報告番号	甲　第　13626　号

主　論　文　の　要　旨

論文題目　**Characterization of driving behavior in terms of distance with the promotion of electric vehicles**
(電気自動車の推進のための走行距離に関する運転行動分析)

氏　　名　何　嘉杭

論　文　内　容　の　要　旨

The promotion of electric vehicles (EV) requires studies on various aspects, so that the limited battery range could fit the travel demand of consumers, especially the daily travel distance should be focused in order to determine the battery size. From the perspective of EV producer, it is not enough to understand the customer's attitude towards purchasing EV by simply understanding the user's daily driving demand. The other characteristics should also be focused when considering the suitable EV driving range for a specific consumer groups, so that the variables that affect people's driving habit could be determined here.

The first part of this dissertation brought up the goal of vehicle electrification, especially considering the environmental benefit of EV. It mainly focuses on the study of characteristics of driving behavior in terms of the daily driving distance with a university carsharing system data. The benefit of vehicle electrification is discussed in many aspects including environment and energy consumption. In this part, we tested five single distribution functions and a mixture model with 2 lognormal components with the DTD of a sharing system. The test of different distribution functions implied the driving pattern in terms of distance cannot be simulated simply by the single distribution function. The mixture distribution with two lognormal components is the best fitted among all the alternatives. In this way, the driving pattern in terms of distance could be determined with each vehicle by its best fitted form, and is used here to quantify the benefit of vehicle electrification. Two types of EV are used here as

reference, to evaluate the emission reduction and available electricity amount. The two EV types could replace 23 and 30 conventional vehicles respectively, and the emission could be reduced by 19% and 24% respectively. The driving cost could make even with the purchase cost of EV after 1.67 years for Type 1 but it's more than 30 years for Type 2. However, if we use both type in the substitution plan, the 30 replaced EV could reach the emission reduction by 27.6%, and the purchase cost would be made even by the driving cost for 11.37 years. This scenario could be adopted if the university wish to accomplish more reduction in the emission.

Even though it might be difficult for each household to have a V2G system, the electrification of private vehicles could still lead to environmental benefit by individually. However, not every driver would be willing to use EV since they have their own preference on their driving habit. Additionally, the existing EV with limited driving range may not be suitable for all the drivers.

In this way, the second part of this study focused on the driving behavior in terms of daily driving distance of private vehicles, the hazard duration model made it possible to consider the effect of other explanatory variables on the driving distance. The driving preference, and the reason of that preference is revealed in this part. The drivers in this part mainly live in Toyota City, and most of them have fixed job, which implies their driving pattern could be quite fixed. However, the result shows they still have their own preference such as turn to alternative destination nearby due to the terrible weather.

The expanded mixture model from 2 components to 7 components implies the complicated driving behavior. These complicated driving habit could not be explained simply by the distribution function of driving distance. In this way, AFT model is here to measure the effect of variables on driving distance. Compared to the pooled model, the panel AFT model considers the individual difference by using a normally distributed constant. The log-logistic assumption for duration data is the best fitted model among alternatives.

The result determined the factors that affect daily driving distance. The results suggest that the travel distances achieved by people in Toyota City, Japan, is highly dependent on the weather conditions, specifically the precipitation and wind speed. Drivers in Toyota City would prefer an alternative destination nearby during the terrible weather. Socioeconomic indicators, such as age and gender, and vehicle characteristics, such as engine size and vehicle price, also significantly affect the car travel distance. For those who are currently using vehicles with less fuel consumption, they may become the earlier adopter for EV.

Male drivers tend to drive longer than female drivers, and this could be explained by the traditional Japanese family style as women are required to be more focused on families. However, since less than 10% of the participants are female, which made it difficult to be a universal pattern. The situation is same for age difference, even though the result implies elderly

drivers may tend to drive less, but the data set only contains 2 elderly drivers (aged over 65), which made it difficult to summarized the different driving habits between different age groups.

Therefore, the third part of this study mainly focus on the driving behavior of elderly drivers. The data set is divided into 3 different age group as young drivers (aged less than 65), young-old drivers (aged from 65 to 74), and the old-old drivers (aged from 75). The aptitude test result is used to evaluate the driving ability, and the variables for psychological consider are used as interaction items with different age group. In this way, the interaction items could help us in understanding their driving attitude among different age groups. The application of panel survival model with log-logistic, log-normal and Weibull duration on daily travel distance (DTD) and different distribution assumptions on the constant shows the lognormal duration model with normally distributed constant is the best fitted form.

The result implies young-old driver (aged from 65 to 74) and old-old drivers (aged from 75) hold opposite effect on DTD. The young-old group shows the largest positive marginal effect on the DTD while the old-old groups shows the largest negative effect, which implies the driving distance is largely dependent on the driver's age.

The old-old drivers tend to driver shorter distance which can be related with their fading abilities in the aptitude test. However, the higher marginal effect of the interaction items between old-old group and driving attitude imply that even though the old-old driver may have better fitted driving habit with EV, they are also more preferred with risky driving behavior. EV with autonomous functions could be more preferred to them rather than ordinary EV considering the safety problem.

On the other hand, the variables of psychological understanding are not affecting driving distance for young-old drivers compared to other age group. The drivers in this age group prefer to longer driving distance, but this is largely not caused by the psychological consideration. A reasonable guess to this situation is they have more spare time after their retirement. Based on the basic analysis of the DTD by each age group, 96.9% of the trips made by young-old drivers are within 100 km. Thus, even though they may have tendency to drive longer, the existing EV could meet most of their driving demand.

The PSPDS is playing positive effect for both young drivers and old-old drivers in the model. The result shows the marginal effect of two age groups with PSPDS are also close to each other. Compared to young-old drivers, drivers from the other two age groups have stronger purpose of driving, and lead to longer driving distance.

In general, even though the second part of this study determined the elderly drivers tend to drive less than younger drivers. The situation changed when we look deep into the driving distance of different age groups. Psychologically the old-old drivers prefer driving longer distance, but their driving ability limited their driving distance. On the contrary, the

young-old drivers would not be largely affected by their psychological consideration, and they have higher tendency for long distance trips.

The promotion of EV, especially for the EV producer, it requires them to understand their potential customers. As determined in this study, for individual customers, the existing EV already has a driving range which can meet about 95% of their daily travel demand. However, there's still preference in different groups of people, some could be the earlier adopter for EV.

As discussed in the second part, people under 65 who have a fixed job and the commuting distance is also quite fixed could be easier to become EV adopter, especially for those who already have hybrid vehicle or the vehicles with lower fuel consumption. For those beyond 65 and under 74, compared to other age groups, they may not easily become the user of EV, even though their driving demand could be largely fulfilled by EV. The EV with longer driving distance could be more attractive to them. For those beyond 75, their driving distance could be easily covered by existing EV, but since they have tendency for risky behavior tendency, for safety reason, it might be better to recommend the EV with autonomous driving functions to them.