An Analysis of Drivers' Behavior on Speed Selection

Kyungwoo Kang
Associate Professor
Department of Transportation Engineering
Hanyang University
396 Daehakdong, Ansan, Kyunggi-do
Korea 425-791
Fax: +0345-406-6290
E-mail: kyungwoo@email.hanyang.ac.kr

Donjoo Lee
Research Associate
Department of Transportation Engineering
Hanyang University
396 Daehakdong, Ansan, Kyunggi-do
Korea 425-791
Fax: +0345-406-6290

abstract: Many studies have been reported for drivers' speed selection behavior in the last decade. Most of previous studies, however, have concentrated on the relationship between drivers' speed selection road vehicle characteristics without considering personal characteristics and drivers' perception of speed limit. This paper analyzes Korean drivers' speed selection behavior taking into account of such factors are trip purpose in addition to personal, vehicular, and attitudinal factors. Major findings in this study are as follows: i) Higher speeds are observed for male drivers and higher personal incomes. ii) The larger the vehicles horse-power is, the higher is actual speed. iii) Work-related trips, trips with more passengers, longer distance trips, and trips which drivers think important are statistically significant factors for a greater speed. iv) People tend to drive faster if their perceived speed limit is higher than the actual speed limit. The results strongly suggest that more traffic safety devices, such as traffic safety signs for speed limit, especially, in urban area, should be installed for driver to recognize the actual speed limit.

1. INTRODUCTION

Numerous studies have been reported in the literature on speed selection behavior since pioneering works by Mohring(1965) who estimated value of time for travel. Most of previous studies for driver's speed selection behavior, however, have focused on the relationship between speed choice and speed limit, road characteristics, and vehicle types without considering personal characteristics and trip purpose. Also, a major field of interest of speed choice analysis by McFarland et al (1987) and Mohring (1965) by investigating the value of travel time for drivers, vehicles, and passengers.

Recent works by Jorgensen et al (1993), Wasielewski (1984) and Rienstra and Rietveld (1996) include driver's characteristics for speed selection in analyzing driver's behavior. Their works are limited, however, because of the use of only limited variables for driver's characteristics. In general, speed selection behavior is determined by the combination of physical characteristics of roads, vehicles, and traffic conditions as well as trip purpose. If we assume that road and traffic conditions were the same, speed selection behavior should be determined by the characteristics of vehicles and drivers including trip purposes. Actually, we can easily observe the importance of those factors from different speed distributions on the same road segments at the same time. Thus, in order to analyze speed selection behavior comprehensively, we should include various factors on not only traditional physical conditions of roads but also vehicle and driver's characteristics including trip conditions.

Ignoring the speed limit is one of the most important factors of traffic accidents, which is quite a well known fact even though the recent experiences of speed limit increase in the USA show some significant reductions of traffic accidents. Traffic accidents are the most serious economic and social losses in modern society. Also, traffic accidents cause massive traffic congestion in urban areas. Usually, speed limits are set by considering various factors such as physical characteristics of roads and drivers behavior.

The main purpose of this research is to study driver's speed selection behavior in Korea using various combinations of variables including vehicles and characteristics of roads and driver's and trip conditions. Target groups are restricted to automobile drivers during off-peak hours because the morning and afternoon peak hours in urban area have severe traffic congestion which driver's desired speed can not be achieved.

This paper has five sections. The first and second section introduce speed selection behavior and literature review of speed selection models. Section three discusses our survey methodology and data characteristics. Section four will summarize survey results including correlation coefficient analysis. Section five explains the various models used in this study and some international comparisons. Finally, concluding remarks and some suggestions of further studies follow.

2. SPEED CHOICE MODELS

After a careful review of the existing literature, we have decided that an economic model for speed selection behavior suggested by Jorgensen and Polak(1995) is acceptable for our purpose. In their model, drivers are subjectively rational, risk neural, and utility maximizing agents. We also assume that driver's speed selection is determined by trip time, safety consideration, and expected speed limit, and speeding ticketing costs.

