해외출장복명서

기　간:　2016. 1. 9~2016. 1. 15

출장지:　미국

출장자:　고용석, 김준기

국토연구원 국토인프라연구본부

Ⅰ. 출장개요

1. 출 장 지: 미국 워싱턴 D.C.

2. 출장기간: 2016. 1. 9~1. 15

3. 출 장 자

소속	직급	성명	비고
국토연구원	연구위원	고용석	
국토연구원	연구위원	김준기	

4. 출장목적

□ TRB 컨퍼런스 참석 및 논문발표, 교통관련 해외전문가 연구인력 유치 활동

- 미국의 워싱턴 D.C.에서 개최하는 TRB(Transport Research Board: 2016. 1. 10 ~ 2016. 1. 14) 제95회 Annual Meeting 참석 및 발표
- TRB Annual Meeting은 모든 교통분야를 포괄하며, 정책입안자·연구자·산업 및 학교 등이 참석하는 국제 컨퍼런스로, 연구 및 정책 교류를 도모하고, TRB Annual Meeting에서 교통관련 해외전문가 연구인력 유치활동

II. 출장일정

날짜	출발지	도착지	방문기관/장소	주요 수행업무	관계자
1.9 (토)	인천	워싱턴 D.C		▌출발(10:15) 및 도착(9:50)	
1.10 (일) ~ 13 (수)	워싱턴 D.C		워싱턴D.C 컨벤션센터	▌TRB 학술회의 참석 및 발표 ▌해외전문가 연구인력 유치 활동	
1.14 (목) ~15 (금)	워싱턴 D.C.	인천		▌출발(11:50) 및 도착(16:30) (기내1박)	

III. 수행사항

1. TRB 컨퍼런스 참석 및 논문발표

□ 일시 및 장소: 2016. 1. 10-14 워싱턴 D.C 컨벤션센터

□ 주요 추진사항

○ TRB의 주요연혁

- TRB는 미국교통학회로서 1920년에 National Advisory Board on Highway Research(고속도로 연구에 대한 국가자문위원회)로 설립되었음
- 1925년 HRB (Highway Research Board)로 명칭 변경
- 1962년 NCHRP (National Cooperative Highway Research Program) 시작(AASHTO funding)
- 1974년 TRB (Transportation Research Board)로 명칭이 변경되어 오늘에 이름
- 1980년부터 본격적인 국가교통정책 현안에 관한 연구를 집중적으로 수행하고 있으며 현재에도 미 의회, 연방정부 및 주정부의 교통부로부터 여러 연구사업 진행 중임

○ 금번 TRB 연례회의는 제95회로 약 900여편의 논문발표 및 250여개의 부스가 설치되었으며 도로 및 교통분야의 관련 전문가 12000여명 이상의 전문가가 참여하여 세계 각국의 도로분야 최신기술과 정보 등을 공유하고 연구결과를 발표함

- 금번 TRB학회에서는 구글카 등 자율주행자동차의 최신동향, 각종 교통계획에서의 빅데이터 관련 통계기법 및 기술, 기타 도로포장관련 주제 등 다양한 주제가 다루어졌으며 해당 세션에 참관하여 주요 논문발표를 들었음

○ 본 원의 김준기 연구위원은 다음의 2건의 논문을 발표함

- Exploring the impacts of transport infrastructure on manufacturing location by sector
- Trip making of older adults in Seoul: Age, heteroskedasticity, and trip purpose

○ 또한 별도로 마련된 포스터세션 장에는 각 분야별로 약 750여편이 넘는 주제의 포스터 전시가 이루어졌으며 실제 논문 작성자와 질의응답을 활발하게 진행하였음

- 또한 미국 도로교통관련 공공기관(DOT, FHWA 등)과 각종 민간기업, 세계 각 국의 유수의 도로교통관련 기업 등이 최신기술과 시제품 등을 전시한 전시장도 참관하였음
- 도로관련 계측 장비, 자전거, GIS 및 교통수요분석 시뮬레이션 프로그램 등 다양한 제품 등이 전시되었으며 특히 ENRO사의 최신 수요분석 프로그램과 GIS기반의 다양한 분석

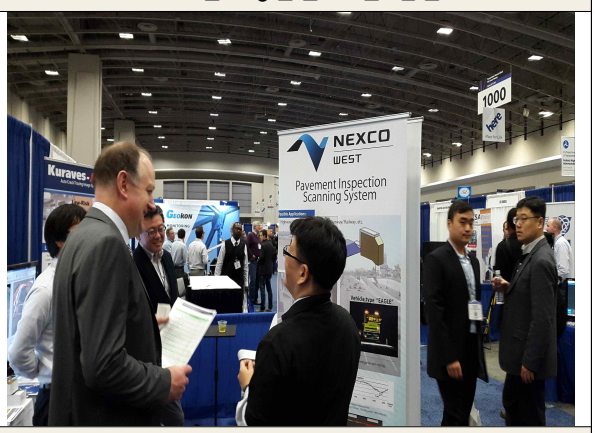
사례에 대한 시연을 관심있게 참관함

- 이상의 모든 세션 프로그램과 특강 등 각종 학회 프로그램 정보는 별도로 제공된 스마트폰 어플로 조회 및 관리가 가능하여 참관 스케쥴 관리를 용이하게 한 것이 매우 인상깊었으며, 새로 건축한 워싱턴 D.C 컨벤션센터에서 모든 프로그램이 이루어져 매우 효율적인 학회 참여가 가능하였음

