A Study on the Impact of the Driving Duration on Abnormal Driving Behaviors of Corporate Taxi Driver

Jin Geol Lee[a] ., Young Ihn Lee[b].

[a,b] *Graduate School of Environmental studies, Seoul National University, Seoul, 151-742, Korea*
[a] *E-mail: skys2580@nate.com*
[b] *E-mail: yilee@snu.ac.kr*

Abstract: The past three years, the share of fatalities of corporate taxis accounted for approximately 50 percent. The cause of this phenomenon is taxi drivers' mandatory driving behavior. Taxi drivers often have to drive longer distances than the other drivers. With this study based on the definitions of the driving duration and the abnormal driving behaviors, the results were drawn through a comparison of the deceleration and acceleration distribution-graph on the test-bed distinguishing driving durations of less than 2 hours and those over 2 hours until the same driver re-entered the test-bed. As a result, it was found that for 8 drivers (26.7%) out of the 30 drivers, there was an increase in the probability of abnormal driving behaviors by driving duration. However, there is no correlation between the remaining 22 drivers (73.3%) and driving duration.

Keywords: Black box data, Abnormal driving behaviors, Driving duration

1. INTRODUCTION

In 2010, there were 13,124,972 passenger cars and 483,955 Commercial cars. Despite the fact that commercial vehicles compose only 3.4% of the total number of cars they still account for a large percentage of traffic accidents.

In addition when I look at the fatalities statistics in terms of the car-to-person status for the past three years, the share of fatalities of business-cars is approximately 50 to 55 percent. Particularly, the share of fatalities of corporate taxis accounted for approximately 50 percent.

The cause of this phenomenon is taxi drivers' mandatory driving behavior. Taxi drivers often have to drive longer distances than the other drivers. Therefore, taxi drivers tend to be more vulnerable traffic accidents. These risks are suppositions based on research that Dalziel and Soames Job(1997) conducted on the relationship between taxi drivers` traffic accidents and causal factors related to their level of fatigue and amount of driving experience.

Also in the study entitled “The Effect of Workload on Urban Bus and Taxi Drivers` Fatigue and the Mediating Effects of a Negative Emotional State,” a survey questionnaire was used to identify the factors associated with fatigue. The survey was composed of questions about age, the possession of a driver's license, the retention period, the experiences of falling asleep in the car, the frequency and length of breaks etc. During the past two years, taxi drivers` experience of traffic accidents was examined. The findings showed a negative correlation between the average relaxation time and the experience of a traffic accident.

That is, it was found that drivers who took less time to relax experienced more accidents. Because of finding, we can guess that the possibility of a traffic accident occurring is likely to increase.

Therefore, this study will use black box data to analyze the impact of abnormal driving

behaviors on driving duration one of the many causes of traffic accidents corporate taxis are involved in.

2. LITERATURE REVIEW

“The Effects of Driving Behavior Determinants and Job Satisfaction on Taxi Drivers` Reckless Driving Behavior” determined the following results. Taxi drivers in narrow cockpits are working about 12 hours per day. Several threatening factors exist in their job environment (complex road environment, smoke, bad weather, and the threat of drunken passengers etc.). So taxi drivers' mealtimes and breaks should be guaranteed. The traffic accidents of taxi drivers can cause serious social losses.

Therefore, a lot of effort is required to prevent taxi drivers from being involved in traffic accidents. Given the job environment of taxi drivers, they should be given a reasonable amount of opportunities to reduce their fatigue because doing so is the most important action that must be taken for reducing traffic accidents.

The study of Choi Yong Jun(2000) shows that for commercial car drivers, the working conditions(work hours, number and length of breaks, shifts, etc.) and work environment (physical environment, temporal constraints of conducting business, etc.) have a significant relationship with complaints of fatigue symptoms. In particular, the working time (pressure to engage in long driving, dispatch time, etc.) and breaks (irregular and insufficient breaks, etc.) in everyday life are the factors closely related to fatigue.

The study entitled “Development of a Critical Value According to Dangerous Drive Behaviors” developed ergonomic threshold reflected threshold which is determined through the simulation programs. Also types of dangerous driving were separated by speeding, acceleration, deceleration, and rotation.