Under these assumptions, the drivers choose their speeds to minimize total travel costs taking consideration of the existing conditions described above. As a result we arrive at Equation (1), where driver i chooses desired speed s in unit distance d. The total travel cost, $TTC(i)$ can be written as:

$$TTC\ (s)_i = TMC\ (s)_i + VOC\ (s)_i + ACC\ (s)_i + TKC\ (s)_i + TFC\ (s)_i \qquad (1)$$

where $TMC(s)_i$, $VOC(s)_i$, $ACC(s)_i$, $TKC(s)_i$, *and* $TFC(s)_i$ are, respectively, defined as travel time value, vehicle operating cost, accident cost, toll and traffic violation cost for driver i. Of course either a driver observes speed limit or does not get caught by police even though he/she violates speed limit, then $TFC(s)_i = 0$.

In order to simplify Equation (1), we further assume the same operating costs for the same type of vehicles in unit section of road. Also, tolls for all types of vehicles are assumed to be the same ($ACC(s)_i = p(s)_i \cdot L(s)_i$, $TFC(s)_i = q(s)_i \cdot F(s)_i$), then Equation (1) can be re-written as:

$$TTC\ (s)_i = TMC\ (s)_i + p(s) \cdot L(s) + q(s)_i \cdot F(s)_i \qquad (2)$$

where $p(s)_i$ is the subjective probability of accidents for driver i at speed s for unit segment of road d, $L(s)_i$ is expected accident costs for driver i at speed s in unit segment of road d and $q(s)_i$ is subjective probability for being caught driver i at speed s in speed limit(s_{max}). And finally, $F(s)_i$ is expected speeding ticket cost for driver i over speed limit (s_{max}) at speed s in unit segment of road d.

After some simplifications, the following Equation (3) can be obtained from the minimization behavior for drive of total travel costs;

$$\log(\hat{s}) = h(\log k - \log D - \log D_1) \quad (3)$$

Above Equation (3) can be defined by using D_1 and h, which are constant and D and k are parameters to be estimated. Also k is the value of time for drive and D is included in accident costs and ticket costs for over speed limits. The parameter values of D and k can be further determined as in Equations (4) and (5).

$$\log D = g_o + \sum g_l l + \sum g_m \log m \quad (4)$$

where l is perceived likelihood of being caught for speeding on the surveyed segment of road including perceived financial loss if caught exceeding the speed limit, and m is vector of characteristics of drivers such as age, sex, and driving experiences.

On the other hand, the value of travel time (k) of drivers can be estimated by the following Equation (5).

$$\log k = g'_o + \sum g'_\delta + \sum g'_\theta \log \theta \quad (5)$$

where δ is trip purpose and θ is a vector of characteristics of drivers such as their monthly income and types of job.

Substituting Equations (4) and (5) into Equation (3), the following Equation (6) can be obtained:

$$\log \hat{s} = w_o + \sum w_i i + \sum w_j \log j \quad (6)$$

where w_0 is $h(g'_0 - g_0 - \log D_1)$, i is the same as l, and j is the same as m which is defined Equation (4).

In this specification, the values of parameters of w_i and w_j can be interpreted as percentage changes and elasticity of speed s.

3. DATA COLLECTION METHODS

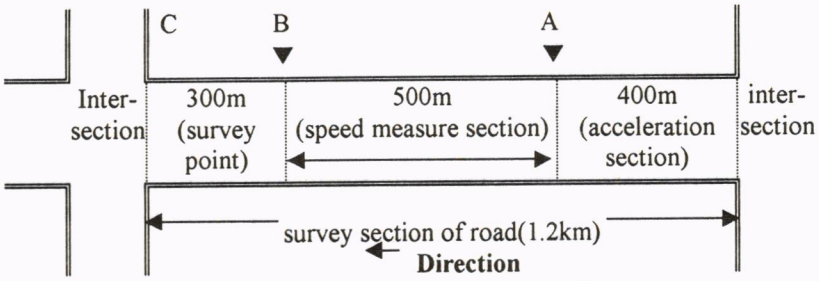
3.1 Data Collection

In order to estimate our model, we need two types of data sets, namely, speed data which are measured in the survey segment of road and characteristics of drivers, roads, vehicles, and trip purposes.

