Effect of Trip Purpose on Psychological Process for Car Use Reduction

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Abstract: The objectives of the paper are to investigate process of voluntary change in travel behavior and to evaluate the impacts of psychological factors by trip purpose. For the analysis, a total of 1,000 samples, randomly selected from three cities in the Seoul Metropolitan area in Korea were used. The survey questionnaire contained 10 sections (including four sections for psychological factors) and 19 questions. We also constructed three psychological process models by trip purpose (Commuting, Shopping, and Leisure trip) based on a structure equation model using AMOS 16 software. The estimation results showed there are different variables that can affect the process of voluntary car use reduction and the coefficient of trip purpose. Furthermore, this paper suggests an effective MM policy guideline that considers the features of trip purpose based on the estimated models.

Keywords: *Mobility Management, Trip Purpose, Psychological Factors*

1. INTRODUCTION

The use of motor vehicles in the Seoul metropolitan area is growing at an alarming level, as it is in other Asian capital cities. Within the Seoul metropolitan area in 2006, the total number of trips per day is 58,811,377, with 29.9% of these trips representing private car use. Despite traffic congestion and the increasing price of oil, the use of private car grows every year. To cope up with this rapid increase, there is an urgent need to implement appropriate transportation policies. There have been many case studies about Transportation Demand Management (TDM) and this issue has been studied quite extensively in Korea. However, because of the limitation of TDM, which is that they are unaccompanied by any mandatory enforcement, no significant change could be effected. For this reason, another approach to policy-making must be considered in order to solve this problem.

The existing transportation policy for relieving urban traffic congestion can be categorized as consisting of three strategies. These strategies are the expansion of infrastructure such as highway networks, reducing the demand for travel, and planning to supply facilities that can improve the quality of public transportation. The policies related to reducing travel demand have various advantages over the other two strategies, and avoids the problems of huge

expense and influencing the generation of travel demand. In general, this strategy consists of a hardware-based method called TDM and a software-based method, Mobility Management (MM)[1]. The most representative measure of TDM, which has a longer history than MM, is road pricing. In addition, park and ride and car restriction by zones are now referred to as TDM. Communication-based transportation policies that attempt to induce voluntary behavioral changes from car use to other modes of travel are referred to as MM. Depending on circumstances, measures for reducing travel demand may cover a broad variety of actions ranging from "push" measures to "pull" measures. (Garling and Fujii, 2006) TDM and MM can be promoted together to induce sustainable transportation, as reported in the above citation. In Korea, however, MM is still a foreign concept as transportation policy and has not been studied widely. Therefore, the effective introduction of MM in Korea necessitates a detailed analysis of trips.

There has been some previous research on MM policy in terms of the psychological influences on travel behavior. Loukopoulos (2005), for example, proved that individual awareness of the environment is a somewhat larger influence on restrained vehicular usage than socioeconomic factors (e.g., whether one has an auto or not, household income, etc.). Choocharukul et al. (2008) constructed a structure equation model to explain the psychological effects of travel behavior on the choice of residential location by commuters. Taniguchi and Satoshi (2007) devised a model, which shows that the assumptions leading to reduced vehicular use are influenced by a behavioral intention to do so, and that this intention is influenced by psychological factors, which include the perception of behavioral control. The abovementioned psychological relationship was applied in the present study. Choocharukul (2007) proposed an extension of the theory of planned behavior (TPB) to investigate whether psychological factors can be used to predict behavioral intention with respect to future car use. A recent research by Taniguchi (2010) also tested an integrated process model of travel behavior modification, and she verified her model using data obtained from travel feedback programs (TFPs). A review of existing literature shows that there is hardly any research about the psychological influences that consider the purpose of trips. However, such an understanding is essential for the effective promotion of MM policy.