The study entitled “Recording of Dangerous Driving Using Automobile Black Boxes” classified dangerous driving into four types by considering the data on traffic accident statistics. The black boxes of automobiles were used to analyze driving data for classifying the types of dangerous driving.

In the case of foreign countries, the Federal Motor Carrier Safety Administration reported that traffic accidents caused by fatigue or sleepiness account for under 4% of the total number of traffic accidents. But if rigorous analysis is implemented, the figure will be about over 30%. Also, the National Transportation Safety Board (NTSB, 1995) reported that 58% of commercial car drivers had experienced accidents by falling asleep at the wheel.

American traffic laws limit the continuous driving time of drivers of commercial vehicles. These drivers cannot drive more than 10 hours at a time and must take a break of a minimum of 8 hours after driving. The exception is that in the case of continuous driving time of 15 hours, the brake time given is 10~30% of the total working time. (NHTSA, 2002.)

3. ANALYTICAL METHOD

3.1 Definitions of abnormal driving behaviors

For definitions of abnormal driving behaviors, first of all, examples of traffic accidents covered by insurance during a period of 3 specific years is shown in Table 1 below. The table contains driving behaviors leading to traffic accidents such as a rear-end collision during a lane change and a vehicle that passes quickly and veers as a result of speeding.

Table 1. The classified types of driving using data on traffic accidents by insurance companies for 3 years

Driving type	Type description
Case1	Bump the side of the car in the next lane when making a lane change
Case2	Bump the corner of the car in the next lane when making a lane change
Case3	Bump the rear of the car in the next lane when making a lane change
Case4	Bump the rear of the car in the next lane after making a lane change
Case5	Bump the front of the car after failing to make a lane change
Case6	Bump the front of the car after making a lane change
Case7	Collision at the median and crossing the centerline when making a lane change
Case8	Bump the corner of the front of the car when making a lane change
Case9	Engage in rapid overtake and at the same time case8
Case10	Engage in rapid overtake and at the same time case1
Case11	Engage in rapid overtake and at the same time case6
Case12	Bump the overtaken car when making a lane change and rapid overtake
Case13	Get into an accident when making a lane change twice
Case14	Bump the side of the car when making a lane change
Case15	Bump the rear of the car due to sudden braking
Case16	Bump the diagonal by pulling the brake
Case17	Create road secession by pulling the brake
Case18	Create rollover by pulling the brake
Case19	Create straight secession due to drowsy driving on the curve
Case20	Create road secession by speeding on the curve
Case21	Cause an accident on another curve after overtaking a car
Case22	Cause an accident by crossing the lane on the curve
Case23	Cause an accident by crossing the lane on the second curve
Case24	Cause an accident by overtaking a car on the curve
Case25	Cause an accident by crossing the shoulder of the road on the curve
Case26	Cause a rollover accident on the curve
Case27	Cause a bump accident by crossing the lane on the curve
Case28	Bump the car in front by stopping rapidly after making a lane change
Case29	Bump the rear car by stopping rapidly after making a lane change

The classified types of driving which cause traffic accidents are shown in Table 2; the information was gathered through statistics data of accidents acquired from insurance companies**.**

Table 2. The classified types of dangerous driving based on accident data from insurance companies

Division			Classification type of dangerous driving
Case of Table 1	1,2,3,4,5,6,7,8,9	→	Rapid lane change
	15,16,17,18		Rapid deceleration / Sudden braking
	9,10,11,12,13,14		Lane change after rapid acceleration
	28,29		Rapid stop after making a rapid lane change
	19,20,21,22,23,24,26,27		Noncompliance safety speed at the turning section

Second, the report (2008) by Korea Institute of Construction & Transportation Technology

Evaluation and Planning (KICTEP) was reviewed for examining the types of risky driving shown in Table 3 below.