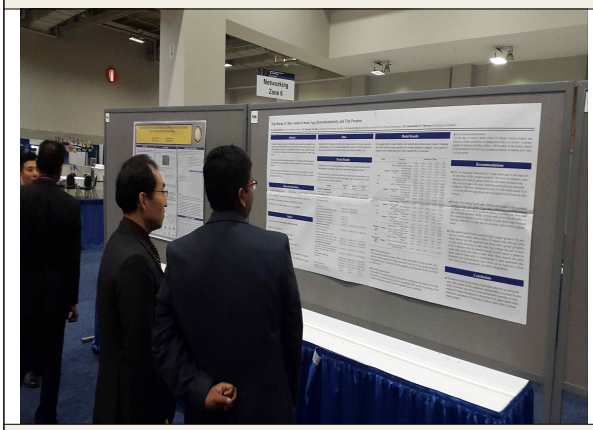
▲ 미 교통부장관 기조연설 참관

▲ 자율주행관련 세션 참관

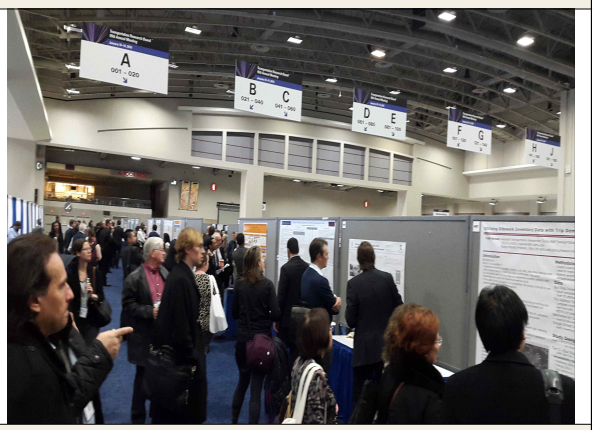
▲ 미국 FHWA에서 개발한 도로계측장비 전시물



▲ 전시부스에 참여한 일본 NEXCO사



▲ 포스터 세션에서 질의응답



▲ 포스터 세션 참관 전경

2. 교통관련 해외전문가 연구인력 유치 활동

□ 일시 및 장소: 2016. 1. 10-14 워싱턴 D.C 컨벤션센터

□ 주요 추진사항

- KOTAA(Korean Transportation Association in America) 모임에서 국토연구원 홍보: 미주지역에서 활동하고 있는 교통전문가들의 모임인 KOTAA 모임에 참석하여 국토연구원 홍보 및 관심을 보이는 해외전문가와 인적 네트워크 구축
- TRB 컨퍼런스 기간 동안 해외 연구인력 면담(2010. 1.10(일)~1.14(목)): TRB 컨퍼런스 기간 동안 국토연구원 홍보활동 수행 및 해외전문가와 인적 네트워크 구축
- KOTAA 집행부의 배려로 국토연구원과 도로정책연구센터의 주요 연구활동에 대해 소개하였으며 센터 홍보 브로슈어를 배포하여 기관소개 및 채용정보 등을 제공하였음

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<tr><td>▲ KOTAA 연구원 홍보 1</td><td>▲ KOTAA 연구원 홍보 2</td></tr>
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<tr><td>▲ KOTAA 연구원 홍보 3</td><td>▲ 연구원 홍보 4</td></tr>
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부록

1. Presentation

Trip Making of Older Adults in Seoul: Age, Heteroskedasticity, and Trip Purpose

Dr. Jin-Seok Hahn Korea Environment Institute, **Dr. Hyoung-Chul Kim** Chungnam Development Institute, **Dr. Joon-Ki Kim** Korea Research Institute for Human Settlement, **Dr. Gudmundur F. Ulfarsson** University of Iceland

Abstract

This study investigates trip making of older adults using a population-representative data sample from the 2010 Household Travel Survey in Seoul. The trip making variation of the older population is more likely to be heteroskedastic than the younger population (under 65 years old). The investigation was therefore done with a heteroskedastic ordered logit model.

The analysis showed that trip making characteristics of older adults varied with age group and trip purpose. Age was statistically significantly correlated with a source of heteroskedasticity.

Specific results showed that men 65 or older have a lower probability of making more trips than women, suggesting transportation policy needs to consider the genders differently.

Research Questions

- What is the factors affecting trip making of older adults?
- How different the heteroskedasticity of age groups when they makes trip?
- Difference in trip making behavior across elderly age groups
- Difference in trip making behavior across all age groups

Model

This study uses the heteroscedastic ordered logit model.

- Model 1: All age groups
- Model 2: Younger population aged less than 65
- Model 3: The older adult population aged 65+
- Model 4: The older adult population aged 65 through 74
- Model 5: The older adult population aged 75+
- Model 6: The older adult population aged 65+ for mandatory trip purpose
- Model 7: The older adult population aged 65+ for discretionary trip purpose

Data

Data from the 2010 Household Travel Survey in Seoul were used. The survey was sent to a random sample of 105,974 households, sampled from a total of 3,520,505 households in Seoul. The survey response rate was 83.9% (*The Korea Transport Institute, 2011*).

Model Results

A likelihood ratio test showed that separating the data into the younger population and the older population was statistically significantly better than the all age group model.

There are statistically significant differences in trip making characteristics between the older adult and the younger population. Age was significantly correlated with a source of heteroscedasticity.

Variables	Model 3 65+	Model 4 65 - 74	Model 5 75+
Individual Characteristics			
Family relation, Householder	0.581(0.077) ‡	2.074(0.429) ‡	0.735(0.199) ‡
Family relation, Spouse	0.492(0.072) ‡	1.829(0.385) ‡	0.588(0.174) ‡
Family relation, Children			
Family relation, Parents			
Age			
Gender, Male	-0.166(0.038) ‡	-0.387(0.110) ‡	
Driver's license & Automobile ownership	0.162(0.032) ‡	0.299(0.085) ‡	
Employment level, Work at home			
Employment level, Full time work	1.407(0.153) ‡		
Employment level, Part time work	1.589(0.173) ‡		
Employment level, Self-employed	1.675(0.175) ‡		
Employment level, Not employed	1.827(0.186) ‡	0.678(0.141) ‡	0.354(0.095) ‡
Household Characteristics			
Number of family members	0.072(0.014) ‡	0.226(0.051) ‡	0.108(0.033) ‡
Number of preschoolers			
Household monthly income, < $1,000			
Household monthly income, $1,000 – $3,000	0.056(0.011) ‡	0.406(0.107) ‡	0.129(0.055) ‡
Household monthly income, $3,000 – $5,000	0.176(0.036) ‡	0.552(0.141) ‡	0.220(0.088) ‡
Household monthly income, $5,000+	0.246(0.047) ‡	0.643(0.165) ‡	0.343(0.114) ‡
Environmental Characteristics			
Bus or subway station within ten-minute walk	0.411(0.067) ‡	2.279(0.465) ‡	0.911(0.240) ‡
Destination TAZ, Number of shopping-related facilities within a 400 m radius from subway stations	0.034(0.004) ‡	0.067(0.014) ‡	0.031(0.008) ‡
Heteroskedastic variable, Age	-0.004(0.001) ‡	0.005(0.003) ‡	-0.007(0.003) ‡
Threshold, μ_1	3.943(0.398) ‡	7.455(1.491) ‡	3.055(0.779) ‡
μ_2	4.376(0.441) ‡	8.313(1.661) ‡	3.382(0.862) ‡
μ_3	5.635(0.566) ‡	10.722(2.140) ‡	4.467(1.135) ‡
Number of observations	23,912	10,511	5,401
Log-likelihood at convergence	-19567.0	-14997.3	-4162.8

$Y^* = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$

Model Results

The marginal effects of major variables were analyzed and compared across models. Comparing older adults and the younger population, the younger population is generally more sensitive to changes in most variables and shows a higher marginal effect in most cases.