The purpose of this study is to investigate the process of voluntary change in travel behavior and the potential impact of psychological factors on this process, in terms of the attributes of a trip's purpose. The data related to the ratio of choice of transportation mode to trip purpose in 2007, within the Seoul metropolitan area, is listen in Table 1. As can be seen from the table, the ratios differ depending on trip purpose. The ratio of using a car for a commuting is lower than the ratio of using a car for other kinds of trips. However, the actual level of traffic congestion caused by private cars remains high because Seoul is surrounded by about 30 satellite cities. Therefore, in this study, we constructed a process model to determine voluntary reduction of car use by trip purpose, taking into account the relevant psychological factors. Our goal is to gain insights that can be translated into detailed and effective MM policies.

[1] MM (Mobility Management): This is intended to influence individual awareness and certain psychological factors to encourage a voluntary change in behavior. It includes providing specific information on public transit, developing travel campaigns, and travel education. A typical method involves participants reporting their travel behavior, or requesting the information that could truly induce changes in travel behavior. Participants might also receive feedback that includes information about CO_2 emission of cars, advice on how to reduce car use, and individualized information on public transit that could be used as an alternative. (Taniguchi and Fujii, 2007) Since the end of the 1990s, MM has attracted increasing attention in European Union (EU) countries, Australia, and Japan, as soft measures that are designed to change car use behavior.

Table 1 Ratio of mode choice by trip purpose (%)

Mode/Trip purpose	Commuting	Shopping	Leisure
Private car	11.0	27.2	23.2
Bus	37.0	29.5	26.1
Train	39.4	24.6	28.1
Bicycle	0.9	0.9	1.4
On foot	11.7	17.7	21.2

Figure 1 illustrates the proposed framework for a structure equation model, in which direct paths represent assumed causal relations. We also hypothesized that the process for a voluntary reduction in car use consists of three steps (Attitude to Car Use Reduction →Behavioral Intention→Actual Action to Car Use Reduction), as well as the psychological factors can influence the step of "Attitude to Car Use Reduction". In addition, it was hypothesized that habits and differences in travel time between private car and public transport negatively affect the second step, and it was assumed that trip condition attributes such as members and information have an impact on whether actual action is taken. Besides we can assume that there are different valuables which can influence on each step by trip purpose.