Table 3. The classified types of dangerous driving

Type of dangerous driving	
Violation of the speed limit	Driving too fast at the straight section
	Driving too fast at the curve section
Acceleration	A quick start
	A burst of speed
Deceleration	A sudden stop
	Rapid deceleration
Lane change	Rapid lane change
	Successive rapid lane change
	Crossing the centerline and inside lane violation
Turn	Rapid left(right) turn
Acceleration + Turn	A burst of speed + Rapid lane change
	A burst of speed + Successive rapid lane change
	A burst of speed + Rapid left(right) turn
Deceleration + Turn	Rapid deceleration + Rapid lane change
	Rapid deceleration + Successive rapid lane change
	Rapid deceleration + Rapid left(right) turn
Negligence from just looking forward	Negligence from just looking forward
Drunk driving	Drunk driving
Dozing off at the wheel	Dozing off at the wheel

Finally, black box data was reviewed for definitions of the abnormal driving behaviors referring to the above contents. Consequently, in this study, the abnormal driving behaviors were defined using information by deceleration and acceleration because there is a limitation of data. Table 4 shows the results.

Table 4. Defined abnormal driving behaviors in this study

Abnormal driving behaviors		Description
Acceleration	A quick start	In case the stopped vehicle leaves suddenly
	A burst of speed	In case the speed of the driving vehicle increases suddenly
Deceleration	A sudden stop	In case the driving vehicle stops suddenly
	Rapid deceleration	In case the speed of the driving vehicle decreases suddenly

3.2 Definition of the driving duration

In this study, the driving duration is defined as the period of time from the moment the vehicle is started for the first time (namely the time to input data) to the time that the vehicle stalls completely, with a consideration of the features of commercial vehicles and the margin of error for the data.

Also, there is an assumption that the data gap under 1 hour is regarded as continuous driving time. This is because taxi drivers wait for their customers and it takes some time for customers get into or out of the taxi, based on the characteristics of corporate taxi data.

3.3 Assumption of the normal driving behaviors

Shim, Kywan Bho (1998)'s study found that "It is on average 2 consecutive hours during which human beings can concentrate on their work continuously. So if humans work repeatedly, such as driving for over 2 hours, they will feel fatigue and sleepiness." So this study assumed that normal behavior is the case of driving less than 2 hours.

3.4 The analysis procedure

When proceeding with this study based on the definitions of the driving duration and the abnormal driving behaviors, a similar time zone was selected in order to restrict the factors affecting the abnormal driving behaviors. And the same test-bed for analysis was set using GPS coordinates. Drivers who passed through the test-bed twice a day were selected in order to overcome the limitation of a lack of information about the drivers. The data on the drivers who pass through the test-bed twice with a driving duration of less than 2 hours until entrance to the test-bed was re-extracted.

Therefore, the results were drawn through a comparison of the deceleration and acceleration distribution-graph on the test-bed distinguishing driving durations of less than 2 hours and those over 2 hours until the same driver re-entered the test-bed. The flow of the analysis procedure is shown in the following Figure1.

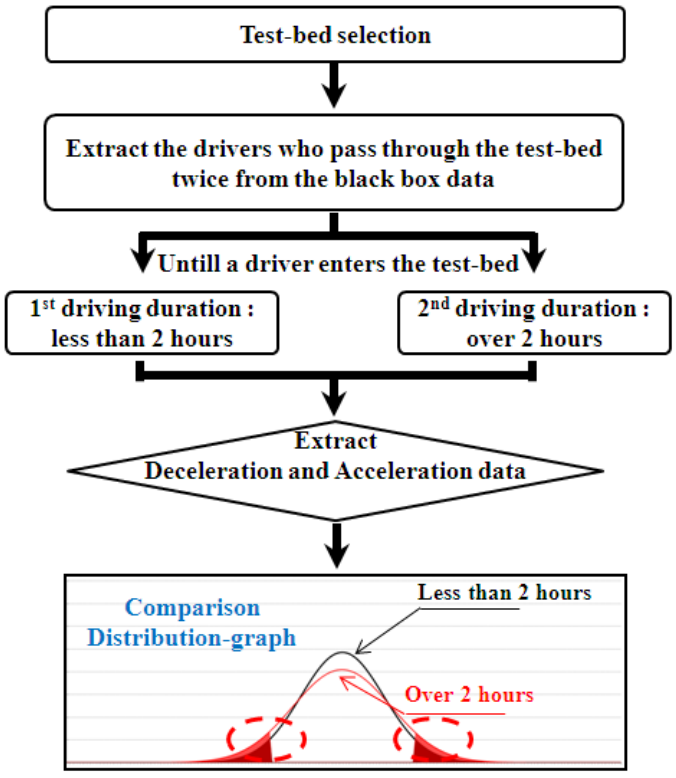

Figure 1. The flow of the analysis procedure

The outlier is the value that is obtained from the section $(m-2\sigma) \sim (m+2\sigma)$ in case of generally normal distribution. Consequently, when a comparison is performed with the deceleration and acceleration distribution-graph, the difference of probability of the outlier judged in this study is the probability of abnormal driving behaviors by the driving duration.

