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主　論　文　の　要　旨

論文題目　**The effects of environmentalism and attitudes toward physical activity on travel behaviors**
(交通行動における環境意識と運動に対する態度の影響)

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論　文　内　容　の　要　旨

Traveling is one among human daily activities, and mobility has become a fundamental aspect of life. To date, the automobile industry and technologies have made it much easier for people to travel, from lower cost of owning a car to cheaper traveling by car sharing. The concept of travel footprint becomes relevant to this context: the more people travel, the more energy we consume and the more emissions we bear. Mass transit is clearly an intuitive solution, nevertheless people view this solution differently. For example, the travelers may want to satisfy their (unlimited) demands and, thus, preferring car use. The policymakers, on the other hand, concern how to keep travel footprints controllable for their environmental purposes. This dissertation takes the policymaker view in seeking for solutions of attracting travelers to public transport (PT). We are particularly inspired by the idea of (1): Triggering the traveler's norms to behave more pro-environmentally, i.e. using PT instead of private cars and; (2): Promoting PT uses by focus on their health benefits (e.g., more intakes of physical activities than car uses).

Specifically, we attempted to examine the effects of environmentalism and Attitudes toward Physical Activity (APA) on several travel behaviors. We are motivated by the potentials of intervening these general attitudes in shaping travel mode uses

toward sustainability, i.e. more PT uses and less private car uses. We set three explicit objectives in this dissertation, including a proposal for combined policies, a suggestion for expanding the list of determinants for travel behaviors, and some methodological improvements. To facilitate these objectives, we followed basically three steps, including a literature review step, a framework development step, and an analysis step. Four cases studies were carried out in the last step using two data sets.

Our works initiated with understandings on the concept of attitude. We then explored various ways that attitudes diffuse over behavioral intentions and overt behaviors. From the literature reviewed, we designated the 'Motivation and Opportunity to serve as the major Determinants' (MODE) model and the Theory of Planned Behavior (TPB) as the theoretical bases for our postulation on the effects of environmentalism and APA on travel behaviors. Considering the popularity of some theoretical models, we designated a choice model framework and a Structural Equation Model (SEM) framework for examining the postulated effects. We introduced several logit-based choice models that can be used with mode choice data, and a standard SEM following a three-steps approach: a principal component analysis, a confirmatory factor analysis, and a full SEM, that is applicable to behavioral data.

The choice model framework and SEM framework were applied using two data sets. The first data set was obtained through a mobility management conducted in Asuke, a small rural town in Japan. Asuke is a low densely populated area where PT system includes only community bus and school bus with low frequencies. Data from Asuke were used with expectation that an established effects of APA on bus uses and bus use intentions would support policies in promoting for bus use by means of intervening on the factor APA. In contrast, the second data set was obtained by an online survey conducted in Nagoya city, Japan in 2018. Nagoya is a highly populated city with full public transport facility, and the data set collected in Nagoya includes only car drivers. This sample allowed for testing the effects of environmentalism and APA on mode choice behaviors and car use behaviors. The corresponding findings thus can contribute to efforts in promoting for public/active transport and for car use reduction.

We conducted four case studies with three forms of travel behaviors investigated, including travel mode choice behaviors, car use behaviors, and bus use intentions.

First, we tested the effects of environmentalism and APA on mode choice behaviors in the case study in Chapter 4. The data set collected in Nagoya was used

including 821 respondents with 1840 reported trips. The Integrated Choice and Latent Variable (ICLV) model and Latent Class Choice (LCC) model were employed, followed by sensitivity and validity analyses. In the estimation results of the ICLV model where environmentalism was allowed to directly affect railway utility, and APA was modeled to cause bicycle and walking utility, only the effect of APA on walking utility was found being significant. The LCC model found a significant negative effect of environmentalism on the probabilities of being in Class 1 (e.g., pro-physical activity group) relative to Class 2 (e.g., pro-environmental group), and a significant positive effect of APA on the probabilities of being in Class 1 versus Class 2. This study thus confirmed the effect of environmentalism on the choices of rail and the effects of APA on the utilities/choices of walking, bicycle. In addition, the LCC model framework was found being useful in heterogeneity treatments in mode choice models with latent variables. Finally, this study revealed that cares for private benefits were higher than cares for environmental issues.

The result of the case study in Chapter 4 was supported by the result from the case study in Chapter 5. We tested the effect of APA on bus utility in a binary logit mode choice model between car and bus. The Asuke data set was used for estimating two postulated models, a clinic/hospital trips model of a sample consisted of 591 trips, and a shopping trips model with 734 trips, both in the Asuke sample. The analytic data were highly unbalanced. As a result, we embedded the Firth bias correction method into the model estimations. We found significant (indirect) effect of APA on bus utility for both cases with and without the bias correction method. In the case without the Firth method, we found very large standard errors in the estimates of some parameters. These errors, however, were reduced significantly when the Firth method was applied. This study thus confirmed the effect of APA on mode choice and signified the usefulness of Firth method in rare choice data.

In the case study in Chapter 6, car use behavior was of our interest. We tested several SEMs that allowed for reciprocal relationships and correlated error terms. The analytic sample included 900 respondents in the Nagoya data set. We employed chi-square difference tests to identify the best models from the postulated models, from that we could make hypothesis inferences. Three main findings were derived. First, unobserved determinants of environmentalism and car use accounted for more than 85% of their variances. Second, we found a significant negative correlation between environmentalism and car use. Finally, a significant causal effect from car use to

environmentalism was found, but not in the opposite direction (e.g., from environmentalism to car use). This study thus confirmed that the relationship between environmentalism and car use behavior is mainly due to correlation, and that car use reduction policies should focus on factors other than environmentalism. This study has illustrated the importance of allowing various types of relationship, i.e. the best models could not be identified without allowing for reciprocal relationships and correlated latent variables.

In the case study in Chapter 7, the low bus share in Asuke motivated us in examining Bus Use Intention (BUI) as an immediate determinant of bus use. We postulated that APA can be linked to BUI as bus use includes certain physical activities. To test this assumption, we based on TPB in assuming that APA causes BUI indirectly through its effect on TPB mediators. This was operationalized by using SEMs and an additional multiple-group analysis. The analytic sample consisted of 1604 respondents was extracted from the Asuke data set. Overall, we found significant effects of APA on BUI in both direct and indirect way. However, the TPB mediators helped to observe these effect clearer and improved the model ability in accounting for the variance of BUI. Further, the effects were stronger for certain groups, such as young people, employed people, and car users. Thus, this study provided an empirical evidence for the hypothesis that APA causes BUI.

Overall, the four case studies converged on the same finding that environmentalism and APA have certain effects on travel behaviors. Policymakers, thus, can see this finding as a suggestion for combining transport policies with environmental and health policies as a cost-effective solution. For the literature in transport studies, we suggested environmentalism and APA as determinants of travel behaviors, and we expect that future studies will give more interests in these factors.

Keywords: Revised NEP scale; New Ecological paradigm; Attitude toward physical activity; Travel behavior; Data separation; Mode choice model; Theory of planned behavior; The MODE model.