

EXPLORING THE MODE CHOICE IN DAILY TRAVEL BEHAVIOR OF THE ELDERLY IN TAIWAN

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Abstract: This paper is aimed to explore the factors that might affect the elderly people's mode choice behavior in Taiwan. Under the structure of disaggregated demand analysis, a conceptual framework on elderly people's mode usage is formulated. All kinds of mode usage of elderly people are categorized into three alternatives, which are related to the explanatory variables by a multinomial model. Empirical study is conducted through the data released from the Institute of Transportation of Taiwan. Empirical results show that age, gender, employment status, and living environment are proven to be the significant factors that influence mode usage of the elderly in Taiwan. By overcoming the limitation of data sources, we do conduct a pioneer study in discussing the mode choice of elderly people in Taiwan. Conclusions from this study can serve as a worthy and valuable example for Asian countries that are also confronting the problem of population aging.

Key Words: Mode usage, Elderly people, Multinomial logit model

1. INTRODUCTION

With the improvement of medicine and health care, average life of people in Taiwan increased in the past decades. Along with the decrease of birthrate, population composition of this society has been altered by the raise of old age proportion. From the official statistics shown in Figure 1, proportion of children aged under 15 declined but proportion of elderly people aged over 65 rose in past years. The aging index, the number of elderly people aged over 65 divided by the number of children aged under 15 in the same year, has increased during these years, which indicates that Taiwan society has also encountered the problems of population aging that have occurred in most of the developed countries. In addition to the issues of continuing the life of the elderly, more and more attention is focused on the arrangements of their daily life.

Most of the elderly in Taiwan live together with their children. It is considered that elderly people's lives are cared by their kids in traditional Chinese customs. In former agriculture society, traveling a long distance for elderly people was less. If they have to travel, they would be accompanied by their children. As the Taiwan society changes into intensive industrial one over the past few decades, the elderly can not always travel under the escort of their children. Huang (2002) declared that today more and more elderly people in Taiwan travel to attend activities by themselves. The rapid growth of the elderly population has created special transportation challenges in Taiwan. Facing these coming challenges, factors that would affect elderly people's mode usage have to be identified first.

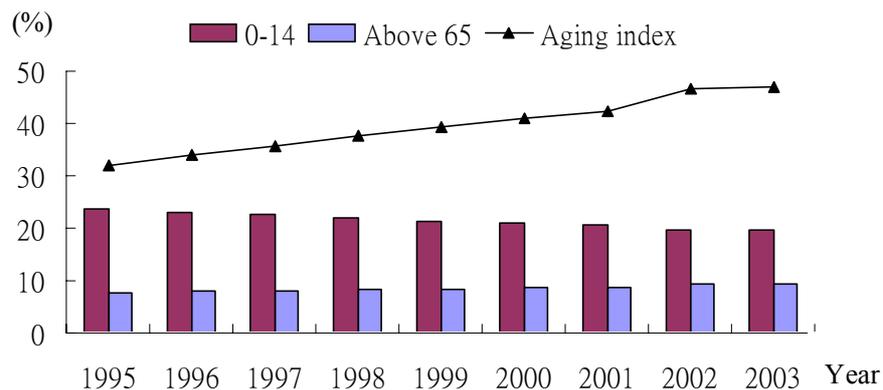


Figure 1 Changing Proportions of Young and Elderly People in the Population Composition of Taiwan

Before discussing the travel demand of elderly people, we would introduce modes which are used in the road transportation of Taiwan briefly. Mode usages in road transportation of Taiwan can be simply divided into the public transportation usage and private vehicle usage. Usage of public transportation in Taiwan includes buses and rail service. Freeway bus service and local bus service form a bus network in Taiwan. Freeway bus transports passengers from cities to cities, and local bus provides citizens short distance tours around their town. Besides, the Mass Rapid Transit (MRT) and the Taiwan Railway Administration (TRA) provide travelers two kinds of rail services. Mass Rapid Transit service satisfies people who travel inner city. Now the only one operating MRT system in Taiwan serves the Taipei City and neighboring areas while the Taiwan Railway Administration serves the intercity travelers. Trunk line of the TRA has formed a loop around this island. All public transportation services in Taiwan provide fare discounts for elderly people. Among them, local buses and MRT are free for elderly people aged over 70 years old; and the loss of the service providers is subsidized by government.

Private vehicles used in Taiwan include the automobiles and motorcycles. In addition to the automobiles that are used daily by people in Taiwan, the common motorcycle usage is the key difference between the road transportation in Taiwan and most of the western countries. Most motorcycles in Taiwan are scooters, which can be handled and operated easily. They are allowed to run everywhere except freeways and expressways. Taxes and fees of using motorcycles are much cheaper than those of automobiles; therefore, riding motorcycle provides people in Taiwan a convenient and cheap way to travel. According to the official registration records, about 12 million motorcycles are possessed by the all 23 million citizens in Taiwan. Except for people aged under the legal age for riding, motorcycles are ridden by people of every age in Taiwan, including the elderly that we are interested.