The following Equation 1 is the occurrence probability of abnormal driving behaviors by

driving duration. And Equation 2 is the probability of abnormal driving behaviors in the case that the driving duration is over 2hours.

$$UP = P' - P \tag{1}$$

where,

UP : Probability of abnormal driving behaviors by driving duration
P' : Probability of abnormal driving behaviors in the case that the driving duration is over 2hours
P : Probability of abnormal driving behaviors in the case that driving the duration is less than 2hours

$$P' = 1 - \int_{m-2\sigma}^{m+2\sigma} \frac{1}{\sqrt{2\pi\sigma}} \exp^{-(x-m)^2/2\sigma^2} dx \tag{2}$$

where,

m : Average of deceleration and acceleration
σ : Standard error of deceleration and acceleration
P : Calculated by method such as P'

4. BUILDING MATERIALS

The test-bed, a 3.5km section near a garage, was selected. The data was built using the process shown below because we needed to transform the shape of raw data for analysis.

Step 1. Test-bed selection

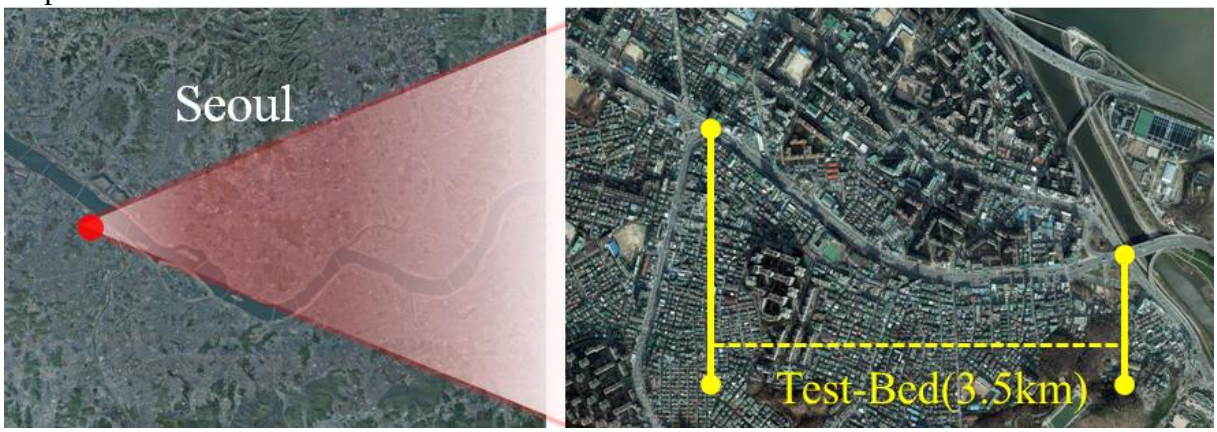

Figure 2. Selected Test-bed

Step 2. Extract the drivers who pass through the test-bed twice from raw-data using GPS coordinates

