energies

MDPI

Article

Do People Drive Light Cars Carefully? A Comparative Study of Risky Driving Behaviors between Light Cars and Others

Yanning Zhao [1,*] and Toshiyuki Yamamoto [2]

1 Department of Civil Engineering, Nagoya University, Nagoya 464-8603, Japan
2 Institute of Materials and Systems for Sustainability, Nagoya University, Nagoya 464-8603, Japan; yamamoto@civil.nagoya-u.ac.jp
* Correspondence: yzhaoatnu@gmail.com; Tel.: +81-52-789-3729; Fax: +81-52-789-5728

Received: 17 February 2020; Accepted: 26 March 2020; Published: 1 April 2020

check for updates

Abstract: The first aim of this study was to examine whether people drive light cars carefully in comparison with standard-sized cars. The second aim was to evaluate the factors that influence these risky driving indicators. Data were collected from 49 drivers in Aichi Prefecture, Japan, from November 2014 to January 2015. Risky driving behaviors included; (1) speeding, (2) high speed on a non-expressway, (3) high speed on an expressway, (4) high right/left turn rate, (5) long travel, (6) driving at night, (7) driving on an expressway, and (8) driving frequency. At first, the frequency or number of these indicators was compared between the light car group and the standard size car group by a t-test. Second, regression models were established to evaluate the influence of age, gender, living area, and car classification on each risky indicator. The t-test results showed that there was no significant difference in risky driving behaviors between the light car group and the others. The regression models confirmed that car classification did not significantly influence risky driving behaviors. Although age might affect car size selection, an interaction effect between these two factors was not observed. The results of the comparison and regression analysis revealed that drivers of light cars did not drive more carefully than drivers of standard size cars. The risky driving behaviors may partially contribute to the high injury and fatality rates of light cars. Therefore, we suggest that automakers and policymakers should provide more safety education and driving assistance for drivers of light cars.

Keywords: light car; risky driving behavior; travel pattern; dangerous driving; speeding

1. Introduction

Energy consumption and pollutant emission (e.g., CO, NO_x, PM) of vehicles have been major global problems since the last century [1–3]. To decrease the fuel emission of vehicles, the development of lighter and smaller vehicles has been a trend in the automotive industry [4]. Although car classification varies in different countries, increasing numbers of companies and organizations have noticed that the lighter the automobile becomes, the faster its market will grow [5]. In Japan, the sales of Kei cars (under 660 cc) have surpassed 40% and have remained on an upward trend since 2014 [6]. The market shares of small and mini cars in Europe were more than 30%, almost equal to the sum of SUV, off-road vans, sport, luxury, upper medium, and medium vehicles [7].

The light weight of a vehicle can significantly decrease energy consumption. Joost [8] confirmed that the fuel efficiency of a car can be improved by 6–8% for each 10% reduction in weight. To reduce the air pollution, California promotes low emission vehicles by light duty [9]. Moreover, Sun et al. [10] predicted that because lightweight material will be widely used in the automobile industry with the reduction in costs, the energy saving and emission reduction will be archived in the near future.

However, a main obstacle to the widespread use of light cars (please see Section 2.1 for the definition of "light car") was that lighter weight was often accompanied by worries about lower safety [11]. Actually, a high fatality rate of light-car-related accidents has been an unavoidable problem. Sparrow [12,13] demonstrated that the drivers of small cars had higher accident rates than other drivers in any kind of accident. Table 1 [14] lists the accident rates and fatality rates (the proportion of deaths within accidents) from 2010 to 2013 in Japan. It shows that although light cars had lower fatalities in single-vehicle accidents, its fatality rates were higher in collision with other cars. These statistics reflect that light cars performed poorly in occupant protection although they were less aggressive to other vehicles. In Table 2, we summarized the data in the studies of Sparrow [13] and Mu and Yamamoto [14]. It shows that although the deaths per 10^4 vehicles of light car were lower than other classes in 1980–1982, the former had surpassed the latter since 2010. Moreover, according to a report from MLIT, Japan [15], the fatality rate for mini car drivers (under 50 cc) was even higher than that for Kei cars. These findings suggest that lighter cars often have weaker crash safety.

Table 1. Accident rate (%) and fatality rate (%) of light cars and others from 2010 to 2013 in Japan.