Facing a variety of mode usage, how elderly people in Taiwan would arrange their ways of travel is the main concern in this study. To realize that, this study try to formulate the consideration of elderly people's travel through both the theoretical and empirical ways. Conceptual framework on elderly people's mode usage is discussed and formulated in the next section. Materials and methods of our empirical study are introduced in the third section of this paper. In the fourth section we would describe and interpret the findings generated from our empirical study. Detail discussions of elderly people's mode choice behavior are illustrated in the fifth section. At last, conclusions of this study and suggestions for further studies are raised in the last section of this paper.

2. CONCEPTUAL FRAMEWORK ON MODE CHOICE OF THE ELDERLY

In order to realize the mode choice of the elderly, we would start to discuss the traditional formulation on individual's mode choice model. The basic concept in formulating travelers' mode choice is hypothesized that travelers would choose the mode which maximizes their utility. Money and time spending in their travel are two observable variables that are most referred. However, these two explanatory variables are not effective in formulating elderly people's mode choice. Elderly people are less sensitive to the travel time and cost than younger people. Hensher and Alsnih (2003) pointed out that safety, comfort, and emotional reliance are factors that elderly people would consider in arranging their way of travel. Among these three factors, safety might be the most important one. As we know, aging often leads to physical disabilities that make traveling difficult, hazardous, or impossible. In addition, Guerrier (1998) and Walton (2000) had all proved that physical capacities such as seeing, hearing, balancing and reacting of elderly people are significantly worse than those of young people. Elderly people are more likely to be involved in crashes, and they are also more likely to suffer serious injury in crashes (Giuliano, 2003). That is, both the probabilities and consequences of travel accidents occur on elderly people would be more than those occur on young people in a given scenario. Chen (2001) proved the risk of old travelers is definitely higher than that of young travelers. Accordingly, mode choices of elderly people can be hypothesized as being influenced by their safety considerations, especially their risk perception toward every way of travel that they might adopt. This hypothesis is consistent with the finding from Noland (1995) that travelers' risk perception toward traveling by a given mode would affect their willingness to use it.

Different ways of travel bring elderly travelers different levels of difficulties in ensuring their safety. For example, driving personally demands full attention of elderly people along the whole trip, while bus riding only demands elderly people's attention to their approaching to the right stop to get off the bus. Different levels of difficulties influence elderly people's traffic safety directly. Therefore, mode choice of elderly people can be hypothesized as the results from their own safety evaluations, i.e., a compromise between personal abilities and travel complexities. Based on the hypothesis, we would further identify the ways that elderly people travel and the factors that influence their ways of travel respectively.

2.1 The ways that elderly people travel

There are a variety of ways of travel that the elderly would adopt, such as driving automobiles, taking buses, taking automobiles driven by others, and so on. To simplify our further discussion, all the mode usages are categorized into three alternatives, namely, being a private vehicle driver (PVD), being a public transportation passenger (PTP), and being a private vehicle passenger (PVP). The principles how different kinds of mode choices are categorized are discussed respectively as following.

First, driving automobile and riding motorcycle personally are categorized into the alternative of PVD. These two ways of travel both demand elderly people's full attention to interact and react with the traffic that surrounds. Therefore, difficulties of ensuring the safety of the elder who choose these two options are relatively high. Second, taking buses and taking the mass rapid transit are categorized into the alternative of PTP. Elderly people who choose this group of mode choices do not need to react instantaneous with traffic on the route. The only thing they need to care is the threat happens in their approaching or transferring. Therefore, the degree of difficulties of ensuring elderly travelers' safety in the group of PTP is lower than

those in the group of PVD. Lastly, taking automobiles and motorcycles which are operated by others are categorized into the alternative of PVP. Elderly people who choose these ways of travel do not need to react to the traffic directly along their trip. Therefore, to ensure the safety of elderly people who choose these two ways of travel is much easier.

In addition, elderly people who travel only by non-motorized ways such as bicycling or walking are excluded in this study. It is because interests of this paper are on the competitiveness between mode choices on the road. Non-motorized ways of travel usually occurs in the area outside the roads, such as sidewalks, parks, or bicycle lanes. Purposes of people who travel in those ways are for recreation and leisure mostly, not for participating activities. It is much different from the travel demand that we are interested; therefore, we would only focus on the motorized ways of travel in following discussions.

2.2 Factors to elderly people’s decisions of mode usage

After discussing the ways of elderly people travel, we would discuss the factors that might influence elderly people’s way of travel. An analytical diagram is shown as Figure 2. As Figure 2 shows, mode choices of elderly people are influenced by factors from four dimensions, including personal socioeconomic characteristics of the elderly, vehicle operating abilities of the elderly, activities participating patterns of the elderly, and traffic environment that the elderly would encounter. Explanatory variables that represent each dimension are discussed respectively as following.