Speed can be measured by using video cameras and detectors. In order to obtain personal data for drivers, however, drivers must be stopped and interviewed in the middle of road. In case of other studies, police assistance is required in order to conduct field interviews[See, Jorgensen *et al* (1993)] and license matching programs[Wasielewski (1984)]. In our study, we rule out the police assistance, because driver's speed selection behavior can be modified when police appears. At the same time, license matching method can not describe the exact driver and passenger which may not be the same as vehicle registration indicated.

In order to avoid such difficulties, we have selected 4 lanes of each direction of 1.2Km road

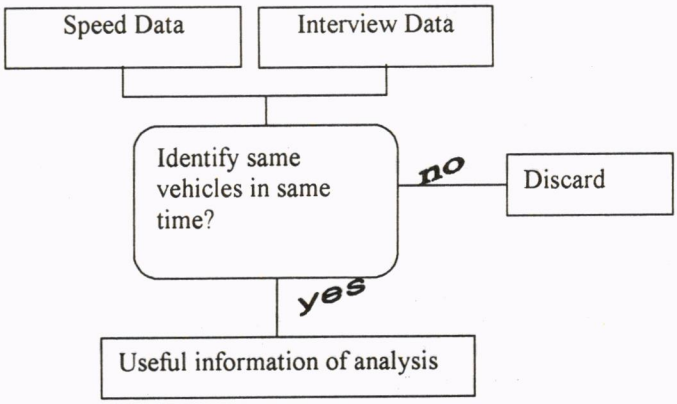
section of city of Ansan which has approximately half million population and one of the first planned major industrial cities in Korea where there are no entry or exit points. In the surveyed section of road, two speed limit(70Km/hour) traffic signs are installed. During the survey period, no police was present or visible for speeding control. Below [Figure 1] shows the survey section of the road.



[Figure 1] Description of Road Section

The speed of vehicles is measured between point A and point B. In point A, vehicle license plates are recorded in order to make sure that the same vehicle is at the point B. Then, field interviews are conducted at the point C where vehicles are stopped at red traffic signal for approximately 100 seconds long.

Field survey consists of 18 questions, among which four questions are recorded by interviewers are about license number, sex, occupancy, and seat belts. The remaining 14 questions for the characteristics of drivers, vehicles and trip purposes are collected from interviews with drivers. Survey was conducted from August, 13 (Tuesday) to 16 (Thursday) in 1996. Survey time was selected from 10:30 AM to 5:00 PM in order to collect various trip purposes. A total 2,889 of vehicle speed observations and 769 of field interviewed data are collected. After a careful review of vehicle speed data and field data, 349 observations are selected for our analysis in speed selection behavior. Below [Figure 2] shows the useful observation selection procedure.



[Figure 2] The useful data selection procedure

3.2 Descriptive Statistics

As we indicated earlier data sets for driver's speed behavior consist of four major components. the first component shows personal characteristics of drivers such as age, sex, driving experiences, monthly income, and the past experiences of accidents. The second component includes vehicle and safety characteristics such as the nature of insurance, horse-power, seat belt, airbag, anti-lock brake, power steering and automatic transmission. The third component records trip characteristics such as trip purpose, urgency of trip and accompanying passenger. Finally, the perceived characteristics of drivers for being caught of speeding, expected financial loss for speeding and the knowledge of speed limit on survey section of road.