Model	Variable		Number of Trips 1	2	3	4	5+
Model 2 (< 65 vs. 65+)	Gender, Male		0.000	0.001	0.000	-0.001	-0.000
	Employment level	Driver's license & Auto. owner	-0.001	-0.017	0.004	0.010	0.003
		Full time work	-0.020	-0.499	0.127	0.293	0.100
		Part time work	-0.022	-0.525	0.133	0.308	0.105
		Self-employed	-0.022	-0.539	0.137	0.316	0.108
		Not employed	-0.026	-0.640	0.163	0.375	0.128
	Bus or subway station within ten-minute walk		-0.008	-0.185	0.047	0.108	0.037
Model 3 (65- 74 vs. 75+)	Gender, Male		0.004	0.054	-0.012	-0.020	-0.006
	Driver's license & Auto. owner		-0.004	-0.053	0.012	0.019	0.006
	Employment level	Full time work	-0.032	-0.289	0.104	0.168	0.049
		Part time work	-0.036	-0.327	0.118	0.190	0.055
		Self-employed	-0.038	-0.344	0.124	0.200	0.058
		Not employed	-0.043	-0.379	0.136	0.220	0.064
	Bus or subway station within ten-minute walk		-0.009	-0.085	0.030	0.049	0.014
Model 4 (65- 74 vs. 75+)	Family relation	Householder	-0.029	-0.214	0.079	0.125	0.038
		Spouse	-0.025	-0.189	0.070	0.111	0.034
	Bus or subway station within ten-minute walk		-0.009	-0.070	0.026	0.041	0.013
			-0.031	-0.255	0.087	0.138	0.042
Model 5 (65- 74 vs. 75+)	Family relation	Householder	-0.025	-0.179	0.065	0.106	0.034
		Spouse	-0.020	-0.136	0.052	0.085	0.019
	Employment level	Not employed	-0.012	-0.081	0.031	0.051	0.011
	Bus or subway station within ten-minute walk		-0.031	-0.216	0.081	0.132	0.029
Model 6 (Mandatory trips (65+) vs. Discretionary trips (65+))	Family relation	Householder	-0.041	-0.105	0.050	0.072	0.024
		Spouse	-0.032	-0.081	0.039	0.056	0.018
	Driver's license & Auto. owner		-0.015	-0.037	0.018	0.026	0.008
	Bus or subway station within ten-minute walk		-0.069	-0.176	0.084	0.121	0.040
Model 7 (Mandatory trips (65+) vs. Discretionary trips (65+))	Family relation	Householder	-0.016	-0.119	0.049	0.066	0.020
		Spouse	-0.011	-0.092	0.034	0.046	0.013
	Driver's license & Auto. owner		-0.004	-0.032	0.013	0.018	0.005
	Bus or subway station within ten-minute walk		-0.031	-0.238	0.097	0.132	0.039

- Individual characteristics
The householder tends to be more likely to make more trips in all age groups. Trip making of women tended to be higher than that of men for all age groups except for the population aged 75 and older. Driving appears as an important factor of mobility of older adults.

- Household characteristics
The number of household members was positively correlated with making more trips. The number of preschoolers did not have a significant effect on the trip making of older adults. Household income is also an important factor of mobility.

- Environmental characteristics
The bus stop or subway station within 10 minutes walking distance was linked to a higher probability of making more trips in all models. A greater number of shopping facilities within a 400 m radius of the subway station in the destination TAZ led to an increased probability of making more trips in all age groups

Recommendations

- First, trip frequency characteristics of older adults aged 65 and older differ from those of the younger population. Moreover, trip frequency characteristics for a specific group within the older adult population may vary even if the age is the same, depending on the physical and health conditions. Therefore, transportation policy for older adults should be diversified for different age groups and trip purposes to maximize its effectiveness.
- Second, Trip making significantly differed with regards to the economic condition of the older adults. Older adults with a high household monthly income were more likely to choose making more trips than those with less financial resources. Public services need to provide affordable or free means of transport to ensure mobility of older adults under financial hardship, especially for trips that are necessary such as doctor appointments.
- Older adults showed lesser sensitivity than younger groups to the presence of a public transit station within a 10 minute walk, although public transit stations are still significant and linked with a greater probability of older adults choosing to make more trips. Perhaps this lack of sensitivity is indicative that the present location of public transit is geared towards other needs than these of older adults. More research into public transit needs of older adults is recommended to better understand what hindrances and inconveniences exist which can be improved to allow older adults to more conveniently use public transportation.

Conclusions

- The analysis showed the trip making of older adults varied with age and trip purpose. Main variables that had a statistically significant effect on increasing the probability of more trips were: driver's license and automobile ownership, not being employed or being self-employed or with part time work, higher monthly household income, and presence of a bus stop or a subway station within 10 minutes walking distance.

2. 논문

Trip Making of Older Adults in Seoul: Age, Heteroskedasticity, and Trip Purpose

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Word count: 5,808 words text + 5 tables x 250 words (each) = 7,058 words

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ABSTRACT

Korea is experiencing a rapid increase in the number and proportion of the older population aged 65 and older. This study investigates trip making of older adults using a population-representative data sample from the 2010 Household Travel Survey in Seoul. The trip making variation of the older population is more likely to be heteroskedastic than the younger population (under 65 years old). The investigation was therefore done with a heteroskedastic ordered logit model.

The analysis showed that trip making characteristics of older adults varied with age group and trip purpose. Age was statistically significantly correlated with a source of heteroskedasticity. This suggests unobserved heterogeneity that is correlated with age and affects trip making, likely individual physical and psychological conditions.

Specific results showed that men 65 or older have a lower probability of making more trips than women, suggesting transportation policy needs to consider the genders differently. Older adults were more sensitive to having a driver's license and an automobile than younger groups but less sensitive to nearness to public transit stations. This indicates the importance of automobiles for older adults' mobility but also suggests the locations of public transit may not be geared enough for the needs of older adults.

The results show the development of transport policies needs to consider the variance among the aged, such as financial condition, gender, driving licensure and automobile ownership.

Keywords: aging; trip frequency; heteroskedasticity; elderly; ordered logit; travel behavior

INTRODUCTION

The world is experiencing an unprecedented population aging. Korea is also experiencing a rapid increase in the number and proportion of the older population aged 65 and older. The magnitude of this demographic change is striking. Korea became an aging society in 2000 (defined as a society with 7% or more of the population aged 65 and older), and it is projected to become an aged society (14% or more of the population aged 65 and older) in 2018 and a post-aged society in 2026 (20% or more of the population aged 65 and older) (*1*). While major developed countries (France, Germany, Italy, Japan, and the United States) are expected to take 62 years to become aged societies and 25 years to become post-aged societies on average; the projections for Korea are that it will only take 18 years for Korea to become an aged society and 8 more years to become a post-aged society (*2*).