	Single-Vehicle Accident Rate*		Multi-Vehicle Accident Rate		Fatality Rate in Single-Vehicle Accidents**		Fatality Rate in Multi-Vehicle Accidents	
	Light Cars	Others	Light Cars	Others	Light Cars	Others	Light Cars	Others
2010	0.0310	0.0220	0.78	0.79	2.89	3.36	0.24	0.19
2011	0.0280	0.0200	0.74	0.75	2.93	3.50	0.25	0.18
2012	0.0250	0.0180	0.72	0.72	3.00	3.41	0.23	0.19
2013	0.0220	0.0160	0.67	0.68	4.47	4.51	0.22	0.19

* Accident rate is the number of accidents per amount of vehicles. ** Fatality rate is the proportion of deaths within accidents.

Table 2. Deaths/10^4 vehicles in 1980–1982 and 2010–2014.

	Deaths/10^4 Vehicles	
	Light Cars	Others
1980	0.75	0.99
1981	0.55	0.98
1982	0.61	0.97
...		
2010	0.47	0.35
2011	0.43	0.34
2012	0.43	0.33
2013	0.39	0.30
2014	0.38	0.31

Although many relevant papers and reports confirmed that a bigger, heavier vehicle is safer than a smaller, lighter one [16,17], we have not known whether drivers of light cars fully understand this fact. Because the high fatality rates may be partially caused by people's risky driving behaviors [14], the drivers of light cars should drive more carefully if they understand the lower safety of their cars. Myers [18] claimed that the ultimate safety factor was the driver rather than vehicle size. Although their conclusion may exaggerate the influence of car type on driving safety, it partially reflects the facts. For example, most drivers will drive carefully if they are told that the car has some problems. However, it was unclear whether the driver of a light car will keep reminding himself/herself of the car's low safety. Yuan et al. [19] defined how to examine whether an adult was a "high-risk driver". Sparrow and Whitford [12] found that 78% of the accidents occurred in urban areas, accounting for less than 40% of fatalities. He explained that both environment and rules helped to decrease fatalities in urban areas because drivers tend to drive slower in urban areas than in areas with low population densities. Thus, he pointed out that drivers and their driving behaviors were more important than car size in driving safety. On the other hand, the different speed limits of light cars and others before 2000 (before 2000: light car and others were 80 and 100 km/h, respectively; after 2000: both are 100km/h) might also contribute to the lower fatality rates for light cars in the 1980s. Many previous studies [20–22] also found the relationship between age and risky driving. Simons-Morton et al [23,24] studied the influence of age on risky behavior and then provided a three-dimensional model to analyze risky teenage driving behavior. Furthermore, by reviewing a series of studies in the literature [25–31], we summarized the following risky driving factors: (1) inexperience; (2) teenage passengers; (3) distraction while driving, including from using cell phones and texting; (4) speeding (please see Section 2.1 for the definition of "speeding"), close following, turning across the intersection, and other risky driving; (5) drinking and driving; (6) driving at night; (7) being male, a teenager, or both; and (8) driving for a long time/distance. Some of these factors (1, 2, 6, 7, and 8) can lead to risky driving, while some of them (3, 4, and 5) are risky driving behaviors in themselves. Moreover, young people and people with lower social economic status are more likely to buy small cars. As mentioned above, they are also more likely to undertake risky driving behaviors. Hence, it may not be the type of car but the age that contributes to risky driving.

According to the fatality data and the relation between driving behavior and safety, we assumed the following two possibilities:

1. Drivers of light cars did not drive more carefully than other classes. It partially contributed to the high fatality of light car-related crashes;
2. Although drivers of light cars had tried to avoid risky behaviors, it could not compensate for the low collision safety of this car class.

Both possibilities required attention. If the former was true, more education and driving assistant should be given to the drivers of light cars. If the latter reflected the fact, we should treat the low safety of light cars more seriously because careful driving may play a limited role in driving safety. Therefore, the first aim of this study was to confirm whether people drive light cars carefully by comparing risky driving behaviors between drivers of light cars and others. As mentioned earlier, although they are much safer than they were a few years ago, the crash safety of light cars still cannot be compared with that of larger vehicle classes. However, driving behaviors can be examined among different car classes if they have the same participant components and the experiment is carried out in the same area. The further aim was to evaluate the factors that influence these risky driving behaviors. The factors included age, gender, living area (please see the definition of "living area" in Section 2.1), and car classification (light car or not).