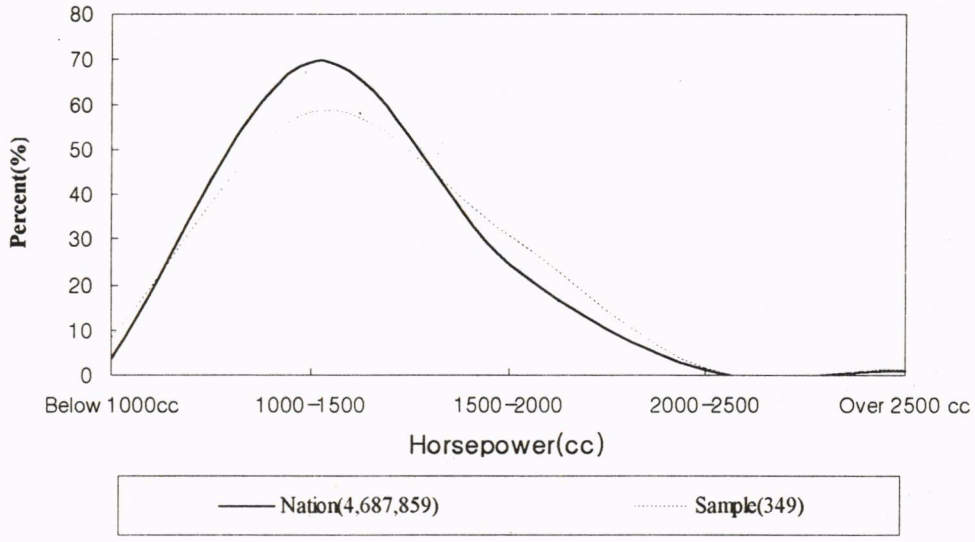
In our sample, there are 314 male drivers which account for about 90%. In order to make sure that our sample represent national average, we compared our values with national averages. In national scale, female driver license registrations account for almost 23% which is much higher than the 10% of female drivers in our sample. Since female driver's license is generally much higher than actual drivers in road it is reasonable to assume that the sex distribution in our sample does not deviate from the national averages.

As we see below [Table 1] for age distribution, 0.9% are for teens, 20% for twenties, 48% for thirties, 24% for forties, and 6.6% are for sixties and over sixties account for 0.6%. The average age of sample was 34.6.

[Table 1] Age-Sex distribution of sample (Unit : Person(%))

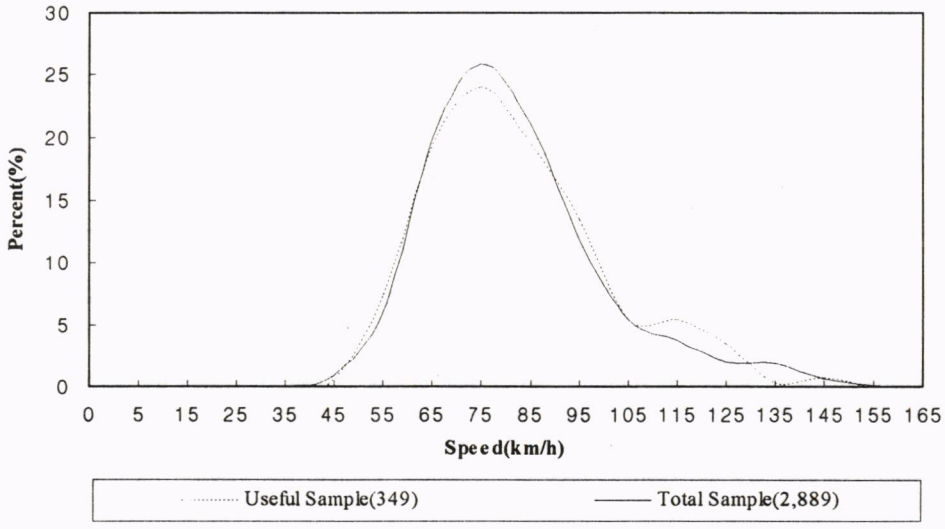
Sex / Age	Female	Male	Total
10	0	3	3(0.86%)
20	10	59	69(19.77%)
30	21	147	168(48.14%)
40	3	81	84(24.07%)
50	1	22	23(6.59%)
60	0	2	2(0.57%)
Total	35(10.03%)	314(89.97%)	349(100.0%)
National Total	3,687,059(22.5%)	12,716,700(77.5%	16,403,759(100%)