The effect of an aging society on economy, health care, and retirement systems has received significant attention (*3*), and there is growing research on the effect on transportation (*4–7*) although much remains to be investigated. An aged population tends to travel less compared to a younger population (*8*), but current cohorts of older adults travel more frequently than the aged population in the past (*9–11*). Various factors such as individual characteristics, household characteristics, and built environment characteristics combine to affect older adults' trip behavior (*11–15*).

Public transportation or bicycle are used daily by over 70% of the population the Seoul metropolitan area; for example, 7 million people use the Seoul Metro (subway) daily (*16*). Seoul also has a well-established bus system and discounts on transfers between the bus system and the subway. The public transportation service in Seoul is superior to those of many other countries (*17*). The travel behavior of the aged population in Seoul is expected to be different from other countries, due in part to the subway being free for people at 65 and older.

Korea is preparing for the rapid aging of its population in various fields including housing, finances, and transportation. For successful implementation of transportation policies in an aging society, it is necessary to understand the travel characteristics of the older population. In this study, we have analyzed variables that affect trip making by the older population in order to help form a basis for the development of evidence-based transportation policy for this aging society.

LITERATURE REVIEW

The literature on travel behavior suggests that individual, household, and environmental characteristics affect the trip making of the older population. Age is negatively correlated with trip making for older adults (*8, 18–19*). The travel characteristics of older adults differ significantly from those of the younger population (*15, 20–22*). Travel characteristics vary even within the older adult group (*10, 23*), and it is necessary to divide the older adult group into different age groups and analyze the trip characteristics with respect to individual health conditions (*4*). Moreover, the older population exhibits varying trip characteristics depending on individual lifestyle (*12*) and whether the individual can drive (*24*).

Health is a major factor affecting the trip making of older adults and is closely related to their mobility (*18, 25*). Disability acts as a hindrance to trip making for some older adults. When analyzing the correlation between age and number of trips, age alone is an insufficient explanatory variable to explain the decreasing number of trips of older adults. Rather, deterioration of health and a subsequent decrease in number of trips explains the relationship between age and trip making better than age alone (*18*).

There are conflicting views on the effect of gender on trip making of older adults, and it is difficult to conclude that one gender always makes more trips than the other (*8, 15, 18–19*).

Income also has a close relationship with the trip making of older adults, and those that drive themselves tend to make more and longer trips (*8, 15, 18*).

Public transportation affects the trip making of older adults to a certain extent. In some research it has not been found to affect the mobility of older adults (*24, 26, 27*). On the other hand, high-quality public transportation service has been found to improve the mobility of older adults (*3, 6, 11, 21, 28–31*). These studies show that depending on the level of service provided by public transportation, it may or may not serve as effective means of transportation for older adults.

Previous studies have examined socio-economics and the trip characteristics of older adults (*11, 21, 32–37*). However, even within the same age group, the trip making of the older adult population is expected to be more influenced by each individual's health and physical condition compared to the younger population, information that is often unobserved. To account for some of the effect of such unobserved individual characteristics as psychological disposition and health, this paper explored if the age of older adults is correlated with a source of heteroskedasticity. This study also considered the characteristics of the trip destination for older adults in addition to individual and household characteristics in the analysis of older adults' trip making characteristics.

DATA DESCRIPTION

Data from the 2010 Household Travel Survey in Seoul were used. The survey was sent to a random sample of 105,974 households, sampled from a total of 3,520,505 households in Seoul. The survey response rate was 83.9% (*38*). Households are asked to record information on all household members and trip information for all household members six years old and older, with adults filling out information for the children. Survey questions involve personal characteristics (age, gender, driver's license, occupation, occupation type, etc.), household characteristics (number of household members, number of preschoolers, vehicle ownership, housing type, monthly income, etc.), and trip characteristics (trip purpose, transportation mode, characteristics of origin and destination, etc.). To account for the characteristics of the destination on the trip making of the older adult population, we surveyed the number of shopping facilities (department stores, large shopping malls, etc.) for each of the 423 traffic analysis zones (TAZ) in Seoul. We have restricted the analysis to facilities within 400 m radius of a subway station in the destination TAZ to study the effect of public transportation accessibility on trips to shopping facilities.

The observed average number of trips was 2.42 trips per person for people age 65 and older, where a trip is defined as any trip out of a location for longer than 10 min. total time. For example, a bicycle trip for exercise (home to home) is considered a trip with a leisure purpose if it takes more than 10 min. If one trip for one trip purpose requires multiple transport modes, then each travel mode is recorded and considered an individual trip. When the trips were categorized into mandatory trips (commuting, work, etc.) and discretionary trips (recreation, entertainment, dining, visiting relatives, etc.), the average number of mandatory trips was 2.03 trips per person and the average number of discretionary trips was 2.26 trips per person in 2010. Table 1 presents the data description of the explanatory variables used in the analysis.

TABLE 1 Data Description

Variables		Frequency		Percentage	
		All	65+	All	65+
Individual					
Family relation	Householder	86,711	15,994	36.3	66.9
	Spouse	52,902	5,653	22.1	23.6
	Children	92,949	38	38.9	0.2
	Parents	6,361	2,226	2.7	9.3
Age	< 65	215,011		90.0	
	65+	23,912	23,912	10.0	100.0
	65–74	18,511	18,511	7.7	77.4
	75–84	4,772	4,772	2.0	20.0
	85+	629	629	0.3	2.6
Gender	Male	124,434	13,755	52.1	57.5
	Female	114,489	10,157	47.9	42.5
Driver's license	Yes	136,522	12,974	57.1	54.3
	No	102,401	10,938	42.9	45.7
Employment level	Work at home	2,096	417	0.9	1.7
	Full time work	68,404	3,384	28.6	14.1
	Part time work	12,285	1,246	5.1	5.2
	Self-employed	42,067	6,753	17.6	28.2
	Not employed	114,071	12,113	47.7	50.7
Household					
Number of family members	One	11,236	3,119	4.7	13.0
	Two	31,248	10,730	13.1	44.9
	Three	58,534	5,432	24.5	22.7
	Four	105,171	2,529	44.0	10.6
	Five or more	32,734	2,103	13.7	8.8
Number of preschoolers	None	214,194	23,037	89.6	96.3
	One	19,635	662	8.2	2.8
	Two	4,878	201	2.0	0.8
	Three or more	216	13	0.1	0.1
Automobile ownership	Yes	201,589	17,085	84.4	71.4
	No	37,334	6,827	15.6	28.6
Household monthly income (USD)	< $1,000	17,482	6,627	7.3	27.7
	$1,000 ~ $3,000	102,206	11,541	42.8	48.3
	$3,000 ~ $5,000	76,652	3,827	32.1	16.0
	$5,000+	42,583	1,917	17.8	8.0
Bus or subway station within ten-minute walk	Yes	234,214	23,225	98.0	97.1
	No	4,709	687	2.0	2.9
Trips					
Number of trips	One	1,900	328	0.8	1.4
	Two	168,857	18,385	70.7	76.9
	Three	21,885	2,027	9.2	8.5
	Four or more	46,281	3,172	19.4	13.3

