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主　論　文　の　要　旨

論文題目　**Charging Behavior of Battery Electric Vehicle Users in Japan**
（日本における電気自動車利用者の充電行動）

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論　文　内　容　の　要　旨

Electric vehicles are expected to reduce fossil fuel dependency, improve urban air quality, and thus help the transition to more sustainable and environment-friendly travel. These effects are dependent greatly on how an electric vehicle is used. However, researches have shown that it is challenging for users to utilize batteries and charging infrastructure in an optimal way. Therefore, this study aims to explore how factors influence the way people currently charge their vehicles by using battery electric vehicle usage data extracted from a two-year field trial in Japan, with the hope of encouraging users to make effective use of battery and charging infrastructure. In addition, researches have shown that electric vehicle recharging in the evening or during off-peak hours has less of an impact on the electricity grid. However, users tend to recharge electric vehicles randomly at their convenience without considering the state of the electricity grid. Therefore, this study also aims to explore how factors influence choice behavior related to recharge timing by using the same data, with the hope of

encouraging users to charge during off-peak hours by adopting suitable measures.

A stochastic frontier model is first used to explore how factors including charging infrastructure and battery technology associate the way people currently use batteries, as well as to explore whether good use of battery capacity can be encouraged, with the remaining charge when mid-trip fast charging begins is treated as a dependent variable. The estimation results obtained using four models, for commercial and private vehicles, respectively, on working and non-working days, show that remaining charge is associated with number of charging stations, familiarity with charging stations, usage of air-conditioning or heater, battery capacity, number of trips, Vehicle Miles of Travel, speed, and the type of business. However, the associated factors are not similar for the four models. In general, battery electric vehicles with high-capacity batteries are initiated at higher remaining charge. The estimation results also show that there are great opportunities to encourage more effective battery usage. It appears that the stochastic frontier modeling method is an effective way to model the remaining charge at which mid-trip fast-charging should be initiated, since it incorporates trip and vehicle characteristics into the estimation process to some extent.

Then this thesis explores how battery electric vehicle users choose where to fast-charge their vehicles from a set of charging stations, as well as the distance by which they are generally willing to detour for fast-charging. The focus is on fast-charging events during trips that include just one fast-charge between origin and destination in Kanagawa Prefecture, Japan. Mixed logit models with and without a threshold effect for detour distance are applied, and the former shows a better model fitting. Findings from the mixed logit model with threshold show that private users are generally willing to detour up to about 1750m on working days and 750m on

non-working days, while the distance is 500m for commercial users on both working and non-working days. Users in general prefer to charge at stations requiring a shorter detour and use chargers located at gas stations, and are significantly affected by the remaining charge. Commercial users prefer to charge at stations encountered earlier along their paths, while only private users traveling on working days show such preference and they turn to prefer the stations encountered later when choosing a station in peak hours. Only private users traveling on working days show a strong preference for free charging. Commercial users tend to pay for charging at a station within 500 meters' detour distance. The fast charging station choice behavior is heterogeneous among users. These findings provide a basis for early planning of a public fast charging infrastructure.

Lastly, this thesis examines choice behavior in respect of the time at which battery electric vehicle users charge their vehicles. The focus is on normal charging conducted at home after the last trip of the day, and the alternatives presented are no charging, charging immediately after arrival, nighttime charging, and charging at other times. A mixed logit model with unobserved heterogeneity is applied separately for commercial and private vehicles, and estimation results suggest that state of charge, interval in days before the next travel day, and vehicle-kilometers to be traveled on the next travel day are the main predictors for whether a user charges the vehicle or not, that the experience of fast charging negatively affects normal charging, and that users tend to charge during the nighttime in the latter half of the trial. On the other hand, the probability of normal charging after the last trip of a working day is increased for commercial vehicles, while is decreased for private vehicles. Commercial vehicles tend not to be charged when they arrival during the nighttime, while private vehicles tend to be charged immediately.

Further, the correlations of nighttime charging with charging immediately and charging at other times reveal that it may be possible to encourage charging during off-peak hours to lessen the load on the electricity grid. This finding is supported by the high variance for the alternative of nighttime charging.