The Horsepower of surveyed vehicles shows that, below 1200cc represent for 5.1%, between 1200cc and 1500cc account for almost 60% which is the major portion of our sample, and over 2000cc vehicles account for mere 3%. As shown below [Figure 3], the majority of surveyed vehicles are between 1200cc and 1500cc. Vehicle registration fees for different classifications of horsepower heavily discourage for vehicles over 2000cc classes in Korea.



[Figure 3] Distribution of Horsepower of Vehicles

Also, [Figure 4] below shows that the speed distribution of total sample and useful sample as defined above. The two speed distributions are very similar, which indicate that our sample used in the analysis is not biased in our selection process. The average speed of total sample was 83.2 Km/hour, which is higher than the speed limit of 70Km/hour in surveyed section of road.



[Figure 4] Speed distributions for total and useful sample

In order to verify the statistical significance, we conducted "F" and "T" tests between total and useful samples for speed data. As shown below [Table 2], we do not reject the null hypothesis for a statistically significant different distribution between total and useful sample for speed data.

[Table 2] Speed distribution for total and useful sample

Category	Observations	Average speed (km/h)	Standard Error	Minimum	Maximum
Useful Sample	349	82.67	18.73	50.46	145.40
Total Sample	2,889	83.29	19.05	50.01	149.90
F-test	F'= 1.03	DF = (2888,348)		Prob>F' = 0.6952	
T-test	T =-0.57	DF = 3236		Prob>|T| = 0.5670	

3.3 Correlation Coefficient Analysis

Below [Table 3] shows that correlation coefficients among variables selected for speed selection behavior in Korea. As earlier defined before, variables from A1 to A7 are characteristics of drivers, B1 to B7 are vehicle and safety characteristics of vehicles, C1 to C3 are trip characteristics, and D1 to D4 are driver's perceived likelihood for being caught in speeding and financial losses. Finally, E1 is speed data for the useful sample.

In terms of personal characteristics of drivers, obviously age and driving experiences are positively correlated at the 1% level of statistical significance. The correlation coefficient between age and driving experiences is 0.58. Also, between age/driving experiences and horsepower/safety features of vehicle are positively correlated. This result indicates that income increases with age, and large vehicles have more safety features than small vehicles. The safety features of vehicles such as anti-lock brakes and airbag are popular in larger vehicles and the correlation coefficient is 0.55 which indicates that both safety features are strongly correlated.

Interestingly, vehicle speed variables are not correlated with other variables. Only trip purpose, anti-lock brakes and horsepower of vehicles are positively correlated with the vehicle speed. This result clearly indicates that the vehicle speed is combination of other different characteristics of variables which is difficult to detect from sample correlation coefficients alone.