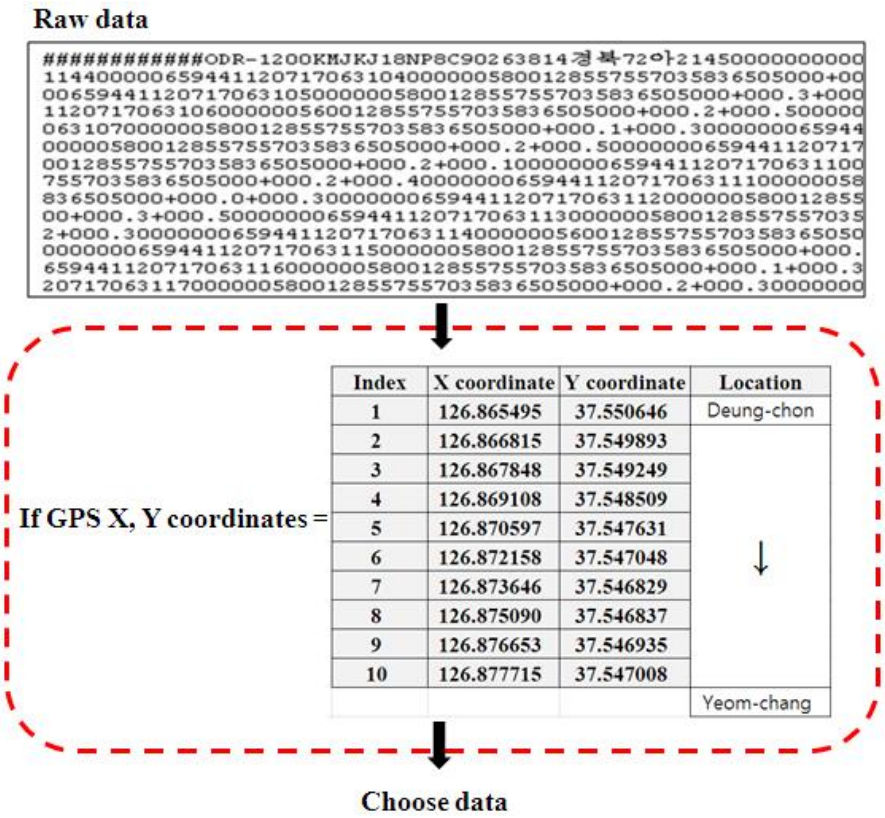

Figure 3. Extract the drivers who pass through the test-bed twice

Step 3. Re-extracting drivers in the case of less than 2 hours of driving duration until the first entrance into the test-bed

Step 4. Extract the time and speed when the drivers pass through the test-bed

Table 5. Final extracted driver data separated by continuous driving time (sample)

Driver 1(time and speed data of the test-bed)			
1st driving duration : less than 2 hours		2nd driving duration : over 2 hours	
Time(sec)	Speed(m/s)	Time(sec)	Speed(m/s)
0:00:00	17.22	08:00:00	19.44
0:00:01	18.06	08:00:01	19.72
0:00:02	18.06	08:00:02	20.00
0:00:03	17.78	08:00:03	20.00
0:00:04	16.94	08:00:04	20.56
0:00:05	16.94	08:00:05	20.83
0:00:06	17.78	08:00:06	20.83
0:00:07	18.06	08:00:07	20.83
0:00:08	18.06	08:00:08	21.39
0:00:09	17.22	08:00:09	21.67
0:00:10	16.11	08:00:10	21.67
0:00:11	15.00	08:00:11	21.67
0:00:12	14.17	08:00:12	21.94
0:00:13	13.89	08:00:13	21.94
0:00:14	13.89	08:00:14	21.94

Step 5. Calculate the deceleration and acceleration of the drivers who pass through the test-bed

Step 6. Compute the probability of abnormal driving behaviors in the deceleration and acceleration distribution- graph

There is a total of 30 samples that went through the above process and Table 6 below shows the final building data of drivers as examples.

Table 6. Example of final building data form

Drivers	Time (sec)	Speed (m/s)	X coordinate	Y coordinate	Deceleration and Acceleration (m/s^2)
Less than 2hours	0:00:00	3.3333	127.128	37.533	0.000
	0:00:01	3.0555	127.128	37.533	-0.278
	0:00:02	3.3333	127.128	37.533	0.278
	0:00:03	3.0555	127.128	37.532	-0.278
	0:00:04	3.0555	127.128	37.532	0.000
	0:00:05	2.2222	127.128	37.532	-0.833
	0:00:06	1.9444	127.128	37.531	-0.278
			.		
			.		
			.		
Over 2hours	5:00:10	0.0000	126.865	37.547	0.000
	5:00:11	0.0000	126.865	37.547	0.000
	5:00:12	0.0000	126.865	37.547	0.000
	5:00:13	0.0000	126.865	37.547	0.000
	5:00:14	1.3888	126.865	37.546	1.388
	5:00:15	2.2222	126.865	37.546	0.833
	5:00:16	2.5555	126.865	37.546	0.278
	5:00:17	2.2222	126.865	37.546	-0.278
	5:00:18	2.2222	126.865	37.546	0.000

6. RESULT

Lastly, the deceleration and acceleration distribution-graph was drawn of drivers using building data, and we tried to calculate the probability of abnormal driving behaviors using the equations mentioned above.