METHODS

The objective of this work is to investigate trip making of older adults in Seoul and in particular to test whether age was correlated with a source of heteroskedasticity. To achieve this end, each individual is viewed as being able to choose how many trips they will make during the day. The participants were classified into five groups for those that made one trip, two trips, three trips, four trips, and five or more trips. The modeling framework therefore becomes a choice model. Since

these groups have a clear ordering from the least to the greatest number of trips, an ordered choice model is suitable. The heteroskedastic ordered logit model can model the choice between such ordered groups while accounting for heteroskedasticity that is a function of an individual-specific variable. Naturally, if the purpose of the investigation was to simply predict the number of trips of each person, a count model regression such as the Poisson or the Negative Binomial could have been used. However, in this work, the focus is on identifying the variables that influence each participant's choice of trip making while simultaneously testing if age was correlated with a source of heteroskedasticity, and for this purpose the heteroskedastic logit model provides an excellent research tool.

An ordered choice model is appropriate when the dependent variable categories are ordinal (*39*). In general if the dependent variable y has observable categories numbered $j = 0, 1, 2, \dots, J$, it can be linked to an unobserved random utility, here termed U^*, by the following:

$$\begin{aligned} y &= 0 \quad \text{if } U^* \le 0, \\ &= 1 \quad \text{if } 0 < U^* \le \mu_1, \\ &= 2 \quad \text{if } \mu_1 < U^* \le \mu_2, \\ &\dots \\ &= J \quad \text{if } \mu_{J-1} < U^*, \end{aligned} \tag{1}$$

where μ_j is an estimable parameter, and U^* has a linear-in-parameter form that can be expressed as

$$U^* = \boldsymbol{\beta} \boldsymbol{x}_n + \epsilon_n, \tag{2}$$

where $\boldsymbol{\beta}$ is a vector of estimable coefficients, $\boldsymbol{x}_n$ is a vector of observed variables for observation n, and ϵ_n is an error term. If ϵ_n is assumed to be identically and independently logistically distributed, this leads to the ordered logit model, and the probability that y is j is (*40, 41*):

$$P(y = j) = P(\mu_{j-1} < U^* < \mu_j) = F\left(\frac{\mu_j - \boldsymbol{\beta} \boldsymbol{x}_n}{\sigma}\right) - F\left(\frac{\mu_{j-1} - \boldsymbol{\beta} \boldsymbol{x}_n}{\sigma}\right), \tag{3}$$

where F is the cumulative distribution function of the logistic distribution and σ is the variance of the error term.

This model can be extended to investigate heteroskedasticity in the error term by writing the variance of the error term as a function (*41*):

$$\sigma_n^2 = \exp(\boldsymbol{Z}_n \boldsymbol{\gamma})^2, \tag{4}$$

where $\boldsymbol{Z}_n$ is a vector of variables explaining the error term variance of the n-th observation, and $\boldsymbol{\gamma}$ is the associated vector of estimable coefficients. With equation (4), the heteroskedastic ordered logit model can account for the variability of the variance across the observations unlike the ordered logit model which assumes equal variance. A detailed discussion of the heteroskedastic ordered logit model is provided by (*42*).

Coefficients can be estimated using the method of maximum likelihood (*41*). The likelihood function for the heteroskedastic ordered logit model is

$$L = \prod_{j=1}^{J} \prod_{n=1}^{N} \left[F\left(\frac{\mu_j - \boldsymbol{\beta} \boldsymbol{x}_n}{\sigma_n}\right) - F\left(\frac{\mu_{j-1} - \boldsymbol{\beta} \boldsymbol{x}_n}{\sigma_n}\right) \right]^{w_{nj}}, \tag{5}$$

where w_{nj} is the weight or expansion factor of the n-th observation experiencing trip making category j.

The models estimated in this study test heteroskedasticity as a function of age. A total of seven models were estimated to investigate the trip making choices of older adults and compare with younger participants and the group as a whole. There were also two models estimated using a subset of the data based on trip purpose. The following models were estimated:

- Model 1: All age groups
- Model 2: Younger population aged less than 65
- Model 3: The older adult population aged 65+
- Model 4: The older adult population aged 65 through 74
- Model 5: The older adult population aged 75+
- Model 6: Model for mandatory trip purpose - the older adult population aged 65+
- Model 7: Model for discretionary trip purpose - the older adult population aged 65+

The models were developed first by including all available relevant variables and then variables with coefficients not significantly different from zero at the 0.1 level of significance (90% confidence level) were restricted out of the models to improve efficiency. Likelihood ratio tests were used to investigate if the separation into finer groups were statistically significantly better than the overall model in terms of likelihood. To further study the differences across the models marginal effects were calculated for the variables.

RESULTS

Models Comparing Trip Making across Age Groups (Models 1–5)

To compare trip making characteristics of the older adult population with the younger population, Models 1 (all age groups), 2 (younger population), and 3 (the older adult population) were estimated. A likelihood ratio test showed that separating the data into the younger population and the older population was statistically significantly better than the all age group model, which provides evidence that there are statistically significant differences in trip making characteristics between the older adult and the younger population (Table 2).

Next, Models 4 (ages 65 through 74) and 5 (age over 75) were estimated to identify differences in trip making characteristics within the older adult population (Table 3). Model 3 is repeated in the table for comparison purposes. A likelihood ratio test showed that separating the data into those two groups, 65 through 74, and 75 and older, is statistically significantly better than the model of everyone 65 years old and older. This shows that the trip making characteristics of the population aged 65 through 74 were statistically different from those of the population aged over 75.

The results show that age was found significantly correlated with a source of heteroskedasticity (Table 2). Interestingly, the heteroskedasticity grows with age in the 'all ages' model but when it has been split into younger than 65 and 65+ the results show that heteroskedasticity starts to reduce with age for the older group. When the older group is split in two groups, 65 through 74, and 75+ (Table 3), the results show that heteroskedasticity continues to grow up to 75 although the effect is not statistically significant at the 0.1 level, and then the heteroskedasticity starts to drop in the oldest group of those 75+ years old. It is also telling that the significance of heteroskedasticity due to age becomes less when the group contains a narrow age range of 10 years. Taken together it shows that there is heteroskedasticity due to age overall and the effect of age on heteroskedasticity varies with age. This shows that there is quite a complex unobserved effect due to age and there is an important age-based variance in trip making. Clearly age itself is just a number, so it is not age as a number that is the cause here but rather unobserved variation across people, for example due to health condition, psychological effects, and even taste and personality; all of which are being captured by the age variable.

