Drinking, Texting, Being Young, or Getting Old: Which One is the Most Dangerous While Driving?*

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Abstract

The causes of car accidents can be attributed to the types of driving: e.g., impaired, distracted, novice and cognitively declined. This study attempts to measure the risk of drinking, texting, young and aging while driving using the framework by Levitt and Porter (2001). Drinking has been a major factor in causing serious accidents and there is a growing concern with the other types. We find that drink driving is the riskiest among these four types; it is approximately three times more dangerous than sober driving. However, aging is also more than 2.7 times more dangerous. This suggests that similar stringent regulations are required and the need for advanced safety systems such as automatic brakes is urgent.

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1. Introduction

Car accidents are caused by particular types of driving. One of the major categories is impaired driving. Thus, the risk of drunk driving has been widely studied in the literature (Levitt and Porter 2001, Taylor et al. 2010). In addition to drunk driving, concerns have recently been growing over two other causes of impaired driving: i.e., texting and aging. Because of widespread cell phone usage, using a cell phone has become an important form of impaired driving. New regulations on this type distracted driving have been introduced in many countries. Furthermore, because cognitive and motor skills deteriorate with age or possibly dementia, older drivers are considered to have a higher chance of causing accidents (Loughran and Seabury 2007). In particular, in aging countries such as Japan, the number of older drivers is increasing (the number of license holders aged over 74 was 2.83 million in 2007 and 5.4 million in 2017). While the number of deaths related to car accidents in Japan has declined over the years (5796 in 2007 and 3694 in 2017), the ratio of older people has increased from 47.4 percent in 2007 to 54.7 percent in 2017. In addition, the news media has made the general public aware of the rising number of accidents caused by older drivers.[2] With regards to driver's age, the news sometimes also reports car accidents caused by reckless driving of young drivers. Inexperienced drivers may be also a risk factor for car accidents. However, there has been no systematic study comparing the risks of these types of driving.

This study uses a systematically collected dataset for Japan from 2007 to 2017 that contains the number of deaths and injuries, as well as the type of driving related to these accidents. We employ Levitt and Porter's (2001) framework to measure the relative risks of each type of driving. Our empirical analysis shows that drink driving is the riskiest among these four types: i.e., drink driving is at least three times riskier than sober driving. Because of the aggregation level of our data, these results are comparable with the most aggregated data results in Levitt and Porter (2001), in which drink driving is 3.79 times riskier than sober driving. The aging is also a risk factor for fatal accidents: it is more than other 2.7 times riskier than otherwise. In a rapidly aging country such as Japan, the risk of older drivers is (or will be) high. Hence, the need for an intelligent transport system that delivers safer modes of transport is urgent and the drivers' licensing system for people with cognitive decline should be reviewed.

While texting is at least 1.7 times more dangerous, this is subject to under-reporting problem. Unless there is an evidence that drivers are using cell phones while driving, it is difficult to verify the cell phone usage after the crash. Thus, this result remains rather suggestive. With regard to novice drivers, young drivers do not pose more accident risk than otherwise. Despite the news report reckless driving by young drivers, probably due to a stringent driver's license system for obtaining new driver's license in Japan, statistically young drivers are not riskier in our sample.

2. Model

[2]For example, in May 2018 in Japan, a 90-year-old driver went through an intersection despite a red traffic light, hitting four people, one of whom died.

To measure the relative risk of driving type, we employ the framework developed by Levitt and Porter (2001). In this section, we briefly review the Levitt–Porter framework. Based on their model, the distribution of accidents is expressed by a multinomial distribution. In this study, the types of driving are dichotomized: e.g., drinking or sober, texting or nontexting, young or nonyoung, old or nonold. We denote the type drinking (texting, young, or old) as D and sober (nontexting, nonyoung, or nonold) as S. While there could be possible cases such that an old driver is drinking, we focus on the two-type cases for the simplification of analysis and the robust interpretation of results.[3]