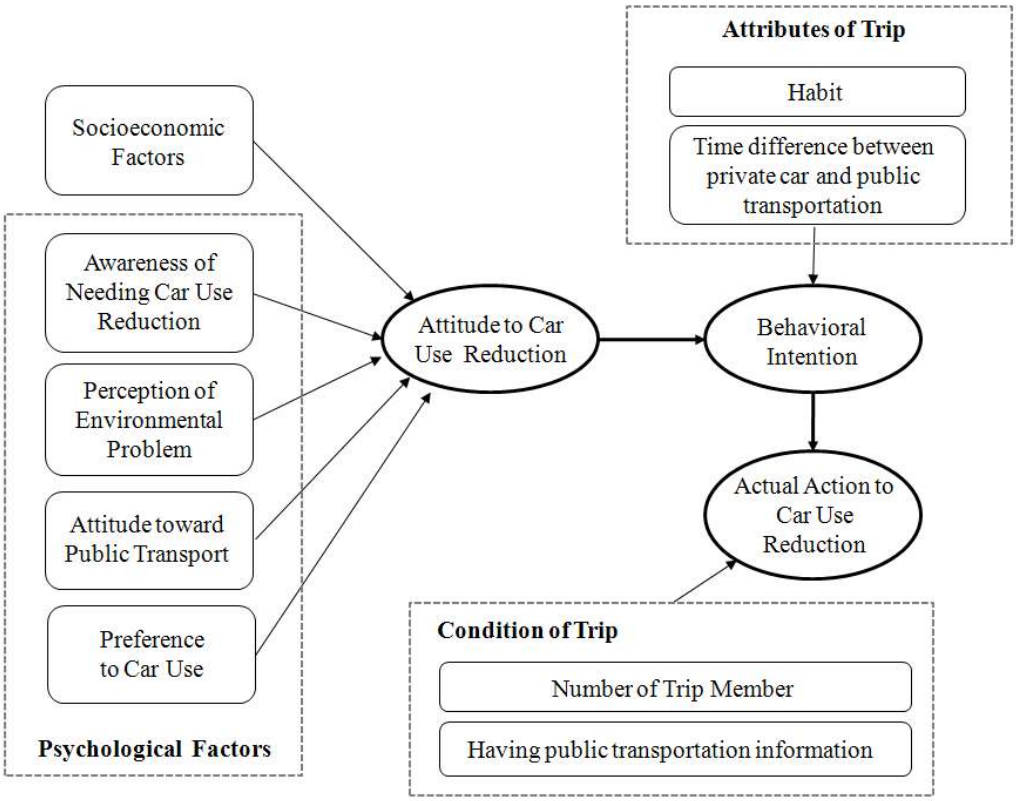

Figure 1 Proposed modeling framework

The following section describes research methodologies including samples and a questionnaire. The third section presents the estimation results (by trip purpose) obtained using the proposed model. Finally, we end the paper with discussion and conclusions.

2. DATA

A total of 1,000 citizens were randomly surveyed from 3 smaller cities neighbouring Seoul in Korea, namely Suwon, Anyang, and Sungnam. The abovementioned cities are satellite cities located in the suburbs of Seoul. The survey lasted for five days, beginning June 9, 2009. The survey carried out in the form of individual interviews. The rationale behind selecting the abovementioned cities is that almost all of the travel that takes place in these cities is in connection with commuting to Seoul, since these cities themselves are not self-sufficient.

Table 2 Data descriptive statistics

Variables	Suwon	Anyang	Sungnam	Total
Gender (% men)	50.2	49.7	50.0	50.0
Age (years : mean)	40.54	41.31	41.70	41.19
Number of autos owned (%)				
(1 auto per household)	87.71	98.49	97.34	94.51
(more than 2 autos per household)	12.29	1.51	2.66	5.49
Number of times auto is used (%)				
(2 or 3 times per week)	*58.80*	*61.06*	*46.51*	*55.46*
(4 or 5 times per week)	*20.27*	*20.10*	*46.84*	*29.07*
(more than 6 times per week)	*20.93*	*18.84*	*6.64*	*15.47*
N	301	398	301	1000

The survey questionnaire contained 10 sections and 19 questions, which are given in Tables 3 and 4. In the questionnaire, 4 sections were related to psychology, which enabled us to check a subject's views about [Awareness of need to reduce car use], [Perception of environmental problem], [Attitude toward public transportation system], and [Preference for car use]. The responses were measured on a five-point Likert scale with a defined midpoint and endpoints. For instance, +1 was given when a respondent answered "not at all", and +3 and +5 were given in the case of "neutral" and "yes-strongly". Tables 3 and 4 present how scores were assigned for each query.

The first section of psychological questions about [Awareness of need for reduced car use] consisted of two questions: "Do you think that using a private car can exert a bad influence on the environment?" and "Do you think that using a private car is not good for society?" In addition, to measure the [Perception of environmental problem], respondents were asked, "Do you think that you should worry about environmental problems?", "Do you want people to worry about the environmental problems?", and "Do you think that environmental problems have become more important than anything else?" Similarly, three questions such as "Do you prefer to use train/bus/bicycle?" were used to represent the [Attitude toward public transportation system]. The last psychological section concerned [Preference for using a car], which was explored by the question, "Do you like using a car?" To verify the proposed modeling framework, we also asked three questions related to the process of deciding upon reducing car use, which were classified into the three sections of [Attitude toward Reduced Car Use], [Behavioral Intention], and [Actual Action to Reduce Car Use]. These questions were also measured on a five-point Likert scale, like the above nine psychological questions.