200 **Table 2 Trip Making and Age Model Estimation Results: Model 1 to Model 3**

Variables	Model 1 All ages	Model 2 < 65	Model 3 65+
Individual Characteristics			
Family relation, Householder	0.233(0.016)‡	0.256(0.017)‡	0.581(0.077)‡
Family relation, Spouse			0.492(0.072)‡
Family relation, Children			
Family relation, Parents	-0.207(0.032)‡	-0.112(0.037)‡	
Age	-0.008(0.000)‡	-0.009(0.001)‡	
Gender, Male	-0.074(0.011)‡	-0.066(0.012)‡	-0.166(0.038)‡
Driver's license & Automobile ownership	0.112(0.012)‡	0.103(0.014)‡	0.162(0.032)‡
Employment level, Work at home			
Employment level, Full time work	2.831(0.046)‡	2.900(0.053)‡	1.407(0.153)‡
Employment level, Part time work	2.983(0.050)‡	3.051(0.057)‡	1.589(0.173)‡
Employment level, Self-employed	3.070(0.048)‡	3.128(0.055)‡	1.673(0.175)‡
Employment level, Not employed	3.594(0.049)‡	3.710(0.057)‡	1.837(0.186)‡
Household Characteristics			
Number of family members	0.105(0.005)‡	0.108(0.006)‡	0.072(0.014)‡
Number of preschoolers	0.034(0.012)‡	0.038(0.013)‡	
Household monthly income, < $1,000			
Household monthly income, $1,000 ~ $3,000	0.474(0.022)‡	0.569(0.026)‡	0.056(0.011)‡
Household monthly income, $3,000 ~ $5,000	0.693(0.023)‡	0.797(0.027)‡	0.176(0.036)‡
Household monthly income, $5,000+	0.786(0.025)‡	0.891(0.029)‡	0.246(0.047)‡
Environmental Characteristics			
Bus or subway station within ten-minute walk	1.013(0.031)‡	1.042(0.035)‡	0.411(0.067)‡
Destination TAZ, Number of shopping-related facilities within a 400 m radius from subway stations	0.044(0.001)‡	0.045(0.001)‡	0.034(0.004)‡
Heteroskedastic variable, Age	0.002(0.000)‡	0.003(0.000)‡	-0.004(0.001)‡
Threshold, μ_1	6.157(0.056)‡	6.409(0.065)‡	3.943(0.398)‡
μ_2	6.724(0.060)‡	6.985(0.069)‡	4.376(0.441)‡
μ_3	8.558(0.071)‡	8.870(0.082)‡	5.635(0.566)‡
Number of observations	238,923	215,011	23,912
Log-likelihood at convergence	-217307.4	-197498.1	-19567.0

$\chi^2 = -2[LL(\beta_1) - LL(\beta_2) - LL(\beta_3)] = 484.6,\ \chi^2(0.05, 16) = 26.296.$

201 Standard errors are in parentheses. Confidence level: all greater than 90%, † > 95%, and ‡ > 99%. Coefficients that
202 weren't significant at the 90% level of confidence were restricted to zero and omitted from the table.
203
204

205 **Table 3 Trip Making and Age Model Estimation Results: Model 3 to Model 5**

Variables	Model 3 65+	Model 4 65–74	Model 5 75+
Individual			
Family relation, Householder	0.581(0.077)‡	2.074(0.429)‡	0.735(0.199)‡
Family relation, Spouse	0.492(0.072)‡	1.829(0.385)‡	0.588(0.174)‡
Family relation, Children			
Family relation, Parents			
Age			
Gender, Male	-0.166(0.038)‡	-0.387(0.110)‡	
Driver's license & Automobile ownership	0.162(0.032)‡	0.299(0.085)‡	
Employment level, Work at home			
Employment level, Full time work	1.407(0.153)‡		
Employment level, Part time work	1.589(0.173)‡		
Employment level, Self-employed	1.673(0.175)‡		
Employment level, Not employed	1.837(0.186)‡	0.678(0.141)‡	0.354(0.095)‡
Household			
Number of family members	0.072(0.014)‡	0.226(0.051)‡	0.108(0.033)‡
Number of preschoolers			
Household monthly income, < $1,000			
Household monthly income, $1,000 ~ $3,000	0.056(0.011)‡	0.406(0.107)‡	0.129(0.055)†
Household monthly income, $3,000 ~ $5,000	0.176(0.036)‡	0.552(0.141)‡	0.220(0.088)†
Household monthly income, $5,000+	0.246(0.047)‡	0.643(0.165)‡	0.343(0.114)‡
Environment			
Bus or subway station within ten-minute walk	0.411(0.067)‡	2.279(0.465)‡	0.911(0.240)‡
Destination TAZ, Number of shopping-related facilities within a 400 m radius from subway stations	0.034(0.004)‡	0.067(0.014)‡	0.031(0.008)‡
Heteroskedastic variable: Age	-0.004(0.001)‡	0.005(0.003)	-0.007(0.003)†
Threshold, μ_1	3.943(0.398)‡	7.455(1.491)‡	3.055(0.779)‡
μ_2	4.376(0.441)‡	8.313(1.661)‡	3.382(0.862)‡
μ_3	5.635(0.566)‡	10.722(2.140)‡	4.467(1.135)‡
Number of observations	23,912	18,511	5,401
Log-likelihood at convergence	-19567.0	-14997.3	-4162.8

$\chi^2 = -2[LL(\beta_3) - LL(\beta_4) - LL(\beta_5)] = 813.9,\ \chi^2(0.05, 13) = 22.362.$

206 Standard errors are in parentheses. Confidence level: all greater than 90%, † > 95%, and ‡ > 99%. Coefficients that
207 weren't significant at the 90% confidence level were restricted to zero and omitted from the table.
208
209 With regards to individual characteristics, the householder tends to be more likely to make more
210 trips in all age groups. Trip making decreased with age in the all-age group model (Model 1) and
211 the younger population group (Model 2) (Table 2), but the effect of age was not statistically
212 significant for the population aged 65 and older and the coefficient on age was therefore
213 constrained to zero in models 3 to 5. Although age is found correlated with heteroskedasticity for
214 older adults, it did not affect trip making directly. This may be due to larger representation by older
215 adults who are capable of traveling in the Household Travel Survey, whereas those who have
216 difficulty traveling due to health conditions may have been underrepresented in the survey sample.
217 Trip making of women tended to be higher than that of men for all age groups except for the
218 population aged 75 and older, where gender was not significant. Driving appears as an important
219 factor of mobility of older adults, as those that have a driver's license and own an automobile are
220 more likely to choose to make more trips. This effect was not statistically significant for the
221 population aged 75 and older, probably due to a lack of observations since there are few drivers in