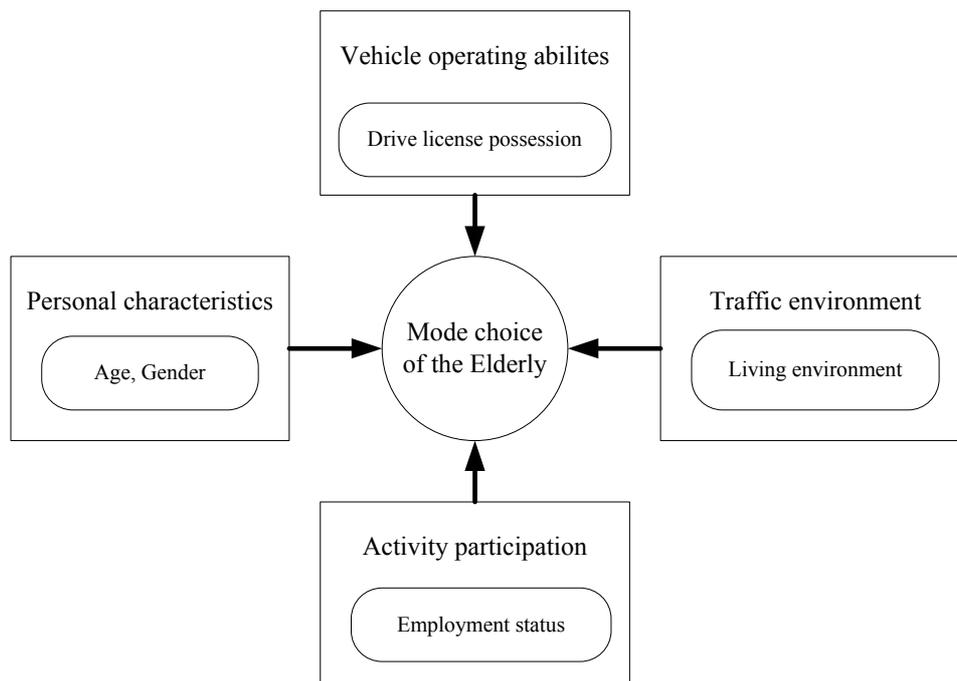


Figure 2 Concept of Mode Choice of the Elderly

First, based on the theory of discrete mode choice, it can be easily convinced that one’s behavior is deeply influenced by his or her personal characteristics such as age and gender. Among all personal characteristics, “age” might be the core factor determining elderly people’s abilities to travel; “gender” helps illustrate the difference between the male and female aged travelers. We would include these two factors that represent personal characteristics of the elderly into our following discussion. Second, vehicle operating abilities of the elderly do influence their mode choice. The factor “possession of automobile or

motorcycles driver license” represents the fact whether the elderly are able and allowed to drive automobile or ride motorcycle or not, which can be easily related to their arrangement for their ways to travel. Third, activities participation patterns of the elderly would alter their mode choice. However, the varying activities participating patterns are seldom discussed entirely. To discuss efficiently, we choose a dummy variable “Employment status” to represent if the elderly should travel routinely or not. It can be hypothesized that commuting routinely would force the elderly to travel efficiently and economically. Thus this variable can help in catching some information about mode choice of the elderly through their activities participation patterns. Lastly, traffic environment that the elderly encounter is also a dimension that we would discuss. It is hard to explore the specific environmental patterns that would be encountered by each of the elderly. What we can do is naively divide the traffic environmental patterns into the urban and the rural type. These two types of traffic environment differ in two ways. One is that traffic in urban areas is heavier than that in rural areas. Elderly people who live in urban areas should face to a more complicated traffic environment than those who live in rural. And the other one is that public transportation service in urban areas is more intensive than that in rural area. In other words, elderly people in downtown can rely on the public transportation service more than those in the country.

3. MATERIAL AND METHOD

3.1 Data collection

For validating our model on the elderly people’s mode choice and disclosing the factors that affect, an empirical study with real data is needed. However, a complete database of elderly people’s travel behavior has not established in Taiwan. It is because issues of elderly people are traditionally discussed in the social welfare sector in Taiwan; former concerns on elderly people in Taiwan are mostly focused on the necessities of life and health care the aging people need, especially those who are unable to maintain their lives. In the sector of transportation, however, travel behavior of the elderly has never been specified apart. A representative database which contains the mode choice and socioeconomic characteristics of the elderly in Taiwan has never been established.

To discuss the travel behavior of elderly people individually, we need the data that can relate the characteristics and mode choice of every given elderly person. Among the numerous databases released from the government in Taiwan, only the database released from the Institute of Transportation (IOT) of Taiwan in the year 2001 could serve as our material. The original database contains the information of investigating 2,000 households around Taiwan. Personal characteristics and mode choices of each household member are recorded into that database. Among all 8,238 respondents in these 2,000 households, 317 respondents aged more than 60 are selected as the materials in our empirical study. The reason why we choose the age of 60 years old as the cutoff between elderly and young people should be noted here. All the official definitions of that cutoff age in Taiwan, Japan, and United States are set at 65. However, more and more people in Taiwan retire before the age of 65. How people would arrange their travel after retirement is also the concern of this study. In addition, elderly people whose age are over 60 in the year 2001 were born before the year of 1941, that is, they were all born before the baby booms after the World War II. These people have experienced all the revolutionary status of Taiwan economy, and they are also the first generation that use motorized vehicles personally in Taiwan. For collecting the information of mode usage from this generation of people, therefore, elderly people who are aged over 60 in that database would be collected as the material in this study.