2. Method

2.1. Terminology

The following concepts should be clearly defined before introducing the participants and data

1. Light car (Kei car):

The definitions of a light car, micro car, and mini car vary in different countries. The subject of this study is light cars ("Kei" in Japanese), which is a category defined by the Road Transport Vehicle Act of Japan. This category has the following six main specifications:

- Engine displacement: under 660 cc
- Engine power: under 47 kw
- Length: under 3.4 m
- Width: under 1.48 m
- Height: under 2.00 m
- Seating capacity: 4 or less

- Loading capacity: under 350 kg

2. Living area

Based on the 2010 population census conducted by the Statistics Bureau of Japan [32], urban areas (Densely Inhabited Districts, DID) are designated in units of census basic unit blocks, and census enumeration districts if there are several census enumeration districts in a census basic unit block. DIDs are defined as areas with a population density of 4000 or more per square kilometer that are adjacent to each other in a municipality, where the total population of the adjacent units is 5000 or more.

- Long trip: a trip longer than 50 km.
- Night time: 19:00–6:00.
- Older driver: a driver who is 65 years old or older.
- Speeding: above 60 km/h on a general road; above 100 km/h on an expressway.
- Trip (the abbreviation of automotive trip): a single journey made by a driver and a car between two points for a defined purpose.

2.2. Participants and Car Types

Data were collected from 49 drivers for this experiment, which was carried out mainly in Aichi Prefecture (this area has a high population density city: Nagoya, several industrial districts, and vast agriculture land), Japan from Nov 11, 2014, to Jan 4, 2015. It should also be noted that although the sample size was small (light car: 14; others: 35), the relatively long experimental period (about two months) helped to collect enough driving data for analysis. All participants drove their own cars. In the two months, each driver drove 34.96 trips (please see Section 2.1 for the definition of "trip") on average, and the total length (average) per driver was 244.89 km. They answered several background questions and permitted the installation of data collection devices in their vehicles. The characteristics of the participants and their cars are shown in Table 3. All participants were divided into the light car group or the standard size car group (without SUV, truck, and bus). The Z-test results show that there were no significant differences between these two groups when comparing drivers' age, gender, or living area. This means that the comparison was conducted with an appropriate control group without self-selection bias.

Table 3. Sample size and distribution in this study.

		Light Car	Others	Total
Age	Older$^{\triangle}$	9 (64.3%)	17 (48.6%)	26 (53.1%)
	Others	5 (35.7%)	18 (51.4%)	23 (46.9%)
	Z-test	0.9957		
Gender	Male	7 (50.0%)	25 (71.4%)	32 (65.3%)
	Female	7 (50.0%)	10 (28.6%)	17 (34.7%)
	Z-test	−1.4236		
Living area	Urban	7 (50.0%)	18 (51.4%)	25 (51.0%)
	Others	7 (50.0%)	17 (48.6%)	24 (49.0%)
	Z-test	−0.0904		
	Total	14	35	49

△ see Section 2.1 for the definition of "older".

2.3. Data

Except for the drivers' characteristics, the following two broad categories of data were assembled in this study.

1. Probe vehicle (PV) data,

2. Road type data.

PV data were collected by in-vehicle devices. They had 171 channels, which recorded GPS (latitude, longitude, and altitude), speed (km/h), engine speed (rpm), clock time, and other data. Data were eliminated while the engine was off or when the GPS data were invalid (e.g., driving in a tunnel, on a mountain road, underneath the viaduct, etc.). Note that once the GPS signal was missed (e.g., after entering a tunnel), the localization estimation algorithm (LEA) operated automatically. Based on this algorithm, the vehicle was assumed to travel in a line extending from the last two GPS records and at the constant speed of the last GPS record. Considering the low credibility of these extrapolations, the estimated data were also discarded in this study.

The Japan Digital Road Map Association [33] classified roads into 9 types: (1) intercity expressway, (2) urban expressway, (3) national road, (4) principal prefectural road, (5) principal municipal road, (6) ordinary prefectural road, (7) ordinary municipal road, (8) others, and (9) uninvestigated. In this study, the former two types were categorized as expressway, while the others were non-expressway.