222 that age group in Korea. It was found that the not employed have the highest probability of
223 choosing to make more trips, followed by the self-employed, with those employed by others
224 having lesser flexibility.
225 In terms of household characteristics, the number of household members was positively
226 correlated with making more trips. Such a trend for older adults may be attributed to the help
227 needed from other family members for older adults to travel. The effect is especially pronounced
228 for the 65 through 74 year old group. Also, larger households provide more opportunities for older
229 adults to participate in activities, which could explain the higher probability of older adults
230 choosing to make more trips when in larger households. The number of preschoolers did not have
231 a significant effect on the trip making of older adults. A higher monthly household income was
232 correlated with a greater probability of making more trips in all models but with the effect reducing
233 for the 75+ group. This implies that household income is an important factor of mobility.
234 A bus stop or subway station within 10 minutes walking distance was linked to a higher
235 probability of making more trips in all models. However the effect was especially large for the 65
236 through 74 year old group. Seoul provides a fare discount for transfer between public transport
237 vehicles (bus and subway, and between different bus lines), offers free subway fare for those 65
238 and older. This along with well-established public transportation infrastructure may explain the
239 increased importance of public transportation for trip making once people reach 65 years or age. A
240 greater number of shopping facilities within a 400 m radius of the subway station in the destination
241 TAZ led to an increased probability of making more trips in all age groups, but the effect is
242 somewhat smaller for older adults. This indicates the attraction of commercial development near
243 subway stations and lends support for such transit oriented development.
244
245 **Models Comparing Trip Making of Older Adults by Trip Purpose (Models 6 and 7)**
246 The study now turns to investigate whether trip making differed by trip purpose for older adults.
247 Toward this goal, trips were categorized as either mandatory (Model 6) or discretionary (Model 7).
248 A likelihood ratio test was used to compare the joint model for 65+ and all trip purposes with the
249 two separate models for 65+ broken down by mandatory or discretionary trip purpose. The test
250 showed the likelihood was statistically significantly improved if the models were split by purpose
251 which shows that trip making characteristics are overall different between mandatory and
252 discretionary trips of older adults (Table 4).
253
254

255 **TABLE 4 Trip Making and Trip Purpose Model Estimation Results: Models 3, 6–7**

Variables	Model 3 65+	Model 6 65+ Mandatory trips	Model 7 65+ Discretionary trips
Individual			
Family relation, Householder	0.581(0.077)‡	1.484(0.326)‡	0.388(0.067)‡
Family relation, Spouse	0.492(0.072)‡	1.151(0.304)‡	0.266(0.055)‡
Family relation, Children			
Family relation, Parents			
Age			
Gender, Male	-0.166(0.038)‡	-0.647(0.184)‡	-0.075(0.034)†
Driver's license & Automobile ownership	0.162(0.032)‡	0.528(0.139)‡	0.113(0.031)‡
Employment level, Work at home			
Employment level, Full time work	1.407(0.153)‡	-0.527(0.124)‡	0.832(0.134)‡
Employment level, Part time work	1.589(0.173)‡		0.670(0.136)‡
Employment level, Self-employed	1.673(0.175)‡		0.665(0.097)‡
Employment level, Not employed	1.837(0.186)‡	—	0.650(0.092)‡
Household			
Number of family members	0.072(0.014)‡	0.167(0.048)‡	0.053(0.013)‡
Number of preschoolers			
Household monthly income, < $1,000			
Household monthly income, $1,000 ~ $3,000	0.056(0.011)‡	0.520(0.149)‡	0.130(0.033)‡
Household monthly income, $3,000 ~ $5,000	0.176(0.036)‡	0.750(0.203)‡	0.233(0.049)‡
Household monthly income, $5,000+	0.246(0.047)‡	0.907(0.252)‡	0.302(0.065)‡
Environment			
Bus or subway station within ten-minute walk	0.411(0.067)‡	2.488(0.451)‡	0.781(0.109)‡
Destination TAZ, Number of shopping-related facilities within a 400 m radius from subway stations	0.034(0.004)‡		
Heteroskedastic variable: Age	-0.004(0.001)‡	0.004(0.002)	-0.009(0.002)‡
Threshold, μ_1	3.943(0.398)‡	6.617(1.161)‡	2.583(0.320)‡
μ_2	4.376(0.441)‡	7.389(1.296)‡	2.928(0.362)‡
μ_3	5.635(0.566)‡	9.513(1.663)‡	3.783(0.467)‡
Number of observations	23,912	6,914	11,569
Log-likelihood at convergence	-19567.0	-5413.2	-9879.8

$\chi^2 = -2[LL(\beta_3) - LL(\beta_6) - LL(\beta_7)] = 8,547.9,\ \chi^2(0.05, 13) = 22.362.$

256 Standard errors are in parentheses. Confidence level: all greater than 90%, † > 95%, and ‡ > 99%. Coefficients that
257 weren't significant at the 90% confidence level were restricted to zero and omitted from the table. Survey participants
258 who were not employed had to be excluded in model 6.
259
260 Coefficients estimated for family relation, gender, and driving, each had the same sign in both
261 Models 6 and 7, which means that these factors contributed to either an increase or decrease in the
262 probability of choosing to make more trips in a consistent manner. In Model 6, older adults with
263 full time work had a lower probability of making more mandatory trips compared to those with
264 part time work, working at home, or self-employed (it should be noted that older adults that were
265 not employed had to be excluded in Model 6). In contrast, working older adults—except those that
266 work at home—had a higher probability of choosing to make more discretionary trips compared to
267 other older adults (in Model 7). The employment level of older adults is shown to affect the
268 probability of choosing to make more trips differently depending on the trip purpose. The
269 probabilities of choosing to make more mandatory and discretionary trips were both increased for
270 older adults with increasing number of household members. The number of preschoolers was not

significant in these models. This may be a consequence of more present-day older adults no longer assuming responsibility for looking after preschoolers. The presence of a bus stop or a subway station within 10 minute walking distance increased the probability of older adults choosing to make more trips for both the mandatory and the discretionary trip purpose. The number of shopping facilities within a 400 m radius from subway stations had a statistically significant effect on the probability of choosing to make more trips for older adults overall, but did not lead to a significant difference by trip purpose.

Marginal Effects of Major Variables Compared Across Models

The marginal effects of major variables were analyzed and compared across models (see Table 5). Comparing older adults and the younger population, the younger population is generally more sensitive to changes in most variables and shows a higher marginal effect in most cases. Notable deviations are having a driver's license and owning an automobile, where the older population is more sensitive than the younger group. Also, there is a larger difference between men and women for the older population, shown by a larger marginal effect on the male gender. With respect to the number of trips, the older population is more sensitive on the one trip category and shows a higher marginal effect there on the variables.