However, only 8 drivers among the 30 drivers appeared to show the probability of an increase in abnormal driving behaviors and in the case of 22 drivers, there appeared to be no correlation.

Figures 4 to 6 below show the examples that show no correlation for difference between

a driving duration of less than 2 hours and that over 2 hours.

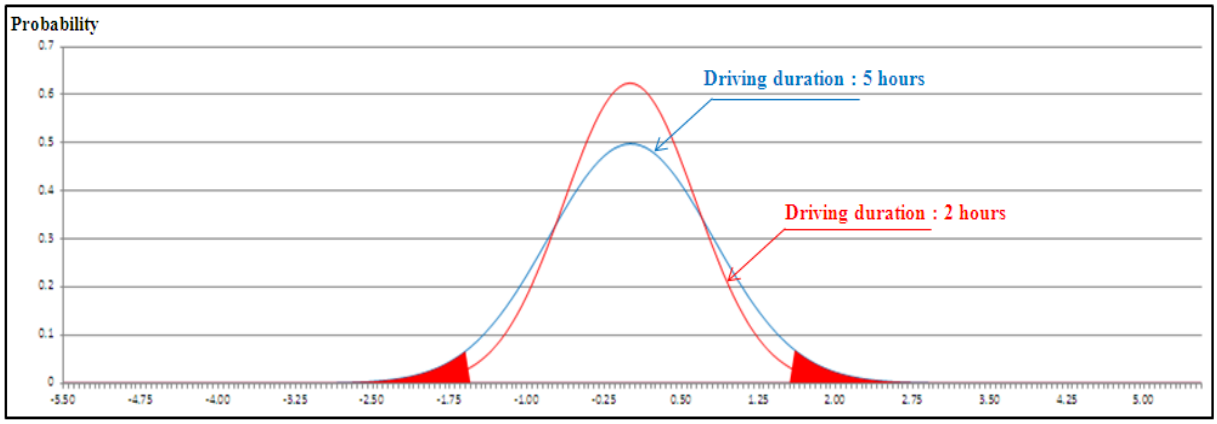

Figure 4. Deceleration and acceleration distribution of driver 12

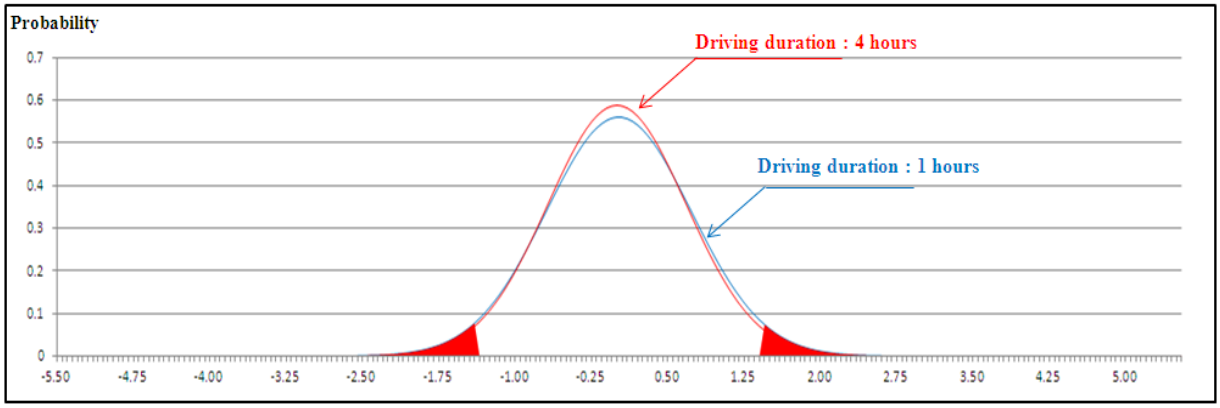

Figure 5. Deceleration and acceleration distribution of driver 14

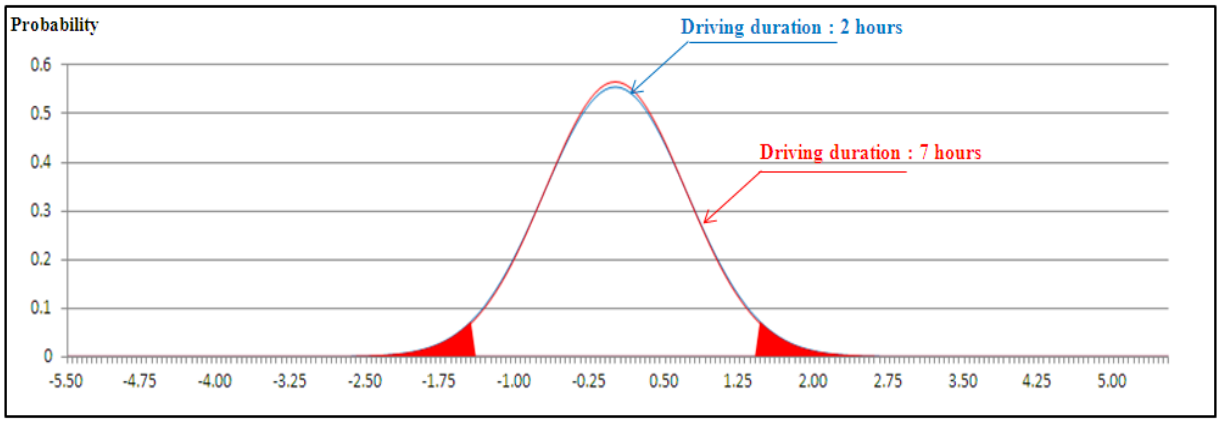

Figure 6. Deceleration and acceleration distribution of driver 22

As a result, it was found that for 8 drivers (26.7%) out of the 30 drivers, there was an increase in the probability of abnormal driving behaviors by driving duration. However, there is no correlation between the remaining 22 drivers (73.3%) and driving duration.

Table 7 below shows the comparison of 30 drivers on the probability of abnormal driving behaviors by driving duration.

Table 7. Comparison of the probability of abnormal driving behaviors by driving duration

No. drivers	Less than 2 hours	Over 2 hours	Variation
	Probability of abnormal driving behaviors (%)		
1	15.05	15.05	-
2	15.20	15.20	-
3	15.58	13.53	▼ 2.04
4	14.74	14.74	-
5	15.10	15.10	-
6	15.46	13.01	▼ 2.45
7	12.20	12.20	-
	.		
	.		
	.		
12	11.30	17.90	△ 6.60
13	15.41	20.11	△ 4.70
14	13.93	12.87	▼ 1.06
15	8.77	14.23	△ 5.47
16	11.02	11.02	-
17	10.30	23.90	△ 13.60