2.4. Risky Driving Behaviours

In this study, the following risky driving behaviors were included and evaluated:

1. Speeding and high speed

- Average speeding time (s) per minute

In Japan, expressways have a 100 km/h speed limit while local roads have different speed limits (40, 50, or 60 km/h) in different areas.

- Average speed while driving under the speed limit

Considering temporary stoppages or parking caused by traffic congestion, intersections, or personal reasons, records with a speed of 0 km/h were eliminated. Abnormal instantaneous speeds (faster than 180 km/h or slower than 0 km/h), which were mostly caused by device error, were also removed. In the data process of this stage, about 0.07% of observations were abnormal.

2. Right/left turn rate:

In Japan, a country where vehicles travel in the left lane, a right turn across the intersection is more dangerous than a left turn [34]. Therefore, the relative ratio of right to left turns was determined. On the other hand, it should be noted that right and left turns are decided not only by safety concerns but also by the navigation system or driving habits. Therefore, we should explain driving safety not only by driving turning rates but also by other indicators.

1. Long distance driving: the rate of long trips (please see Section 2.1 for the definition of "long trip") calculated as the number of long trips as a percentage of total trips monitored;
2. Driving at night (please see Section 2.1 for the definition of "night"): average time (s) spent driving at night per minute;
3. Driving on expressway: average time (s) spent driving on an expressway per minute;
4. Driving frequency: average number of trips per day;

All of these data were converted from a .csv file to a .mat file and analyzed by MATLAB R2015a. Higher values of these indicators represented more dangerous driving. We calculated the average value of each participant and then the average value among all participants' results. Some indicators, such as speeding and driving at night, needed a clear threshold value. They were clarified in Section 2.1. Finally, we compared each indicator between light car drivers and others, and the results will be shown in Section 3.1.

2.5. Data Analysis

First, the mean and standard deviation of each risky indicator was calculated. The results were compared between the light car group and the standard size car group by t-test [35].

Second, regression models were established to evaluate the influence of the factors of age, gender, living area, and car classification on risky driving behaviors. Because each GPS data point could be considered as a single sample case, and multiple samples with unequal sizes were collected from each person, a random effects regression model was constructed to consider unobserved heterogeneity among drivers. Considering that age might affect car selection, the interaction term between age and car classification was also examined in the regression models.

3. Results

3.1. Comparison Between Light and Standard Size Car Groups

The mean and standard deviations of risky driving behaviors were calculated in each car classification group, respectively. The t-test results (t-stat) in Table 4 show that there was no significant difference ($p > = 0.1$) in risky driving behaviors between the light car and standard size car groups. This result demonstrates that risky driving behaviors did not decline when people drove light cars.

Table 4. Comparison of risky driving behaviors between light cars and others.

No.	Indicators of Risky Driving Behaviors	Light Cars	Others	t-Stat
1	Speeding time (s) per minute	1.06 (0.71)	0.98 (0.66)	0.2934
2	Speed on non-expressway	21.72 (1.70)	19.07 (1.84)	1.6400
3	Speed on expressway	65.89 (1.83)	65.25 (1.14)	0.4374
4	Right/left turn rate	0.98 (0.10)	0.99 (0.14)	−1.3055
5	Long trip rate (0~1)	0.05 (0.25)	0.01 (0.10)	1.6316
6	Night travel rate (0~1)	0.11 (0.34)	0.13 (0.25)	−0.2967
7	Expressway time (s) per minute	1.96 (1.41)	1.94 (1.52)	0.0190
8	Trip frequency (times/day)	3.87 (0.94)	3.86 (0.78)	0.0307

3.2. Regression Models

The random effects regression models of risky driving behaviors are shown in Tables 5 and 6. If an independent variable significantly affected the research object, its value is in bold. Observations (780) in Tables 5 and 6 indicate the number of trips. Data groups were divided by participants considering the correlation of data among different trips by the same driver.

The regression models revealed that car size (X4) did not significantly influence the risky driving behaviors examined in this study. Although age might affect car classification selection, no interaction effect was observed between these two influence factors (X5). The results of the regression model not only confirmed the results of the comparison between the two car size groups but also the rationality of the group division. Moreover, it should be noted that the R-squared values were low in the regression models of this study. Although a higher R-squared value often represents a better model that fits data, R-squared does not simply indicate the adequacy of a regression model [36].