Table 3 Questionnaire for data

Variable	Definition
Socioeconomic factors	
(Gender)	+1 = Male, 0 = Female
(Age)	Age of individual in years
(Income per month)	+1 = less than 2 million won, +2 = between 2 and 3 million won, +3 = between 3 and 4 million won, +4 = between 4 and 5 million won,+5 = more than 5 million won
Attributes of Trip	
(Habit: use percentage per week)	+1 = 0%, +2 = 25%, +3 = 50%, +4 = 75%, +5 = 100%
(Time difference: minutes)	(Travel Time in Public Transport) – (Travel Time by Private Car)
Condition of Trip	
Number of Trip Members	Members in Family
Information (how to reach destination using public transportation)	+1 = known, +2 = unknown
Awareness of Need for reduced Car Use	
(Do you think that using a private car can exert a bad influence on the environment?)	+1 = not at all, +2 = no, +3 = neutral, +4 = yes, +5 = yes-strongly
(Do you think that using a private car is not good for society?)	+1 = not at all, +2 = no, +3 = neutral, +4 = yes, +5 = yes-strongly
Perception of Environmental Problem	
(Do you think that you should worry about the problem of the environment?	+1 = not at all, +2 = no, +3 = neutral, +4 = yes, +5 = yes-strongly
(Do you want people to worry about the problem of the environment?)	+1 = not at all, +2 = no, +3 = neutral, +4 = yes, +5 = yes-strongly
(Do you think that the problem of the environment has become more important than anything else?)	+1 = not at all, +2 = no, +3 = neutral, +4 = yes, +5 = yes-strongly
Attitude toward public transportation system	
(Do you prefer to take a train?)	+1 = not at all, +2 = no, +3 = neutral, +4 = yes, +5 = yes-strongly
(Do you prefer to go by bus?)	+1 = not at all, +2 = no, +3 = neutral, +4 = yes, +5 = yes-strongly
(Do you prefer to ride a bicycle?)	+1 = not at all, +2 = no, +3 = neutral, +4 = yes, +5 = yes-strongly

Table 4 (continuation of Table 3)

Variable	Definition
Preference for Car Use (Do you like using a car?)	+1 = not at all, +2 = no, +3 = neutral, +4 = yes, +5 = yes-strongly
Attitude to Reduced Car Use (Do you feel an obligation to reduce your car use?)	+1 = not at all, +2 = no, +3 = neutral, +4 = yes, +5 = yes-strongly
Behavioral Intention (Do you make an effort to reduce car use?)	+1 = not at all, +2 = no, +3 = neutral, +4 = yes, +5 = yes-strongly
Actual Action to Reduce Car Use (Do you actually reduce your car use?)	+1 = not at all, +2 = no, +3 = neutral, +4 = yes, +5 = yes-strongly

3. RESULTS

From the surveyed data, we constructed three psychological process models by trip purpose, as shown in Figure 1, based on the proposed framework for a structure equation model, using AMOS 16 software. The estimation results for the models with socioeconomic variables, psychological factors, and attributes of trip purpose are reported, along with the coefficient and C.R[2], p-value to show the effects on the process of decision-making for reduced car use shown in Table 5 and Table 6. In these two tables, variables with statistical significance can be observed, and using the methods presented in Figures 2–4, they can be used to derive the estimation results of the models by trip purpose.

We can observe the following interesting features from the estimation models. The coefficients of the four variables (preference for car, habit, time difference, information[3]) have a minus sign in all the models. Also, in terms of commuting trips, the number of members has no effect on the psychological process involved in voluntary reduced car use; also the time difference variable does not influence the shopping trip model.

In the case of commuting, psychological factors related to environmental problems and preference for private car do not strongly effect voluntary car use reduction. However, habit, which is usually using a particular mode when respondent have to travel, wields high influence over this model as compared to the other two models (shopping and leisure). The estimated coefficients of shopping trip and leisure trip also showed a similar

[2] C.R (Critical Ratio): This is the estimate divided by its standard error. If we are dealing with random sample variables with standard normal distributions, absolute value of estimates with critical ratios more than 1.96, 2.56 are significant at the 0.05, 0.01 level.