	.		
	.		
	.		
23	6.40	11.86	△ 5.46
24	12.37	10.77	▼ 1.60
25	12.45	21.25	△ 8.80
26	13.24	13.24	-
27	13.69	7.42	▼ 6.27
28	13.30	13.30	-
29	10.63	17.83	△ 7.20
30	10.92	13.32	△ 2.40

7. CONCLUSION AND LIMITATIONS

This paper attempted to find the relationship between the abnormal driving behaviors of taxi drivers and continuous driving time, which is one of the variables affecting driving behavior.

We expected that the relationship between abnormal driving behaviors and continuous driving time would generally have a positive correlation but the results showed that there is no correlation between them.

As for the analysis results, first of all, we took into consideration that taxi drivers may have to wait a long time for their consumers and that many drivers have a lot of driving experience because taxis are commercial vehicles.

Second, the largest limitation of analysis is that feature (age, work experience, gender, etc.) of drivers wasn't reflected sufficiently.

However, 5 drivers among the 30 drivers showed an increased probability of abnormal driving behaviors when they drove over 2 hours.

This may constitute only 17% of the total sample, but this figure should not be ignored in terms of the potential for causing traffic accidents. If we are able to obtain more information about the features of drivers through a survey, such as their work satisfaction in the future, we are certain that a more accurate analysis would be made.

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