Table 5. Regression analysis of speeding time (s) per minute, speed (km/h) on a non-expressway/expressway, and right/left turn rate.

Independent Variable	Description	Possible Values	Speeding Time (s) Per Minute		Speed (km/h) on Non-Expressway		Speed (km/h) on Expressway		Right/Left Turn Rate	
			Estimate (β)	t-Stat	Estimate (β)	t-Stat	Estimate (β)	t-Stat	Estimate (β)	t-Stat
β_0			4.94	3.25**	11.34	2.09*	66.12	23.78**	0.96	21.29**
X1	Age	*1. Old, 0. Young*	−3.03	−1.77*	−7.71	−1.26	2.48	0.77	0.02	0.47
X2	Gender	*1. Male, 0, Female*	−2.86	−2.65*	−5.84	−1.51	−0.56	−0.26	−0.01	−0.20
X3	Living area	*1. Urban, 0. Others*	2.77	1.92	9.42	1.83	−0.18	−0.06	−0.02	−0.50
X4	Light car (under 660 cc)	*1. Yes, 0. No*	−0.65	−0.58	−1.92	−0.47	1.32	0.69	−0.03	−0.83
Interaction effects between age and other independent variables										
X5	X1 × X4	*1. Yes, 0. No*	2.79	1.94	7.94	1.38	−0.78	−0.26	0.00	−0.07
Number of observations (trips)			780							
Number of groups (participants)			49							
Log likelihood			−2621		−3616		−866		120	
Adjusted R^2			0.0087		0.0004		−0.0049		0.0015	

* $p < 0.05$, ** $p < 0.01$.

Table 6. Regression analysis of long trip, night travel, expressway time (s) per minute, and trip frequency (times/day).

Independent Variable	Description	Possible Values	Long Trip		Night Travel		Expressway Time (s) Per Minute		Trip Frequency (Times/Day)	
			Estimate (β)	t-stat	Estimate (β)	t-stat	Estimate (β)	t-stat	Estimate (β)	t-stat
β_0			0.01	0.23	0.31	3.38**	11.34	2.09*	6.55	10.22**
X1	Age	*1. Old, 0. Young*	0.02	0.31	0.10	0.94	−7.71	−1.26	−0.28	−0.39
X2	Gender	*1. Male, 0, Female*	0.01	0.42	−0.08	−1.21	−5.84	−1.51	0.10	0.21
X3	Living area	*1. Urban, 0. Others*	0.00	−0.09	−0.07	−0.79	9.42	1.83	0.24	0.40
X4	Light car (under 660 cc)	*1. Yes, 0. No*	0.03	1.03	0.00	−0.03	−1.92	−0.47	−0.37	−0.78
Interaction effects between age and other independent variables										
X5	X1 × X4	*1. Yes, 0. No*	−0.03	−0.68	−0.19	−1.90	7.94	1.38	0.51	0.75
Number of observations (trips)			780							
Number of groups (participants)			49							
Log likelihood			145		−438		−3616		−1950	
Adjusted R^2			−0.0024		0.0167		0.0004		−0.0039	

* $p < 0.05$, ** $p < 0.01$.

4. Discussion and Conclusions

The primary purpose of this study was to compare risky driving behaviors between drivers of light cars and others. Although light cars exhibit higher injury and fatality rates than standard size cars, some have claimed that the key factor controlling car safety is the driver rather than the car classification. However, crash safety cannot be compared across different car classifications. Recently, customers have increasingly indicated a preference for cars with fuel economy. If automakers downsize vehicles to achieve better fuel economy, occupant safety will be compromised. While many advancements have recently been introduced to simultaneously achieve fuel economy and safety, most of the time lighter and smaller cars still cannot protect people in collisions with larger, heavier models.

The comparison between the light and standard size car groups revealed that drivers of light cars did not tend to avoid dangerous driving factors such as speeding, turning right across an intersection, long travel, driving at night, and driving on an expressway. This demonstrates that most drivers did not realize nor pay sufficient attention to the weaker safety performance of the light car. Note that light cars often have lower top speeds based on automakers' design or based on transportation policies. However, the present study suggested that light cars' average speed was not slower than the average speed of standard size cars, even on the expressway. Although driving too slowly is also unsafe, the higher speed is a major danger factor. Safety consciousness is one of the most potent factors in traffic injury prevention. Most accidents can be traced to drivers' lack of safety consciousness. However, the results of this study demonstrated that drivers did not try to compensate for the lower crash safety of light cars by driving more carefully, and it may partially contribute to the high fatality rates of light cars.