[3] Information variable; If traveler doesn't have any information how to go there destination by public transport, we gave score 2 (refer to Table 3). Who is already known the information, is easy to change their travel modes from private car to public transport.

tendency. For instance, the coefficient of income variable is a minus sign in both models. It means that higher the level of income, lower is the probability of changing travel mode from car to public transport. Besides, the model shows that information has considerable effect on choice of mode in the case of a leisure trip. The number of trip member variable shows that it has negative sign to actual action, therefore we can assume people who already know necessity of car use reduction can hesitate to have actual action when there are many members in their trip.

The overall goodness of fit of the all models appeared to be acceptable with χ^2-value[4] and GFI[5], RMSEA[6], which can be found in Table 6 (Model of Commuting Trip: $\chi 2$ [df = 272] = 1200.94, GFI = 0.870, RMSEA = 0.071, Model of Shopping Trip: $\chi 2$ [df = 272] = 1687.77, GFI = 0.876, RMSEA = 0.072, Model of Leisure Trip: $\chi 2$ [df = 272] = 1797.65, GFI = 0.872, RMSEA = 0.071). These results are discussed in the following section.

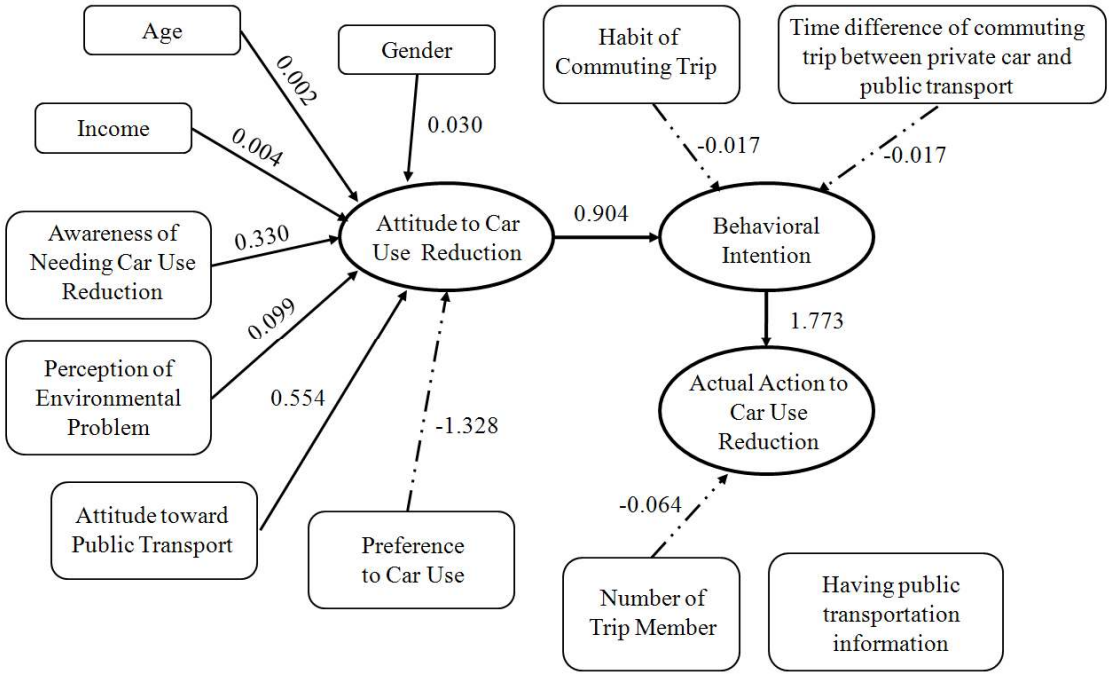

Figure 2 Estimation results of model (commuting trip)

[4] χ^2 - value : When df (degrees of freedom) is 272, $\chi^2 = 311.47$ ($p < 0.05$), $\chi^2 = 329.18$ ($p < 0.01$), $\chi^2 = 349.81$ ($p < 0.001$).

[5] GFI (Goodness-of-Fit-Index): GFI varies from 0 to 1, but theoretically can yield meaningless negative values. By convention, GFI should be appproximately 0.9 or more to accept the model. By this criterion, the present model is accepted.