3.2 Methodology application

To realize the relations between characteristics and mode choice of the elderly, a multinomial logit model (MNL) is applied to distinguish the difference among the mode usage of these three categories of elderly people. MNL is the simplest and most popular practical discrete choice model; it is based on the random utility theory that each option $A_j \in A$ has associated a net utility U_{jq} for individual q . It is assumed that U_{jq} has two components:

$$U_{jq} = V_{jq} + \varepsilon_{jq} \quad (1)$$

which includes a measurable part V_{jq} and a random part ε_{jq} . The measurable part V_{jq} is considered as a function of measured attributes x ; thus V_{jq} is often formulated as a linear combination of x , such as the following:

$$V_{jq} = \sum_k \theta_{kj} x_{jkq} \quad (2)$$

where the parameter θ are often assumed to be the same. Based on the hypothesis of rational choice, Probability of alternative i chosen by individual q can be formulated as:

$$P_{iq} = \frac{\exp(V_{iq})}{\sum_{A_j \in A(q)} \exp(V_{jq})} \quad (3)$$

which is based on the assumption that random residuals ε_{jq} are distributed IID Gumbel (McFadden 1973).

In the formulation of our MNL model, three categories of mode usage, namely: being a private vehicle driver, being a public transportation passenger, and being a private vehicles passenger, would serve as the alternatives that be adopted by elderly people. On the other hand, five explanatory variables, i.e., (1) Age (numerical variables, recorded in integer); (2) Gender (dummy variable, male: 1; female: 0); (3) Living area (dummy variable, urban: 1; rural: 0); (4) Employment status (dummy variable, employed: 1; unemployed: 0); and (5) Vehicle driver license ownership (dummy variable, one or more: 1; zero: 0) are applied into our model to formulate the measurable utility V_{jq} . A brief discussion of these five variables is illustrated as following.

All these five explanatory variables are generated from the concept of the elderly people's mode choice which shown in Figure 2. In our study, how elderly people's mode usage would change as they are getting older is our major concern. Therefore, age is selected as an explanatory variable. Besides, four dummy variables are also introduced into this model. The variable "gender" is designed to tell if there is any difference of mode choice between aged men and women; binary distinction of area, urban or rural, that these elderly people live is recorded as the variable "living area", which indicates the traffic environment that the elderly would encounter daily. The variable "employment status" is designed to realize if these respondents have to commute routinely or not. The last variable "vehicle driver license ownership" is introduced to realize if the elderly are allowed to drive automobile or ride motorcycle personally on the road. The variable also indicates if this elderly person had the vehicle operating experience or not before.

4. FINDING AND INTERPRETATION

4.1 Descriptive statistics

Ages of these 317 elderly people are distributed from 60 to 95 with a mean of 68.28 and standard deviation of 7.68. The age distribution of elderly people in our data in comparison with the age distribution of the elderly declared in official statistics are both shown in Figure 3. From these two distribution curve, proportions of younger elderly people are both higher than those of older elderly people, which is also consistent with common sense.

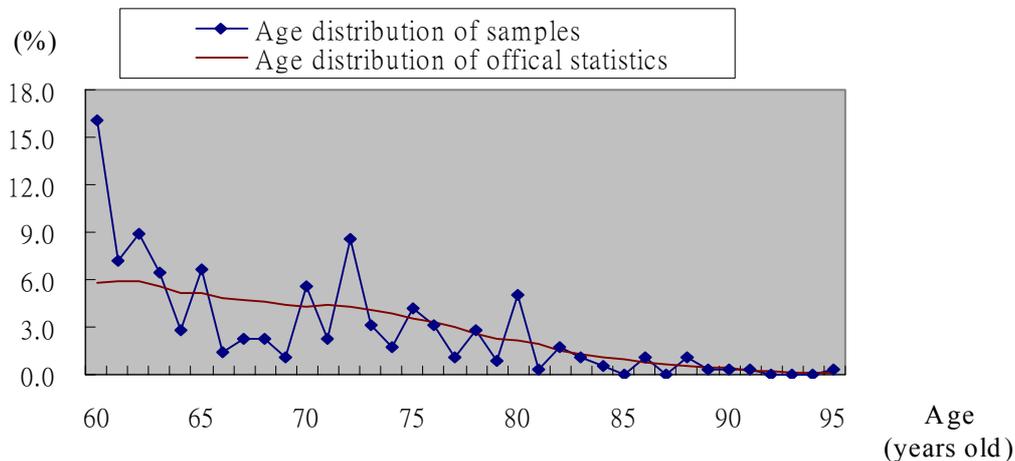


Figure 3 Age Distribution of Samples and Official Statistics

Average monthly income of elderly people in our data is 17,659 NTD (NT dollar; 1 USD is equivalent to about 33 NTD). Among them, 159 (50.16%) elderly people have no income because they're retired or unemployed. In the 137 younger elderly people aged from 60 to 65, 67.1% of them are still employed. With the age increasing, proportion of elderly peoples who are still employed decreases. Only 7 out of 34 elderly people who are aged over 80 are working, and the oldest respondent who is still employed is 83 years old. Numbers of male and female respondents in our data are 192 (60.57%) and 125 (39.34%) respectively. According to the cities where these elderly people live, 183 (57.72%) and 124 (42.28%) respondents are living in the urban areas and rural areas respectively.