[Table 3] Correlation Coefficients

	A1	A2	A3	A4	A5	A6	A7	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	D1	D2	D3	D4	E1
A1	1.00	0.13	0.23	0.24	0.07	0.0	0.12	-0.01	0.13*	-	0.0	0.0	0.01	-0.09	0.02	0.03	-0.00	0.08	0.01	-0.09	0.03	0.05
A2		1.00	0.58	0.32	0.08	-0.02	-0.00	0.02	0.37	0.0	0.2	0.2	0.08	0.18	0.12	-0.01	-	-0.08	-	-0.08	0.08	0.05
A3			1.00	0.24	0.15	0.1	0.11	0.01	0.40	-	0.3	0.3	0.13	0.13	0.17	0.05	-	-0.03	-0.09	-0.07	0.05	0.08
A4				1.00	0.03	0.0	0.01	0.05	0.29	0.0	0.1	0.0	0.14	0.19	0.12	0.01	0.01	-0.09	-0.08	-0.00	0.03	-0.01
A5					1.00	0.3	0.07	0.07	0.05	-	0.0	0.0	0.02	0.05	-0.03	0.03	0.02	0.08	0.13	-0.08	0.00	-0.05
A6						1.0	0.13	0.04	0.06	-	-0.02	0.0	0.05	0.08	0.06	0.02	-0.10	-0.01	0.15	-0.03	-0.03	-0.07
A7							1.00	-0.11	0.07	-	0.0	0.0	0.06	-0.01	0.02	0.13	-0.02	0.01	0.05	0.1	0.16	0.04
B1								1.00	0.00	0.0	0.0	0.0	0.02	0.16	0.01	-0.04	-0.02	-0.06	0.01	-0.03	-0.05	0.06
B2									1.00	-	0.3	0.4	0.34	0.28	0.24	0.08	-	0.02	-0.01	0.0	0.06	0.13
B3										1.0	-0.05	-0.10	-0.04	0.00	-0.05	-0.08	0.09	0.08	0.08	-0.09	0.07	0.00
B4											1.0	0.5	0.17	0.26	0.09	0.08	0.05	0.03	-0.07	-0.04	0.01	0.09
B5												1.0	0.24	0.24	0.11	-0.01	-0.04	-0.06	-0.10	-0.01	0.08	0.15
B6													1.00	0.29	0.09	0.02	0.04	0.08	0.05	-0.03	-0.02	0.07
B7														1.00	0.02	0.01	-0.00	0.05	-0.03	0.0	0.08	0.06
C1															1.00	0.16	-	-	0.02	0.0	0.03	0.03
C2																1.00	-	0.06	0.02	0.0	-0.11	0.16
C3																	1.00	-0.01	0.05	0.0	-0.02	-0.07
D1																		1.00	0.11	-0.02	-0.05	-0.05
D2																			1.00	0.0	-0.02	0.00
D3																				1.0	0.06	0.13
D4																					1.00	0.02
E1																						1.00

*: Statistically significance level of 1%
**: Statistically significance level of 5%

Variables
A1:Sex(M=1,F=0) A2:Age A3:Driving Experiences(Year) A4:Monthly Income A5,A6:Numbers of accidents A7:Experiences of traffic violations B1:Insurance(Yes=1,Other=0) B2:Horse-Power(cc) B3:Seat Belt(yes=1,no=0) B4:Airbag(yes=1,no=0) B5:ABS(yes=1,no=0) B6:Power handle(yes=1,no=0) B7:Auto(yes=1,no=0) C1:Trip purpose(business=1,other=0) C2:Urgency(yes=1,no=0) C3:Passenger D1:Expectation of police(yes=1,no=0) D2:Expected speeding ticket cost D3:Perceived speed limit(km/h) D4:Trip distance(km) E1:Speed(km/h)

4. MODEL SPECIFICATION AND ESTIMATION RESULTS

4.1 Model specification

In the analysis we have five different models for speed selection behavior as follows [Table 4].

[Table 4] Model specification and variables

Category	Dependent Variable	Independent Variables
Model I	Speed	Personal aspects of drivers
Model II	Speed	Vehicle and safety aspects
Model III	Speed	Trip characteristics
Model IV	Speed	Perceived likelihood for speeding
Model V	Speed	All variables for Models I-IV

Models defined in [Table 4], each model is a traditional multiple regression model with dummy variables. Model I uses only personal aspects of drivers, Model II vehicle and safety features, Model III use trip characteristics for drivers, Model IV perceived likelihood for being caught and results of expected ticketing costs for speeding, and finally Model V includes all the variables.