We cannot easily attribute this phenomenon to drivers because most drivers receive nearly the same training before obtaining their license, regardless of whether they decide to drive a light car or not. The findings of this study suggest that more safety education should be provided both during driver training and before buying a light car. Relevant organizations should promote not only preferential policies for light cars but also safety consciousness education for drivers. Automakers could help improve driver behavior by supplying an advanced driver assistance system (ADAS), such as a speed alert system (SAS) or night vision assistance.

The other aim of this study was to evaluate the factors influencing risky driving behaviors. The results confirmed that car classification did not exert a significant influence on risky driving factors. Although drivers' age affected speeding significantly, an interaction effect between age and car size was not observed. These findings verified that the risky behaviors of light car drivers were not caused by the driver's characteristics, such as age, gender, or living area. Safety consciousness education should be promoted among all light car drivers rather than one specific subgroup.

The main limitation of this study was its limited experimental area (Aichi Prefecture, Japan). Therefore, caution should be exercised while extrapolating the results to the general population or a wider area. Additionally, light cars were defined in this study following the definition of "Kei" cars in Japan, but the specifications for light cars vary in different countries. Moreover, mini cars and micro cars are often distinguished as different car size categories, but they were analyzed as light cars in the present research. Therefore, the definition of light cars should be clearly stated before critiquing or citing the results of this study. Another limitation in this research was that some important factors, such as driver mood, traffic jam, and weather conditions, were not evaluated because of the lack of original data. Driver mood could be obtained by the physiological indicator recorder [37,38]. Traffic jams and weather conditions rely on the historical and real-time data. Weather data can be searched via the website of the Japan Meteorological Agency [39], but there were only 23 observation points in the Aichi area (5172.92 km^2). Because physiological devices and on-vehicle cameras could record the objective and subjective data during driving, we will use them in future experiments. Last but not least, a fact should not be ignored: drivers knew they were participating in an experiment, which may have influenced their behavior. Although the relatively long experimental period (two months) may remedy this defect because participants are able to gradually adopt driving with a data recorder, an experiment with a longer period is needed in the future. Further research is planned to recruit drivers from a wider region and to divide the car classifications into more groups.