The older adult population exhibited varying trip characteristics depending on their age group (between ages 65 and 74 and ages 75 and older) and trip purpose (mandatory or discretionary). Being a householder in the 65–74 year old group tended to have a larger impact on the probabilities of trip categories than for householders in the 75+ group (ages 75 and older). This shows a greater sensitivity to head of household status among the 65–74 year old group and with a larger increase in the probabilities of choosing to make more trips than for the older group. Also, the probability of choosing to make more mandatory trips tended to increase more than that of discretionary trips for older adult householders.

Having a bus stop or a subway station within 10 minutes walking distance had a larger impact on the older adult population in the 65–74 year old group and their probabilities of choosing more trips increased compared to the 75+ group. The effect of this variable was more pronounced for the middle group (two to four trips) of discretionary trips than for mandatory trips, where the marginal effect was larger at the tails, away from one trip and towards five or more trips.

TABLE 5 Comparison of Marginal Effects

Model		Variable		Number of Trips 1	2	3	4	5+
< 65 vs. 65+	Model 2	Gender, Male		0.000	0.011	-0.003	-0.007	-0.002
		Driver's license & Auto. owner		-0.001	-0.017	0.004	0.010	0.003
		Employment level	Full time work	-0.020	-0.499	0.127	0.293	0.100
			Part time work	-0.022	-0.525	0.133	0.308	0.105
			Self-employed	-0.022	-0.539	0.137	0.316	0.108
			Not employed	-0.026	-0.640	0.163	0.375	0.128
		Bus or subway station within ten-minute walk		-0.008	-0.185	0.047	0.108	0.037
	Model 3	Gender, Male		0.004	0.034	-0.012	-0.020	-0.006
		Driver's license & Auto. owner		-0.004	-0.033	0.012	0.019	0.006
		Employment level	Full time work	-0.032	-0.289	0.104	0.168	0.049
			Part time work	-0.036	-0.327	0.118	0.190	0.055
			Self-employed	-0.038	-0.344	0.124	0.200	0.058
			Not employed	-0.041	-0.378	0.136	0.220	0.064
		Bus or subway station within ten-minute walk		-0.009	-0.085	0.030	0.049	0.014
65–74 vs. 75+	Model 4	Family relation	Householder	-0.029	-0.214	0.079	0.125	0.038
			Spouse	-0.025	-0.189	0.070	0.111	0.034
		Employment level	Not employed	-0.009	-0.070	0.026	0.041	0.013
		Bus or subway station within ten-minute walk		-0.031	-0.235	0.087	0.138	0.042
	Model 5	Family relation	Householder	-0.025	-0.170	0.065	0.106	0.024
			Spouse	-0.020	-0.136	0.052	0.085	0.019
		Employment level	Not employed	-0.012	-0.081	0.031	0.051	0.011
		Bus or subway station within ten-minute walk		-0.031	-0.210	0.081	0.132	0.029
Mandatory trips vs. Discretionary trips	Model 6	Family relation	Householder	-0.041	-0.105	0.050	0.072	0.024
			Spouse	-0.032	-0.081	0.039	0.056	0.018
		Driver's license & Auto. owner		-0.015	-0.037	0.018	0.026	0.008
		Bus or subway station within ten-minute walk		-0.069	-0.176	0.084	0.121	0.040
	Model 7	Family relation	Householder	-0.016	-0.119	0.049	0.066	0.020
			Spouse	-0.011	-0.082	0.034	0.046	0.013
		Driver's license & Auto. owner		-0.004	-0.032	0.013	0.018	0.005
		Bus or subway station within ten-minute walk		-0.031	-0.238	0.097	0.132	0.039

CONCLUSIONS

In this study, models of trip making were estimated to investigate the travel characteristics of older adults in Seoul. The analysis showed the trip making of older adults varied with age and trip purpose. Main variables that had a statistically significant effect on increasing the probability of more trips were: driver's license and automobile ownership, not being employed or being self-employed or with part time work, higher monthly household income, and presence of a bus stop or a subway station within 10 minutes walking distance. Overall the trip making characteristics of older adults aged 65 and older differ from those of the younger population, and there is a difference between the 65 to 74 year old group and the 75+ group. The trip making

316 characteristics of older adults were different by mandatory or discretionary trip purpose as well.
317 Therefore, transportation policy for older adults should be diversified for different age groups and
318 trip purposes to maximize its effectiveness.
319 The following implications may be relevant to the development of future transportation policy
320 in an aging society. Men 65 or older have a lower probability of making more trips than women in
321 Seoul. This fits the experience that men in Korea travel due to work or public activity. However,
322 older women in Korea tend to make trips to family, to care for grandchildren, to visit relatives, and
323 for various outings. This effect becomes not significant for the group 75 and older. For the female
324 older adults, subsequent study should be conducted to provide detailed analysis of their range of
325 travel, trip purpose, and transportation modes, which in turn should be used for establishing
326 transportation policy customized for female older adults.
327 Age was found statistically significantly correlated with a source of heteroskedasticity. This
328 shows that age is correlated with unobserved heterogeneity in the participants which is affecting
329 their trip making. This effect becomes less significant when the age range is narrow and hence
330 lesser variance. This suggests greater information about the individuals will be helpful, especially
331 information on physical health but possibly also on psychological factors.
332 Older adults showed greater sensitivity than the younger group to having a driver's license and
333 owning an automobile, with an increase in the probability of more trips compared to older adults
334 without a license or without an automobile. This suggests that driving is an important component
335 of older adult travel in the 65 through 74 age range. Older adults however showed lesser sensitivity
336 than younger groups to the presence of a public transit station within a 10 minute walk, although
337 public transit stations are still significant and linked with a greater probability of older adults
338 choosing to make more trips. Perhaps this lack of sensitivity is indicative that the present location
339 of public transit is geared towards other needs than those of older adults. More research into public
340 transit needs of older adults is recommended to better understand what hindrances and
341 inconveniences exist which can be improved to allow older adults to more conveniently use public
342 transportation.
343 Trip making significantly differed with regards to the economic condition of the older adults.
344 Older adults with a high household monthly income were more likely to choose making more trips
345 than those with less financial resources. Public services need to provide affordable or free means
346 of transport to ensure mobility of older adults under financial hardship, especially for trips that are
347 necessary such as doctor appointments.
348 The current Household Travel Survey in Seoul could be improved in the future by considering
349 more detailed individual, household, trip, and environment variables that may affect trip making to
350 further enhance the utility of the survey results. For example, personal conditions such as health
351 condition and disabilities should be included in the survey to capture what are now unobserved
352 individual differences which can lead to age correlated heteroskedasticity.
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