4.2 Estimation results

Each of five models is estimated by ordinary least squares method. Below we will describe some empirical results for each model.

4.2.1 Personal characteristics of speed

As a result of Model I for driver's aspects of speed selection, variables such as sex, monthly income and experiences of accidents are statistically significant for speed selection behavior in Korea.

As shown below [Table 5], male drivers are significantly different from female drivers. Other things being equal, male drivers drive 33% faster than female drivers. This result implies that

Among four variables, horsepower of vehicles and an index (airbag, ABS, power steering and automatic transmission are indexed according to their existence so that the index ranges from 0 to 4) of safety features are statistically strongly significant for speed selection behavior for drivers.

As expected, vehicle with more horsepower tended to make faster speed with correlation coefficient of 0.58. Also, other things being equal, the more safety vehicles there are, the higher the speed is. Finally, seat belts are not statistically significant factors for driving behavior with -0.03 elasticity.

4.2.3 Trip characteristics

All the trip characteristic variables are statistically significant factors for speed selection behavior. Trip purpose and trip urgency are significant factors for a higher speed. Drivers with business trip purpose and urgent trip tend to have a higher speed than non-business trip and casual trips. This result indicates that the more value attached to a particular trip, people tend to drive faster.

The impact of the number of passengers in the vehicles shows, somewhat surprisingly, that the vehicle with more passengers have a higher speed with revealing 1.28 elasticity. This result indicates that even though a driver has responsibilities for passengers, he/she apparently considers the value of travel time a more important factor than the perceived safety considerations for the passengers including himself/herself. Finally, trip distance is not a significant factor for speed selection behavior with 0.68 elasticity.

4.2.4 Perceived likelihood for speeding

Among the perceived aspects of speeding such as likelihood of being caught for speeding, expected financial loss for speeding, and perceived speed limit for the section of road, only perceived speed limit of road is statistically a significant factor for speed selection. With elasticity of 1.01 drivers with higher perceived speed limit of road have higher speed than others.

4.2.5 Combination of all variables

Including all the variables in the Model V, the horsepower of vehicles and perceived likelihood being caught for speeding are statistically significant variables for speed selection behavior with respect elasticity 0.32 and 0.46, respectively.

[Table 5] Estimation results of models

Variables		Model Ⅰ	Model Ⅱ	Model Ⅲ	Model Ⅳ	Model Ⅴ
Personal	Sex	0.33(3.85)*				
	Experiences	-0.06(-1.85)				
	Income	0.81(44.93)*				
	Accidents	-0.03(-2.11)**				
Vehicle & Safety aspects	Horse-power		0.58(94.37)*			0.32(6.75)*
	Insurance		0.06(1.55)			
	Seat Belt		0.01(0.70)			
	Index of Safety		-0.03(-3.10)*			
Trip Aspects	Trip purpose			1.99(9.69)*		
	Trip urgency			0.59(3.18)*		
	Passengers			1.28(6.54)*		
	Trip distance			0.68(10.47)*		
Perceived aspects of speeding	Expectation of police existence				-0.00(0.17)	
	Expected ticketing costs				-0.00(-0.99)	
	Perceived speed limit				1.01(215.42)*	0.46(5.65)*
Observations		298	334	165	215	208
F-value		10397.76	30384.21	536.96	23198.18	42360.19
R^2		0.9953	0.9973	0.9303	0.9970	0.9976

4.3 Comparisons

The speed selection behavior of drivers is a combination of different variables as we mentioned above. Also, different cultural factors in different countries contribute the speed selection behavior. In order to compare with other countries, we have selected researches done by Wasielewski (1984) for the United States of America and Jorgensen and Polak(1993) for Norway.

In Michigan studies, Wasielewski (1984) uses a simple index for the safety feature for speed selection behavior. In his study, selected 800m with two lanes of road for 20 days in his sample. The speed was obtained by Wasielewski (1984) video and then matched with two license plates. The characteristics of drivers was obtained from vehicle and driver registration information. The methodology used in his study is a general liner model using speed as the dependent variable and other information for drivers as independent variables.