One of the important assumptions is called equal mixing, which ensures independence of the composition of driving types and accidents. Drivers of different types exist equally on the road, which implies that the possibility of an accident while driving is independent of the type of driver. The probability that types i and j have an interaction that might cause an accident is equal to the product of the probability of type i and j's incidents. The index I takes the value 1 if drivers have an interaction, N_i is the number of type i drivers, and thus the probability that type i has an interaction is expressed as $Pr(i|I = 1) = N_i/(N_D + N_S)$. Then, the interaction probability is given by:

$$Pr(i, j|I = 1) = N_iN_j/(N_D + N_S)^2.$$

By introducing a risk parameter that shows the probability of causing an accident when there is an interaction, θ_i, the probability that at least one driver makes a mistake causing an accident is:

$$Pr(A = 1|I = 1, i, j) = 1 - Pr(\text{neither driver makes mistakes}) = 1 - (1 - \theta_i)(1 - \theta_j) \approx \theta_i + \theta_j,$$

where $A = 1$ indicates that an accident occurs. The main probability examined is the probability of driving types conditional on the accident, $Pr(i, j|A = 1)$. By Bayes law,

$$\begin{aligned}
Pr(i, j|A = 1) &= Pr(i, j, A = 1|I = 1)/Pr(A = 1|I = 1) \\
&= \frac{Pr(A = 1|i, j, I = 1)/Pr(i, j|I = 1)}{Pr(A = 1, DD|I = 1) + Pr(A = 1, DS|I = 1) + Pr(A = 1, SS|I = 1)} \\
&= N_iN_j(\theta_i + \theta_j)/(2[\theta_D N_D^2 + (\theta_D + \theta_S)N_DN_S + \theta_S N_S^2).
\end{aligned}$$

Denote the relative risk and ratio of driving types, $\theta = \theta_D/\theta_S$ and $N = N_D/N_S$, respectively. Then, the probabilities of an accident involving different driving types are: $Pr(DD, \theta, N|A = 1) = \theta N^2/(\theta N^2 + (\theta + 1)N + 1), Pr(DS, \theta, N|A = 1) = (\theta + 1)N/(\theta N^2 + (\theta + 1)N + 1)$, and $Pr(SS, \theta, N|A = 1) = 1/(\theta N^2 + (\theta + 1)N + 1)$.

Another important assumption is the composition of drivers: i.e., the composition of drivers in one accident is independent of the composition of drivers in other accidents. Then, the distribution of driving types involved in accidents is given by a multinomial distribution. Let A_{ij} designate

[3] If there is heterogeneity within each type, the risk parameter estimates are interpreted as the average effect of that type.

the number of accidents involving types i and j drivers and A_{total} is the total number of accidents. Then,

$$Pr(A_{DD}, A_{DS}, A_{SS}|A_{total}) = [(A_{DD} + A_{DS} + A_{SS})!/(A_{DD}!A_{DS}!A_{SS}!)]P_{DD}^{A_{DD}} P_{DS}^{A_{DS}} P_{SS}^{A_{SS}}. \quad (1)$$

This is the likelihood function and the parameters are θ and N.[4]

In addition to the two-car crash cases, incorporating one-car crashes requires us to introduce the probability that type i driver causes a one-car crash, λ_i. Then, the probability of driver i being involved given a one-car accident, $(C = 1)$, is:

$$\begin{aligned} Pr(i|C = 1) &= Pr(i, C = 1)/Pr(C = 1) = Pr(i, C = 1)/(Pr(D, C = 1) + Pr(S, C = 1)) \\ &= \frac{\lambda_i N_i/(N_D + N_S)}{\lambda_D N_D/(N_D + N_S) + \lambda_S N_S/(N_D + N_S)} = \lambda_i N_i/(\lambda_D N_D + \lambda_S N_S). \end{aligned}$$

Then, the relative probability is expressed as $Pr(D|C = 1)/Pr(S|C = 1) = \lambda N$, where $\lambda = \lambda_D/\lambda_S$. We also include the one-car crash probability in the estimation likelihood function.