[6] RMSEA (Root Mean Square Error of Approximation): There is adequate fit model if RMSEA is less than or equal to 0.08.

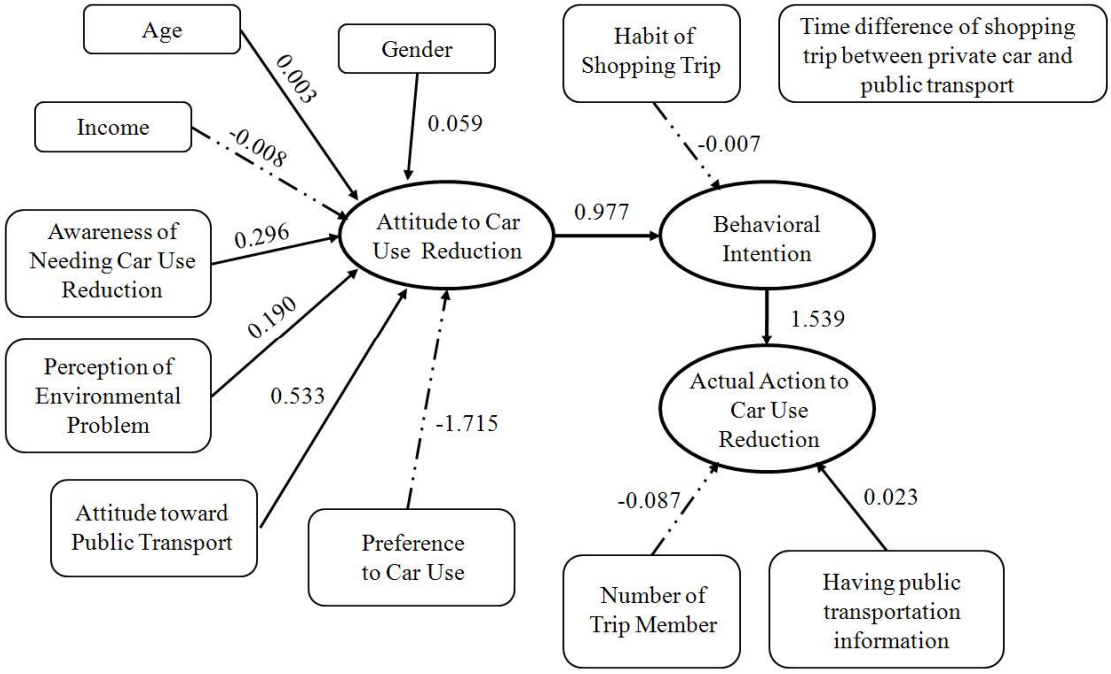

Figure 3 Estimation results of model (shopping trip)