In Norway study, Jorgensen and Polak(1993) develop an economic model for driving behavior between speed limit section and no speed limit section. The sample was collected in 2.8Km, 0.2Km and 0.7Km section of road adjacent to Oslo. Speed data were obtained on site and driver's information was collected by field interviews for 2 days.

Below [Table 6] shows the comparison between this research and Wasielewski (1984). It is difficult to make a direct comparison because of different sets of data used. However, variables for the past experiences of accidents and passengers show opposite results. The sign

for the past experiences of accidents for speed selection behavior in the USA. is positive indicating that the more past experiences of accidents accompanying a higher speed. Also, the number of passengers in vehicles has a negative impact to the speed selection.

[Table 6] Comparison between USA and Korea

Variables	U. S. A. (1984)	This Study (1996)
Experiences of accidents	+	-
Number of passengers	-	+
Sample Size	2,632	349

Below [Table 7] shows the comparison between this research and Jorgensen and Polak (1993) in Norway. Variables such as age and sex are not statistically significant factors in Norway study in contrast to this research. Also, driving experience is a significant positive factor in Norway but negative impact in the study. The results are interesting in terms of speed selection behavior. In this study, we have found that the experienced driver in Korea has more risk averse behavior in speed selection, in contrast to Norway drivers. It is not surprising that if one considers that traffic accident rate in Korea is one of the highest in OECD countries.

Trip urgency variable has a positive impact on speed selection behavior in both studies. Finally, the expected financial loss for speeding is quite a significant factor in Norway but not significant in Korea.

[Table 7] Comparison between Norway and Korea

Variables	Norway (1993)	This study (1996)
Age	Not Significant	+
Sex	Not Significant	+
Experiences of Drivers	+	-
Trip Urgency	+	+
Expectation of Police	Not Significant	Not Significant
Expected financial loss being caught	-	Not Significant
Sample Size	508	349

5. CONCLUDING REMARKS

Unfortunately, Korea has one of the highest traffic accident rate among OECD countries. Korea recorded over 10,000 life losses each year for traffic accidents, which is 3-5 times higher than USA and Japan. And speeding is the major factor for traffic accidents. In this study, we have estimated the speed selection behavior using data collected for speed and 18 different variables including personal characteristics of drivers, vehicle and safety information, trip purpose, and perceived information about speeding in Korea.
We have developed five different models in order to capture different impacts on speed selection behavior. Results indicated that i) male driver with higher income tends to driver faster, and experienced drivers drive more conservatively than others ii) vehicles with more horsepower drive faster, and vehicles with safety feature go slower than vehicles with less safety features iii) business trip and trip urgency are important factors for fast driving and this tendency is related to unexpected severe congestion in urban area in Korea, iv) perceived speed limit on road is an important factor for driving behavior.

As a result of this research, it is revealed that speed selection behavior is a combination of different factors of personal, vehicle, safety, trip and drivers' perception. Some factors such as personal characteristics of drivers are not controllable for transportation policy purpose. Factors such as perceived impacts on drivers are certainly controllable, however, using appropriate transportation policies. Especially, increases in awareness of speed limit and perceived financial loss of accidents are very important factors discouraging speeding. Drivers with more knowledge of speed limit of road tend to observe the posted speed limit more strictly. In order to reduce speeding and accidents in urban area, more safety related traffic signs such as speed limit sign, fine for speeding, and police presence in road would be useful instruments.

Finally, as shown from the international comparisons, speed selection behavior is quite different from one country to another. Thus, further studies are needed for more conclusive evidences in speed selection behavior before an introduce of new measures for speeding policy including increases in speed limit.

ACKNOWLEDGEMENT

The financial support of Korea Science & Engineering Foundation (Number 971-1206-024-1) as acknowledged.

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