3. Data

The data are compiled by the Institute for Traffic Accident Research and Data Analysis, which was founded in 1992 to conduct research on road accidents to reduce their incidence in Japan.[5] As stated on their website, this dataset is comprehensive in that "Japan's police investigate all the fatal and injury traffic accident cases and registers records of all the cases without exception." The data include various characteristics of accidents and drivers, i.e., date and weather, age and gender of drivers, type of violation, and level of injury. While it is interesting to investigate drivers' characteristics in detail, our focus in this study is on the estimation of accident risk related to drinking, texting, and age. The data record whether the driver was drinking or using a cell phone and the age of the drivers when the accident happened. Older drivers are defined as those whose age is 70 years or more. In fact, the government recognizes the risk of older drivers so that drivers who are aged over 69 need to complete a driving course to renew their driver's license. Young drivers are classified as drivers whose age is 25 years or younger.

In this study, we use data of the number of fatal accidents in both primary (primary person who caused the accident) and secondary people involved in car accidents in Japan. Because of the private nature of the data (e.g., because the data records law violations, the responsible person might be identified if there is a particular incident), a certain level of aggregation is required. Our data units include region, month, day, and whether the incident occurred during the day or

[4] If the equal mixing assumption is violated, drinking-drinking (and sober-sober) interactions tend to occur, which leads to fewer drinking-sober interactions. The fact that there is a large number of drinking drivers, but a small number of drinking-sober accidents leads to the low accident risk parameter. Hence, if this assumption does not hold, the estimates are considered as the lower bound of true values.

[5] www.itarda.or.jp/english.

	Drink	Text	Young	Old
Num. of accidents	9	0	201	423
Num. of victims	9	0	209	435
	Drink (1 side)	Text (1 side)	Young (1 side)	Old (1 side)
Num. of accidents	692	88	2414	3907
Num. of victims	727	93	2530	4032
	Drink (single)	Text (single)	Young (single)	Old (single)
Num. of accidents	1067	20	1001	1924
Num. of victims	1088	20	1073	1961
Num. of obs.	1008	1008	1008	1008

Table 1: Summary Statistics

night hours. There are 47 prefectures in Japan, which are aggregated into six regions (Hokkaido–Tohoku, Kanto–Koshinetsu, Chubu–Hokuriku, Kansai, Chugoku–Shikoku, and Kyusyu–Okinawa). The dataset includes the total number of deaths from 2011 to 2017. Hence, the total number of sample units is 6 regions $\times 12$ months $\times 7$ days $\times 2$ day or night $= 1008$.

Table 1 reports the summary statistics. The total number of accidents is nine when both parties were drinking, 0 when texting, 201 when young, and 423 when older. The number of victims are 209 and 435 for young and old, respectively, which is slightly larger than that of accidents. This indicates that there are multiple-victim accidents. When only one of the drivers is classified as one of the types (1 side), the number is higher, but the distribution is similar: i.e., the number of accidents is the highest for older drivers and the lowest for texting. The number of single car crashes again has a similar pattern for one-car cases: 1067, 20, 1001, and 1924 for drinking, texting, young, and older, respectively. However, the relative number of one-car crashes by drink drivers is larger than that in other cases, i.e., drinking causes one-car crashes more frequently than other types of driving.

There is a data issue regarding texting. Because there are no recorded texting–texting deaths, the identification problem arises. This data problem may be generated by a reporting issue. When a texting-related accident occurs, drivers are unlikely to report that they were using a cell phone. Furthermore, cell phone usage cannot be verified without hard evidence such as dashcam records. Hence, we include serious injuries for both or one of the parties involved and also include slight injury for one-car crashes. The definition of a serious injury is one that requires one month or more of treatment. The total number of serious injuries when both parties were texting is nine and the total number of serious injuries when only one side was texting is 565. For one-car crashes, the numbers of serious and slight injuries are 63 and 237, respectively. Incorporating injury data allows us to estimate the model. This creates overbias for fatal crash risk. There is a possibility of underbiases caused by a reporting problem and that of overbiases due to the inclusion of injury data. Therefore, the risk calculated here should be interpreted with caution.