There are 153 (48.26%) elderly people who have motorcycle driver licenses and 108 (34.06%) of them have automobile driver licenses. The driver license in Taiwan can be held permanently, however, the percentage of the elderly with driver licenses is lower than that of the adults in Taiwan. It might be resulted from the experience of the elderly. Elderly people in our data were all born before the year of 1941. Motorized vehicles such as automobiles and motorcycles were not popular until the 80's. Many of them did not experience the motorcycle riding or automobile driving when they were young, thus percentage of driver license possessing is relatively low.

By applying Pearson chi-square test, mode choices are identified to be different among the elderly from different ranges of age. Proportions of each alternative adopted by the elderly from different ranges of age also differ obviously. ($\chi^2 = 66.214$, $df = 8$, $p\text{-value} = 0.000$) As the Figure 4 shows, most elderly people aged from 60 to 64 choose being a private vehicle driver; however, as the range of respondents' age increase, proportion of elderly people who choose being a private vehicle driver decreases; Oppositely, being a private vehicles passenger is least adopted by the elderly aged from 60 to 64, but proportion of the elderly who choose being a private vehicle passenger increases as the range of respondents' age increase;

In addition, even the bus and mass rapid transit are free of charge to the elderly who are aged over 70, proportion of respondents who choose being a public transportation passenger keeps relatively low in every range of age. In summary, younger elderly people tend to drive or ride personally, but older elderly people tend to take cars or motorcycles. Under the stable percentage of being public transportation passenger, it can be concluded that the proportion increases of alternative “PVP” in the higher range of age is mostly transferred from the proportion decreases of alternative “PVD”

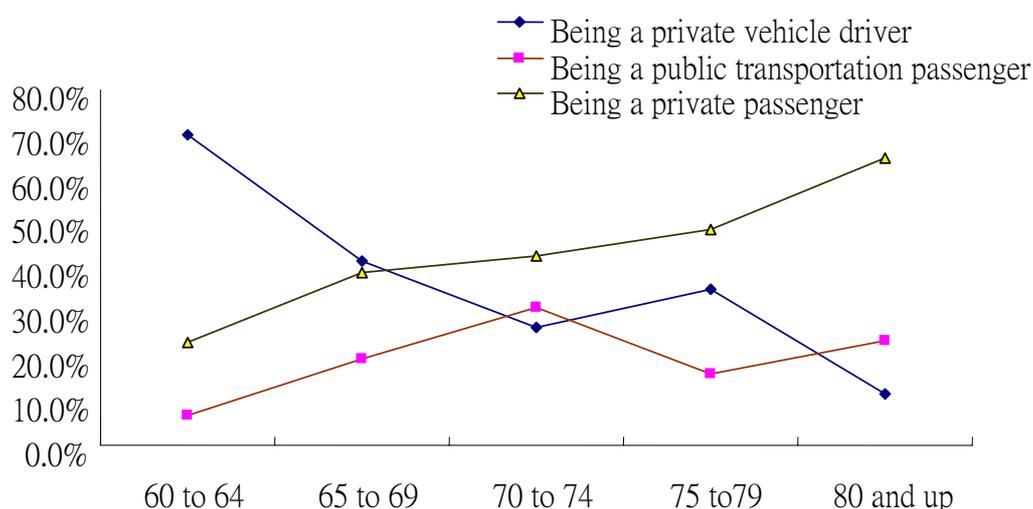


Figure 4 Proportion of Each Alternative Chosen by the Elderly from Different Range of Age

4.2 Results from multinomial logit model

Calibration for parameter of each explanatory variable in our MNL model is conducted through the statistical package “LIMDEP”. The parameter generated from the MNL model is shown in Table 1. All the parameters contained in Table 1 are calibrated by comparing the alternative of PVD. By applying the log-likelihood estimating index, significance of the whole model is at the level of 0.000. All of the significance levels are set at 0.1.