Author Contributions: Conceptualization, Y.Z. and T.Y.; methodology, Y.Z. and T.Y.; software, Y.Z.; validation, Y.Z.; formal analysis, Y.Z. and T.Y.; investigation, Y.Z. and T.Y.; resources, T.Y.; data curation, Y.Z. and T.Y.; writing—original draft preparation, Y.Z. and T.Y.; writing—review and editing, Y.Z. and T.Y.; visualization, Y.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Ministry of Education, Culture, Sports, Science, and Technology, Japan, through a Grant-in-Aid for Scientific Research, grant no. 16H02367.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Transport & Environment, CO2 Emissions from Cars: The Facts. Available online: https://www.transportenvironment.org/sites/te/files/publications/2018_04_CO2_emissions_cars_The_facts_report_final_0_0.pdf (accessed on 22 March 2020).
2. Jeon, H. The Impact of Climate Change on Passenger Vehicle Fuel Consumption: Evidence from U.S. Panel Data. *Energies* **2019**, *12*, 4460. [CrossRef]
3. Erahman, Q.F.; Reyseliani, N.; Purwanto, W.W.; Sudibandriyo, M. Modeling Future Energy Demand and CO2 Emissions of Passenger Cars in Indonesia at the Provincial Level. *Energies* **2019**, *12*, 3168. [CrossRef]
4. Lu, H.; Wang, Z.; Mingtu, M.; Cheng, Y.; Lu, G. Multi-Objective Evaluation Regulation Study of Automotive Lightweight. In *Lecture Notes in Electrical Engineering*; Springer Science and Business Media LLC: Berlin, Germany, 2012; Volume 196, pp. 1047–1056.
5. Mohr, D.; Müller, N.; Krieg, A.; Gao, P.; Kaas, H.W.; Krieger, A.; Hensley, R. In McKinsey & Company. (August, 2013). The Road to 2020 and Beyond: What's Driving the Global Automotive Industry. Available online: http://www.mckinsey.com/~{}/media/McKinsey/Industries/Automotive%20and%20Assembly/Our%20Insights/The%20road%20to%202020%20and%20beyond%20Whats%20driving%20the%20global%20automotive%20industry/The%20road%20to%202020%20and%20beyond%20Whats%20driving%20the%20global%20automotive%20industry.ashx (accessed on 22 March 2020).
6. Toyokeizai Online. (Jan, 2015). Kei and Mercedes-Ben Are Selling Very Well. Available online: http://toyokeizai.net/articles/-/57883 (accessed on 22 March 2020).
7. ICCT. (2016). European vehicle market statistics: Pocketbook 2016/17. Available online: https://www.theicct.org/sites/default/files/publications/ICCT_Pocketbook_2016.pdf (accessed on 22 March 2020).
8. Joost, W. Reducing Vehicle Weight and Improving U.S. Energy Efficiency Using Integrated Computational Materials Engineering. *JOM* **2012**, *64*, 1032–1038. [CrossRef]
9. Transport Policy, California: Light-duty: Low Emission Vehicles. Available online: https://www.transportpolicy.net/standard/california-light-duty-low-emission-vehicles/ (accessed on 22 March 2020).
10. Wenlong, S.; Xiaokai, C.; Lu, W. Analysis of Energy Saving and Emission Reduction of Vehicles Using Light Weight Materials. *Energy Procedia* **2016**, *88*, 889–893. [CrossRef]
11. Organisation fro Economic Co-operation and Development (OECD). Can Cars Come Clean? Strategies for Low-Emission Vehicles. 2004, pp. 51–52. Available online: https://www.itf-oecd.org/sites/default/files/docs/04carscleane.pdf (accessed on 30 March 2020).
12. Sparrow, F.; Whitford, R. The coming mini/micro car crisis: Do we need a new definition? *Transp. Res. Part A: Gen.* **1984**, *18*, 289–303. [CrossRef]
13. Sparrow, F. Accident involvement and injury rates for small cars in Japan. *Accid. Anal. Prev.* **1985**, *17*, 409–418. [CrossRef]
14. Mu, R.; Yamamoto, T. A literature review on microcars' safety. In Proceedings of the 53rd Infrastructure Planning Conference, Sapporo, Japan, 28–29 May 2016.
15. Ministry of Land, Infrastructure, Transport and Tourism (Japan). (June 2012). Accident Analysis for Safety Standard Examination of Mini Car Mobility. Available online: http://www.mlit.go.jp/common/000217255.pdf (accessed on 30 March 2020).