4. Empirical Results

By estimating the log-likelihood function corresponding to equation (1), the relative risk parameters and the ratio of each type of driving are obtained. Table 2 reports the estimation results. The most dangerous type of driving is drink driving, which is approximately three times more dangerous for two-car crashes and 11 times more dangerous for one-car crashes. Because of the level of aggregation of our data, equal mixing is imposed restrictively. Hence, our results are comparable to the coarsest mixing assumption case in Levitt and Porter (2001), in which the relative risk is estimated as 3.79. While the samples are from different nations and time periods, the result of the risk of drink driving is similar. Furthermore, the same implications may be applied such that if we adopt a finer equal mixing assumption, the relative risk is higher. If so, our empirical results are also the lower bound of the risk. Therefore, there are stringent regulations on drink driving. In Japan, because of a fatal accident that occurred in 2006 involving three children, the Japanese government introduced more severe punishments for drink driving in 2007. Such policies reflect the dangers of drink driving.

	Drinking	Texting	Young	Aging
θ	2.903	1.762	1.000	2.753
	(0.081)	(0.062)	(0.253)	(0.127)
λ	11.527	2.38	1.251	2.699
	(0.334)	(0.117)	(0.169)	(0.088)
N	0.017	0.022	0.141	0.148
	(0.0004)	(0.0005)	(0.018)	(0.083)
Log-likelihood	-2757.06	-1782.357	-3559.824	-4576.227

Table 2: Estimation Results

Considering other types of driving, the relative risk is highest for aging: older drivers are 2.753 times more dangerous than otherwise. The estimated ratio of older drivers is 14.8 percent. Because the total number of driver's license holders was 82,076,223 and the number of license holders who are aged at least 70 years was 9,320,223 in 2014 (*Driver's License Statistics* by National Police Agency), the actual ratio of older to younger drivers is 13 percent. Therefore, our estimate is accurate for this variable. Because of the prevalence of older drivers, this estimated risk highlights growing public concern about older drivers' accident risk. Driving is an important transport mode for people in rural areas without a decent public transportation system. Hence, while we may need to introduce a strict license renewal process for drivers with cognitive decline, the introduction of cars with advanced safety devices is urgent. In particular, in a rapidly aging country, such as Japan, such advanced technology will benefit public safety significantly.

Texting is 1.7 times riskier and this result needs to be interpreted with remarks. The estimation result for texting includes not only the number of fatal accidents but also the number of accidents involving only injuries. In this sense, the risk may be overestimated. However, as mentioned in the previous section, the risk of texting may be underestimated because people may not report their usage of cell phones when an accident occurs. Without witnesses or recorded video, it is not always possible to detect the use of cell phones at an accident. Thus, the results for texting should be considered carefully.

The risk of novice drivers is not higher than otherwise. The risk parameter estimate is one as Levitt and Porter (2001) discussed. This contrasts with the results of the young driver's risk in the previous studies using the US data (Levitt and Porter 2001, Loughran and Seabury 2010). This is probably because an intensive learning is required to obtain new driver's license in Japan. People normally have to take driving lessons at least 60 hours (26 hours for classroom lectures and 34 hours for incar driving lessons), which may reduce the risk of car crash by inexperienced drivers.

The relative risk of one-car crashes is also high for every type of driving. These risks are higher than the risks of two-car accidents except for the case of aging. For elderly drivers, the relative risk for two-car accidents and that of one-car crash is similar. These findings again highlight the benefits of advanced safety systems, such as automatic brakes, which can prevent serious crashes.

5. Concluding Remarks

This study attempts to measure the relative risk of certain types of driving: drinking, texting, young, and old. The risk of drink driving is highest among four types, i.e., it is around three times more dangerous than sober driving. Other types of driving are also more dangerous than normal driving except for novice drivers. From a policy perspective, we need to introduce severe punishments or strict licensing procedures for these drivers. New advanced safety technology may simultaneously reduce these risks; thus, incentive policies such as subsidies for cars with advanced safety technology can reduce the number of fatal accidents. Furthermore, the measurement of externalities caused by these types of driving (Levitt and Porter 2001, Edlin and Karaca-Mandic 2006) is also important. Thus, further research is required.

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