Age, employment status, and vehicle driver license ownership are significant factors among these three alternatives. Comparing with alternatives of PVD, parameters of age in the other two alternatives are both positive, which indicates that when these elderly people are getting older, they would tend to drive automobiles or ride motorcycles less. By comparing parameters of age in alternatives of PTP and PVP, the parameter in the latter alternative shows a little bigger than that in the former alternative, which implies that older elderly people would be more likely to take private vehicles than to take public transportation. By examining the parameters of employment status in the other two alternatives, both of them are negative in comparison with alternative of PVD, which implies that elderly people who have to work would tend to drive or ride personally and dislike adopting the other two alternatives, especially selecting the mode usage in the alternative of PVP. Parameters of vehicle driver license ownership in alternative of PTP and PVP are negative in comparison with alternative of PVD, which implies people who own driver licenses would tend to drive cars or ride motorcycles instead of adopting the mode usage of the other two alternatives. As we know, ownership of driver license can represent one’s vehicle operating abilities and experiences; this result is consistent with our expectation.

To realize the detailed effect of each explanatory variable on every alternative, marginal

effects of given variable on specific alternative are contained in Table 2. The parameter of each variable is generated from the regression of explanatory variables on the observed probabilities of each alternative.

Age, gender, employment status, and vehicle driver license ownership are the significant variables in the alternative of being a private vehicle driver. From the sign of parameters that calibrated, male elderly people tend to operate vehicles personally more than female elderly people. Elderly people who are employed tend to operate vehicles personally more than those who are unemployed. Elderly people who have vehicle drive license tend to operate vehicle personally more than those who have no vehicle drive license. Negative parameter of age implies that, as the elderly are getting older, they would tend to operate vehicle personally less.

Table 1 Parameter of Each Variable in MNL Model

Variables	Parameter	S.D	P-value
Alternative of PTP in comparison with alternative of PVD			
Constant	-3.479	2.335	0.136
Gender (male: 1; female: 0)	-0.317	0.567	0.575
Living area (urban: 1; rural: 0)	0.658	0.472	0.163
Age (year old)	0.080*	0.033	0.015
Employment status (employed: 1; unemployed: 0)	-0.832*	0.490	0.090
Vehicle drive license ownership (one or more: 1; zero : 0)	-4.163*	0.628	0.000
Alternative of PVP in comparison with alternative of PVD			
Constant	-2.474	2.124	0.244
Gender (male: 1; female: 0)	-0.719	0.518	0.165
Living area (urban: 1; rural: 0)	-0.494	0.430	0.251
Age (year old)	0.087*	0.030	0.004
Employment status (employed: 1; unemployed: 0)	-0.920*	0.433	0.034
Vehicle drive license ownership (one or more: 1; zero : 0)	-4.027*	0.548	0.000
LL(0) = -323.3454			
LL(β) = -188.4072			
$\chi^2 = 269.8704$			
Degree of freedom= 10			
Significance = 0.000			
Number of samples = 317			

* Significant level at $\alpha = 0.1$

In the alternative of being a public transportation passenger, gender, living area, and vehicle drive license ownership are the significant variables. Signs of each variable imply that: female elderly people tend to use public transportation more than male elderly people; the elderly who live in urban areas tend to use public transportation more than those who live in rural areas; and the elderly who have no vehicle drive license would tend to use public transportation more than those who have vehicle drive license.

All these five variables formulated in our MNL model are significant in the alternative of being a private vehicles passenger. In addition to the positive parameter of age, parameters of

other four variables are negative. These results imply that the elderly would get a ride on a private vehicle operated by others more as they are getting older; female elderly people would tend to get a ride on a private vehicle more than male elderly people; the elderly who live in rural areas would get a ride on a private vehicle more than those who live in urban areas; and the elderly who have no vehicle drive license would get a ride on a private vehicle more than those who have vehicle drive license.

Table 2 Marginal Effect of Each Explanatory Variable on Every Alternative

Variables	Parameter	S.D	P-value
Marginal effect of alternative PVD			
Gender (male: 1; female: 0)	0.514*	0.083	0.000
Living area (urban: 1; rural: 0)	0.031	0.092	0.740
Age (year old)	-0.019*	0.007	0.004
Employment status (employed: 1; unemployed: 0)	0.203*	0.095	0.032
Vehicle drive license ownership (one or more: 1; zero : 0)	0.928*	0.107	0.000
Marginal effect of alternative PTP			
Gender (male: 1; female: 0)	-0.110*	0.052	0.033
Living area (urban: 1; rural: 0)	0.151*	0.056	0.008
Age (year old)	0.005	0.004	0.182
Employment status (employed: 1; unemployed: 0)	-0.051	0.062	0.409
Vehicle drive license ownership (one or more: 1; zero : 0)	-0.308*	0.068	0.000
Marginal effect of alternative PVP			
Gender (male: 1; female: 0)	-0.403*	0.074	0.000
Living area (urban: 1; rural: 0)	-0.181*	0.083	0.029
Age (year old)	0.014*	0.005	0.011
Employment status (employed: 1; unemployed: 0)	-0.152*	0.086	0.076
Vehicle drive license ownership (one or more: 1; zero : 0)	-0.620*	0.095	0.000

* Significant level at $\alpha=0.1$

Findings on coefficients of these explanatory variables in each alternative are interpreted as follows. First, positive parameter of age in the alternative of PVD and negative parameter of age in the alternative of PVP indicate that mode choice of the elderly would become more conservative as the elderly are getting older. This result is consistent with our prior hypothesis that: age is not only a socioeconomic characteristic of the elderly that can be observed easily, but also a factor that is effective in representing their ability to travel. Second, positive parameter of gender in the alternative of PVD and negative parameters of that in the other two alternatives show that male elderly people would tend to operate vehicles personally while female elderly people do not. This might be resulted from the social customs of early society in Taiwan. In that early period, a man in a household would work outside and take the economic responsibilities of the whole family, while a woman in a household is considered to be responsible of housekeeping. Therefore, the fact that male elderly people had more chances to operate vehicles personally than female elderly people in the past results in their ways of travel nowadays.