16. Montoya, R. Are Small Cars Safe? Comparing Car Crash Safety Ratings: Big vs. Small and Old vs. New. Available online: https://www.edmunds.com/car-safety/are-smaller-cars-as-safe-as-large-cars.html (accessed on 22 March 2020).
17. Insurance Institute for Highway Safety, Highway Loss Data Institute (IIHS-HLDI), Vehicle Size and Weight. Available online: https://www.iihs.org/topics/vehicle-size-and-weight (accessed on 22 March 2020).
18. Myers, A.D. Small Car Safety: What Are the Dangers of Driving Small Cars Long Distance? Available online: https://attorney-myers.com/2018/04/small-cars-more-dangerous/ (accessed on 22 March 2020).
19. Yuan, Y.; Du, F.; Qu, W.; Zhao, W.; Zhang, K. Identifying risky drivers with simulated driving. *Traffic Inj. Prev.* **2015**, *17*, 44–50. [CrossRef] [PubMed]
20. Begg, D.; Langley, J. Changes in risky driving behavior from age 21 to 26 years. *J. Saf. Res.* **2001**, *32*, 491–499. [CrossRef]
21. Koppel, S.; Kuo, J.; Berecki-Gisolf, J.; Boag, R.; Hue, Y.-X.; Charlton, J.L. Examining Physiological Responses Across Different Driving Maneuvers During an On-road Driving Task: A Pilot Study Comparing Older and Younger Drivers. *Traffic Inj. Prev.* **2014**, *16*, 225–233. [CrossRef] [PubMed]
22. Wenzel, T.; Ross, M. The effects of vehicle model and driver behavior on risk. *Accid. Anal. Prev.* **2005**, *37*, 479–494. [CrossRef] [PubMed]
23. Simons-Morton, B.; Lerner, N.; Singer, J. The observed effects of teenage passengers on the risky driving behavior of teenage drivers. *Accid. Anal. Prev.* **2005**, *37*, 973–982. [CrossRef] [PubMed]
24. Simons-Morton, B.; Li, K.; Ehsani, J.; Vaca, F.E. Covariability in three dimensions of teenage driving risk behavior: Impaired driving, risky and unsafe driving behavior, and secondary task engagement. *Traffic Inj. Prev.* **2015**, *17*, 441–446. [CrossRef] [PubMed]
25. Aidman, E.; Chadunow, C.; Johnson, K.; Reece, J. Real-time driver drowsiness feedback improves driver alertness and self-reported driving performance. *Accid. Anal. Prev.* **2015**, *81*, 8–13. [CrossRef] [PubMed]
26. Insurance Institute for Highway Safety (IIHS). Fatality Facts 2010: Teenagers. 2010. Available online: http://www.iihs.org/iihs/topics/t/teenagers/fatalityfacts/teenagers (accessed on 30 March 2020).
27. Klauer, S.; Simons-Morton, B.; Lee, S.E.; Ouimet, M.C.; Howard, E.H.; Dingus, T.A. Novice drivers' exposure to known risk factors during the first 18 months of licensure: The effect of vehicle ownership. *Traffic Inj. Prev.* **2011**, *12*, 159–168. [CrossRef] [PubMed]
28. Klauer, S.; Guo, F.; Simons-Morton, B.; Ouimet, M.C.; Lee, S.E.; Dingus, T.A. Distracted driving and risk of road crashes among novice and experienced drivers. *N. Engl. J. Med.* **2014**, *370*, 54–59. [CrossRef] [PubMed]
29. Geyer, A.; Kremslehner, D.; Muermann, A. Asymmetric Information in Automobile Insurance: Evidence from Driving Behavior. *J. Risk Insur.*. First Published: 28 January 2019. Available online: https://onlinelibrary.wiley.com/doi/10.1111/jori.12279 (accessed on 30 March 2020).
30. National Highway Traffic Safety Administration (NHTSA). (2019). Traffic Safety Facts (2018 Data): Alcohol-Impaired Driving. Available online: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812864 (accessed on 22 March 2020).
31. Olsen, E.O.M.; Shults, R.A.; Eaton, D.K. Texting While Driving and Other Risky Motor Vehicle Behaviors among US High School Students. *Pediatrics* **2013**, *131*, 1708. [CrossRef] [PubMed]
32. Statistics Bureau Japan. What is a Densely Inhabited District? Statistics 2010. 2010. Available online: http://www.stat.go.jp/english/data/chiri/did/1-1.htm (accessed on 22 March 2020).
33. Digital Road Map Association, Japan. Data Content. Available online: https://www.drm.jp/database/content/ (accessed on 22 March 2020).
34. Institute for Traffic Accident Research and Data Analysis (ITARDA). (2012). The Right Turn Accident at Crossroads ver.2012, In Japanese). Available online: https://www.itarda.or.jp/itardainfomation/info95.pdf (accessed on 22 March 2020).
35. Fabri, P.J.; Knierim, T.H. Simple calculation of the unpaired t test. *Surgery Gynecol. Obstet.* **1988**, *167*, 381–382.
36. Frost, J. Regression Analysis: How Do I Interpret R-Squared and Assess the Goodness-of-Fit? 2013. Available online: http://blog.minitab.com/blog/adventures-in-statistics-2/regression-analysis-how-do-i-interpret-r-squared-and-assess-the-goodness-of-fit (accessed on 22 March 2020).
37. Lal, S.; Craig, A. A critical review of the psychophysiology of driver fatigue. *Boil. Psychol.* **2001**, *55*, 173–194. [CrossRef]

38. Lal, S.; Craig, A. Driver fatigue: Electroencephalography and psychological assessment. *Psychophysiol.* **2002**, *39*, 313–321. [CrossRef] [PubMed]
39. Japan Meteorological Agency, Weather historical data in Aichi Area. Available online: https://www.data.jma.go.jp/obd/stats/etrn/select/prefecture.php?prec_no=51&block_no=47636&year=2015&month=10&day=8&view= (accessed on 22 March 2020).