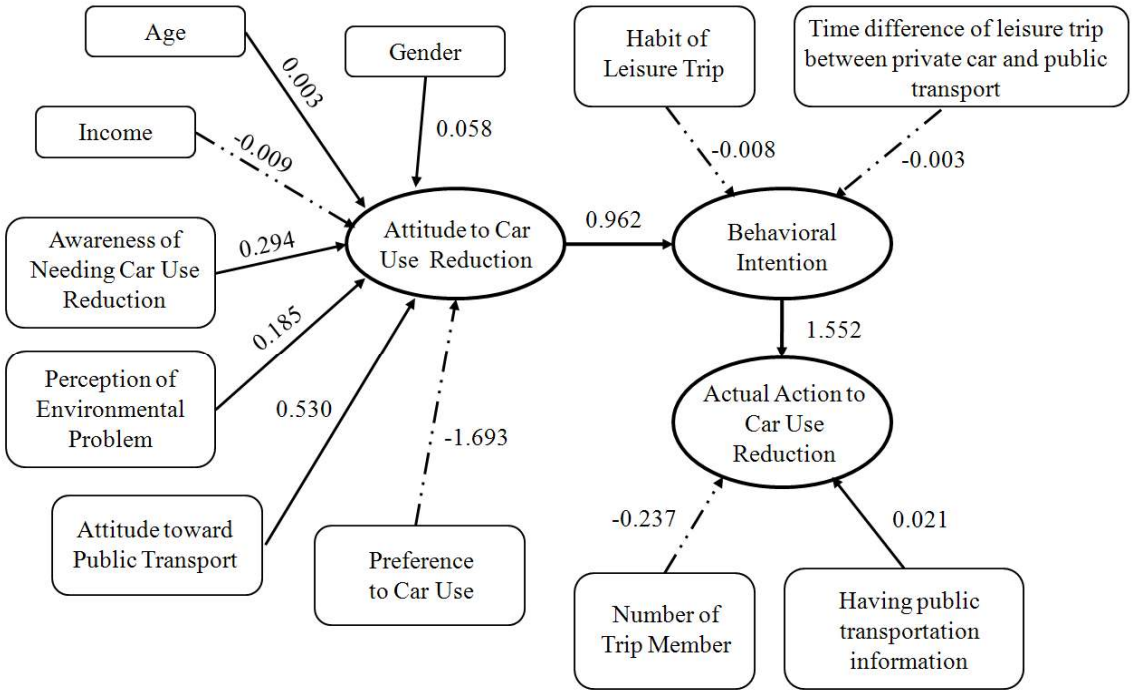

Figure 4 Estimation results of model (leisure trip)

Table 5 Parameter estimates of structure equation models

Variable	Commuting Trip			Shopping Trip			Leisure Trip		
	Estimate	S.E	C.R	Estimate	S.E	C.R	Estimate	S.E	C.R
Socioeconomic Factor									
(Gender→Attitude to Car Use Reduction)	0.030	0.030	1.007	0.056**	0.024	2.351	0.059**	0.024	2.484
(Age→Attitude to Car Use Reduction	0.002	0.001	1.609	0.003**	0.001	2.724	0.003**	0.001	2.719
(Income → Attitude to Car Use Reduction	0.004	0.009	0.440	-0.008	0.008	-0.981	-0.009	0.008	-1.087
Awareness of Need for Car Use Reduction → Attitude to Car Use Reduction	0.330***	0.062	5.342	0.296***	0.049	6.031	0.294***	0.049	6.002
(For Environmental reasons)	0.374***	0.091	4.094	0.375***	0.081	4.636	0.373***	0.081	4.619
(As Social Consciousness)	0.919***	0.155	5.925	0.959***	0.149	6.417	0.956***	0.150	6.391
Perception of Environmental Problem → Attitude to Car Use Reduction	0.099**	0.038	2.610	0.190***	0.033	5.714	0.185***	0.033	5.574
(Worry about environment problem)	0.949***	0.101	9.418	0.906***	0.076	11.861	0.905***	0.076	11.854
(Need for social consciousness for environment problem)	1.198***	0.118	10.148	1.122***	0.087	12.895	1.122***	0.087	12.887
(Importance of environmental problem)	0.916***	0.102	9.007	0.950***	0.082	11.613	0.948***	0.082	11.594
Attitude toward Public Transport → Attitude to Car Use Reduction	0.554***	0.083	6.709	0.533***	0.059	9.081	0.530***	0.059	9.053
(Preference for taking train)	1.442***	0.173	8.332	1.245***	0.112	11.154	1.245***	0.111	11.166
(Preference for taking bus)	1.155***	0.147	7.878	0.931***	0.096	9.744	0.926***	0.095	9.733
(Preference for using bicycle)	1.201***	0.151	7.960	1.160***	0.105	11.079	1.154***	0.104	11.073
Preference for Car Use → Attitude to Car Use Reduction	-1.328***	0.345	-3.853	-1.715***	0.440	-3.901	-1.693***	0.429	-3.945
(In favor of using car)	0.371*	0.214	1.735	0.836**	0.290	2.878	0.757**	0.274	2.762

$*p < 0.05$, $**p < 0.01$, $***p < 0.001$

Table 6 (continuation of Table 5)

