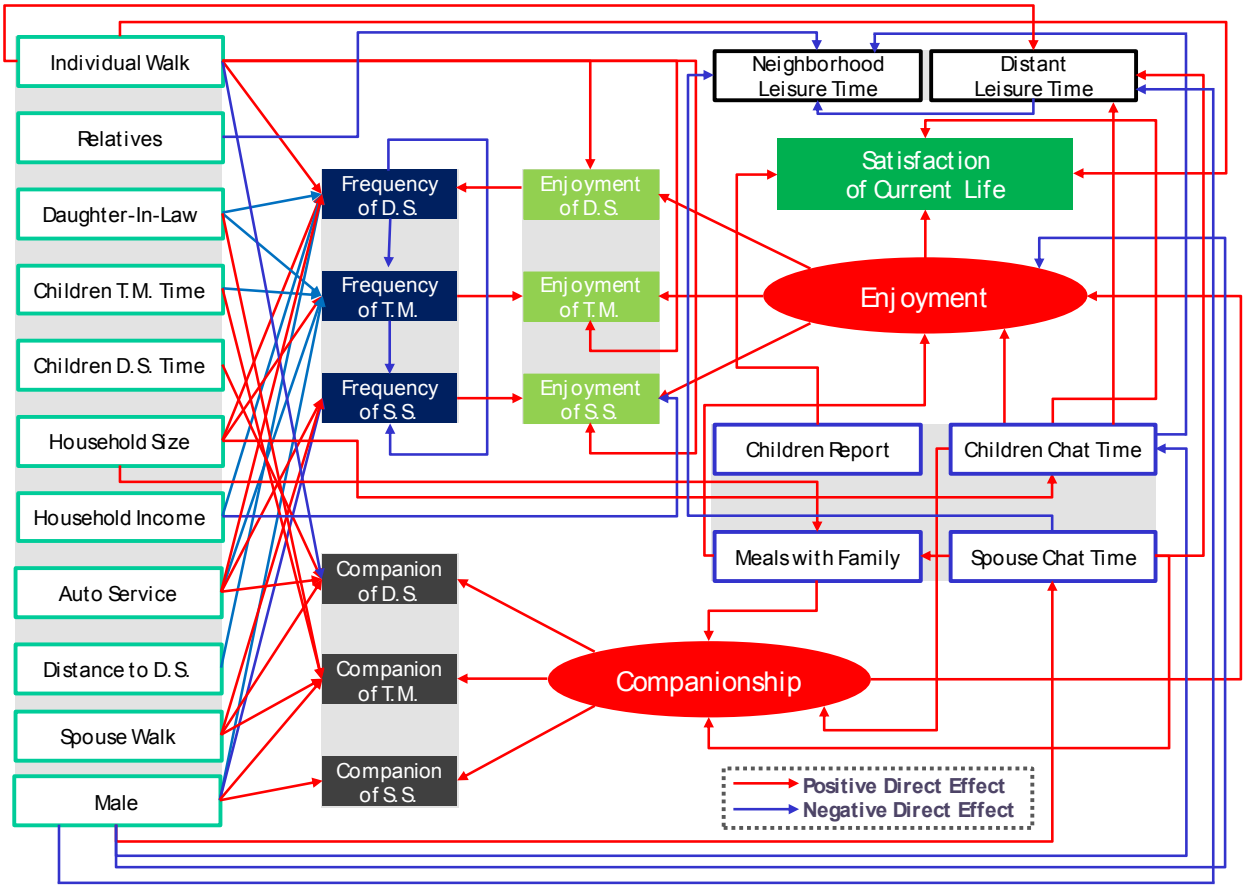

Fig.3 Final Model Structure of Baseline Model

nature of relatively fixed grocery amount by household and this study explicitly explained the mechanism. Second, it verified that household structure is a major determinant of elderly grocery shopping need and enjoyment; e.g., Household size → Family Relationship → Companionship → Enjoyment (→ Satisfaction of Current Life) → D.S. Frequency → T.M. Frequency → S.S. Frequency.

Several additional relationships were also found by comparing four paired-comparison groups which were not found in the single population model (the results are not shown here due to space limitations). Major finding was that co-residence with adult children and better family relationship significantly alleviate difficulties with elderly physical mobility and residential accessibility to grocery shopping places, consequently improving grocery shopping enjoyment of the elderly and then the quality of life for the elderly.

6. Conclusions

Through the three major steps above, this study identified a number of general findings and also provided several interesting original findings. Key findings are summarized below along with the implications for both policy makers and transportation planners.

First, it was found that accessibility does not always lead to more tours despite the easiness of reaching destinations due to the problem of under-reported short trips in traditional self-reporting questionnaire survey, lack of the impacts of intra-household interactions, different travel needs by activity type, and trip-chains/internal movements consideration (inside buildings) in the existing accessibility measures. This finding will contribute to better evaluating transportation planning policies as well as more accurate travel-demand forecasting.

Second, household structure change in Korea will increasingly force the elderly to travel for unpleasing activities rather than for pleasure. This finding implies that in addition to considering traffic safety of the elderly, Korean policy makers should also pay more attention to the effects of household structure changes in order to improve the quality of life for the elderly.

Third, there is clear trade-offs among shopping places due to the nature of relatively fixed grocery amount by household and this study explicitly explained the mechanism which has important implications, especially for transportation planners (e.g. more accurate travel-demand forecasting).

Fourth, grocery shopping is a pleasing leisure activity for particular elderly segments to improve their quality of life better than neighborhood leisure activities which account for the majority of Korean elderly leisure activity time. This finding urges policy makers to give more careful attention to elderly grocery shopping behavior, especially for the elderly who are less mobile or live without their adult children.

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