Employment status of the elderly is the third issue that we would discuss. Positive parameter of this variable in the alternatives of PVD and negative parameter of that in the alternatives of

PVP imply that routine commuting trip would force the elderly to travel by operating vehicle personally. The insignificant parameter on employment status in alternatives of PTP points out that, for most of the elderly in Taiwan, public transportation is not friendly and reliable enough to be used for commuting. More efforts in providing comprehensive public transportation shall be made in Taiwan to encourage elderly people to take advantages of it. The last variable that we would discuss here is the living environment. The significant positive parameter in the alternatives of PTP and negative parameter in the alternatives of PVP reveal that the elderly who live in the urban areas would have more chance to take public transportation than the elderly who live in the rural areas. But those who live in rural would rely more on automobiles or motorcycle operated by others.

4.3 Competition of motorcycle and automobile usage among elderly people

As the illustration in the introduction of this paper, common motorcycle riding is the unique mode usage on the road transportation in Taiwan. In official statistics, the number of motorcycles registered in Taiwan is more than 12 million, i.e., the numbers of motorcycles owned per capita and per household are 0.56 and 1.61 respectively. As we discuss in prior, more than 99% of motorcycles in Taiwan are scooters, which can be ride easily and handily. Patterns of riding a scooter and driving an automobile are quite different. Automobile driving demands much more abilities in controlling the vehicle than scooter riding does. However, the risk of scooter riding is much higher than that of automobile driving. Comparison between these two ways of travel is worthy of discussing. We would further examine the differences between these two ways of travel from our data.

Among the 147 elderly respondents who choose the alternative of being a private vehicle driver in our data, 88 of them travel by riding motorcycles and the other 59 ones travel by driving automobiles. By independent sample T test shown in Table 3, these two groups of respondents show some differences in their age, income, and driver license ownership. Average age of elderly people who ride motorcycles is significantly older than those of elderly people who drive automobiles. It implies that the elderly who keep riding motorcycles might be older than those who keep driving automobiles. Average income of the elderly who ride motorcycles is 22,830 NTD, which is less than the average income, 37,085 NTD, of the elderly who drive automobiles. This finding could be inspected from two perspectives. First, the cost of automobile driving is much higher than the cost of motorcycle riding. Elderly people with higher income would be able to afford automobile driving more. Second, elderly people who have to drive automobile personally might still be responsible for providing the financial support to their families. Thus, their income would be higher than those who ride motorcycles.

From Table 3, the proportion of elderly motorcyclists with motorcycle driver licenses is more than that of elderly automobile drivers with motorcycle driver license; moreover, proportion of elderly automobile drivers with automobile driver license is more than that of elderly motorcyclists with automobile driver license. It is convincible that possession of drive license would affect one's mode choice. Behind these numbers contains in Table 3, however, there are some discussions needed to note. Table 4 shows the number of riders and drivers in different type of driver license ownership.

Among the 88 motorcyclists of these 147 respondents, the number of people who have both the motorcycle and automobile driver license is 33, which is less than the number of people who have only motorcycle driver license. Among the left 59 automobile drivers, the number

of people who have both the motorcycle and automobile driver license is 42, which is more than the number of people who have automobile driver license. The co-possession of car and motorcycle driver license is common among people in Taiwan. It is interesting to note that: among these motorcyclists, most of them can ride motorcycles only; but in those automobile drivers, most of them can both drive automobile and ride motorcycle. This might imply that, the use of automobile is not as common as the use of motorcycles among elderly people in Taiwan. Besides, in the former agricultural society of Taiwan, the cost for automobile driving is much higher than the cost for motorcycle riding. Many elderly people who ride motorcycles might have never driven automobiles their whole lives because of economic limitation. Contrarily, most of the elderly who drive cars would also ride motorcycle because they can afford the cost of motorcycle riding.