Variable	Commuting Trip			Shopping Trip			Leisure Trip		
	Estimate	S.E	C.R	Estimate	S.E	C.R	Estimate	S.E	C.R
Attitude to Car Reduction → Behavioral Intention	0.904***	0.117	7.717	0.977***	0.091	10.744	0.962***	0.091	10.617
(Feeling the obligation to reduce car use)	1.015***	0.122	8.311	1.082***	0.093	11.578	1.084***	0.094	11.531
Characteristics of Trip									
(Habit → Behavioral Intention)	-0.017***	0.005	-3.553	-0.007	0.005	-1.408	-0.008	0.005	-1.485
(Time difference between private car and public transportation → Behavioral Intention)	-0.017	0.014	-1.205		-	-	-0.003**	0.001	-2.528
Behavioral Intention → Actual Action to Car Use Reduction	1.773***	0.192	9.252	1.539***	0.120	12.801	1.552***	0.123	12.626
(Effort to reduce car use)	1.124***	0.142	7.932	1.021***	0.094	10.910	1.023***	0.095	10.738
Condition of Trip									
(Having information of public transportation) → Actual Action to Car Use Reduction)	-	-	-	0.023	0.022	1.042	0.021*	0.022	0.981
(Number of Trip Members → Actual Action to Car Use Reduction)	-0.064	0.136	-0.475	-0.087	0.158	-0.549	-0.237	0.127	-1.861
Actual Action to Car Use Reduction									
(Actual action for reducing car use)	1.118***	0.069	16.278	1.065***	0.056	19.077	1.058***	0.056	18.947
χ^2 [df = 272]	1200.94			1687.77			1797.65		
GFI	0.870			0.876			0.872		
RMSEA	0.071			0.072			0.071		

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

4. DISCUSSION AND CONCLUSION

From the analysis, it is apparent that our hypothesis is supported by the estimated models. The process for voluntary car use reduction consists of the following steps: Attitude to Car Use Reduction →Behavioral Intention→Actual Action to Car Use Reduction. Moreover, in this paper, the variables that influence each step of the abovementioned process have been discussed. Psychological factors can influence the "Attitude to Car Use Reduction" step; "habit" and "time difference" variables negatively affect the Behavioral Intention step. Additionally, trip condition attributes like "members" and "information" influence the "Actual Action step."

The estimated models let us know what are feature of trip purpose and help to make strategy for effective transportation policy. Notably, because different variables affect the process of voluntary car use reduction and its coefficient by trip purpose, the promotion of transportation policy also needs vary according to trip purpose. In case of commuting trips, it was shown that habit is a very important variable and has a strong effect; some psychological variables related to "environmental" and "preference for car" have a comparatively weaker effect. Therefore, apart from campaigning about environmental problems and travel education, MM policy for "commuting trip" should incorporate a strong strategy such as economical support for changing to public transport by company that can stimulate a user to switch to public transport. On the other hand, to manage "shopping" and "leisure trip" which show similar trends, using a travel feedback program that includes information about CO_2 emission of cars, advice on how to reduce car use, and individualized information on public transportation that could be used as an alternative to cars could be the most suitable MM policy. However, in case of leisure trip, information about transit can be a variable of critical importance.

The result of this study is showing the process voluntary change of travel behavior and features of trip purpose as well. Mobility Management (MM) measures have been proved to reduce car use in other countries such as Japan through the application of psychological variables governing car use. However, in Korea, the concept of using MM as a transportation policy is still relatively new, and there exist few case studies about it. Therefore, it is necessary to analyze detailed trip characteristics for effective introduction of MM in Korea, because considering the fact that the existing TDM system is almost at its limits, there is no time to undergo trial and error. Furthermore, several points should be improved in future research. In this study, the impact of traveler characteristics on the process of voluntary car use reduction could not be considered. Classifying the model of the process of voluntary change of travel behavior by traveler characteristics will be useful. Therefore, we hope use the results obtained in this study for future publication.

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