Table 3 Difference between Motorcycle and Automobile Usage

Variable	Descriptive statistics of each group			t-test for equality of Means		
	Group	Mean	S.D	t	df	p-value
Alternative of PVD :						
Income (in NTD)	Elderly who ride motorcycle	22,830	2,0369	-2.913	145	0.004
	Elderly who drive automobile	37,085	3.8622			
Proportion of motorcyclists who have motorcycle driver license (%)	Elderly who ride motorcycle	0.9773	0.1498	5.066	145	0.000
	Elderly who drive automobile	0.7119	0.4567			
Proportion of drivers who have automobile driver license (%)	Elderly who ride motorcycle	0.3750	0.4869	-8.080	145	0.000
	Elderly who drive automobile	0.9322	0.2535			
Age (year old)	Elderly who ride motorcycle	65.772	6.1955	2.317	145	0.022
	Elderly who drive automobile	63.525	5.0492			
Alternative of PVP :						
Age (year old)	Elderly who takes motorcycle	66.689	7.2904	-3.650	55.611	0.001
	Elderly who takes automobile	72.666	8.1378			

Table 4 Number of Riders and Drivers in Different type of Driver License Ownership

	Type of driver license ownership			
	Both	Motorcycle driver license only	Automobile driver license only	Either
Private vehicle usage				
Riding motorcycles	33	53	0	2
Driving automobiles	42	0	13	4

In addition, both of automobile and motorcycle driver license can be held permanently. That is, no matter how one's physical condition is, once he or she pass the driver license examination, he or she is allowed to drive automobiles or ride motorcycles unless being suspended for committing serious traffic violations in Taiwan. Therefore, issuing driving permission without reexamination over a period of time shows that the Taiwan government underestimates the risks of traffic accidents for the elderly whose physical conditions go down day by day.

Another comparison of automobile and motorcycle usage occurs in those who take motorcycles or automobiles that are ridden or driven by others. Among the 107 respondents

who choose the alternative of being a private vehicle passenger, 29 elderly people travel by taking motorcycles and 78 ones travel by taking automobiles. Significant difference of these two groups of elderly people exists in their age. Average age of elderly people who take motorcycles ridden by others is 66.7, which is lower than that of those who take automobiles driven by others. This finding reflects the common consideration of people in Taiwan, i.e., traveling by automobile provides passengers more safety and comfort than traveling by motorcycles. When the elderly are getting older, taking them by automobiles might be more suitable than taking them by motorcycles.

5. DISCUSSION

Results of the multinomial logit model analysis demonstrated that these five factors were strongly related to considerations of the elderly in arranging their ways of travel. The sign of each coefficient generated in the MNL model is convincing and consistent with our hypothesis. In terms of the main hypothesis that mode choice would be affected by age of the elderly, some supportive evidences exist. Proportion of each alternative in different range of age presented in Figure 4 shows a consistent result as we have hypothesized.

Combination of automobile driving and motorcycle riding in the same alternative of mode choice is a specific design in our study. In western countries, motorcycles are only ridden by a tiny proportion of road users. In Taiwan, however, motorcycles are used by most of road users, including the elderly. Undeniably, patterns of motorcycle riding are much more different from those of automobile driving. It might be criticized that how can these two different types of mode usage are categorized into the same alternative. We would once again discuss our concept here. The main considerations on formulating an alternative in this study are the difficulties in ensuring the safety of elderly people. That is, we hope the degree of difficulty of mode usage should be similar to the same alternative and be very different among alternatives. The combination of motorcycle riding and automobile driving in an alternative is not to neglect the difference between characteristics of these two mode usage. In contrary, it is an emphasis on our hypothesis that operating private vehicle personally demands elderly people's full attention to taking care of their own safety.

Some concerns regarding the database that we used in this study should be noted. As we illustrate in the third section, discrete data that relates the elderly' travel behavior and their own characteristics can hardly be found in Taiwan. Therefore, there are some limitations in referring the results from our empirical study that should be noted. The data that we analyze is gathered from the database released by Institute of Transportation in Taiwan, and this data is originally designed for exploring the household vehicle ownership. However, there are 17% of elderly people living in the home for the aged. Travel behavior of these elderly people who do not live with their household is not included in this data. This is a black box that can not be covered by our data. Thus empirical results in our study do identify the relations between mode choice and characteristics of elderly people, but they might be limited to portray the travel behavior of whole elderly people in Taiwan.

6. CONCLUSION

By overcoming the limitation of data source, we do conduct a pioneer study in discussing the mode choice of elderly people in Taiwan. Age, gender, employment status, and living environment are proved to be the significant factors that influence the mode usage of the elderly, and the model of elderly people's mode choice formulated in this study is also

convincible. Findings from this study can be summarized as follows: elderly people would get a ride on a private vehicle operated by others more as they are getting older; elderly male tend to operate vehicles personally more than elderly female, elderly female tend to use public transportation more than male elders; the elderly who are employed would tend to operate vehicles personally more than those who are unemployed; elderly people who live in rural areas would get a ride on a private vehicle more than those who live in urban areas.

After a primary discussion on mode choice behavior of elderly people in Taiwan, many efforts are still needed in caring the activities participation and travel behavior of elderly people. Further studies are suggested as follows: realizing the physical needs of elderly travelers, exploring emotional desire of elders when they travel, and measuring the safety perception of elders. In addition, comparative discussions on travel behavior of elderly people from different culture are also valuable. Facing the problems of population aging that occurs in most countries, more and more efforts are needed for caring the increasing elderly population.

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