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User response to autonomous vehicles and emerging mobility systems

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Mobility systems are evolving with a fast pace all around the world with the emergence of autonomous vehicles, shared mobility solutions and mobility as a service systems (MaaS), with largely unknown implications. The way these systems affect vehicle ownership decisions and travel behavior in general will have critical impacts on our future.

The papers presented in this special issue represent the state of the art in understanding changing mobility systems. The special issue gathers papers from the Transportation Research Board (in collaboration with the Standing Committees on Travel Behavior and Values [ADB10] and Demand Forecasting [ADB40]) as part of a long-standing collaboration with Transportation. Our special issue presents five notable papers that were originally presented at the 2018 TRB Annual Meeting.

The first paper presents an experiment which mimics potential life with a self-driving vehicle. The following two focus on the factors associated with autonomous vehicle adoption, and use data from two different regions in US. The fourth paper presents the outcomes of a field test from Sweden. Finally, the fifth paper presents a modeling approach that matches ride-share trips in a macroscopic travel demand model.

With self-driving vehicles people will not have to sit behind the wheel paying attention to the road. They will not even have to be in the car for various trips, for instance when the car is parking itself. Although autonomous vehicles may bring about several features (i.e. safety and efficiency), the *first paper* by Harb and colleagues "Projecting Travelers into a World of Self-Driving Vehicles: Estimating Travel Behavior Implications via a Naturalistic Experiment" argues that not having to drive will have the biggest impact on future travel behavior. The authors focus on this aspect, and mimic potential life with a self-driving vehicle by providing 60 h of free chauffeur service for each subject over a 7-day period. They analyze the shifts in households' activity-travel patterns with the introduction of the chauffeur service. The study sample consists of 13 households from the San Francisco Bay Area. They record each subject's activity-travel patterns for 3 weeks: 1 week before the

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experiment, experiment (chauffeur) week and 1 week after. Their results are striking. The authors report an 83% increase in VMT from a low of 4% to a high of 341%. They find that all subjects sent the car off to run errands and/or to escort others which make up about one third of the total increase in VMT. They also report that about one fourth of VMT increase is due to 'zero-occupancy' miles. The study confirms our expectation that activity-travel patterns will change with self-driving vehicles: study participants made longer and more frequent trips, and traveled more in the evenings. As with any research study, this study is not without limitations. The authors discuss some of the potential issues with their experiment (i.e. small sample size, whether their experiment truly replicates life with a self-driving vehicle, the limitation on the chauffeur hours and whether 1 week was enough to get into a routine). Despite these limitations, this study makes a unique contribution to our knowledge on self-driving vehicles and their impacts on travel behavior. The authors emphasize that future work should refine their experiment and increase the sample size to develop travel demand models.

The *second paper*, titled "Modeling Adoption Timing of Autonomous Vehicles: Innovation Diffusion Approach", is by Shabanpour, Shamshiripour and Mohammadian. It considers the question of when consumers are likely to purchase a privately-owned autonomous vehicle (AV). The innovation diffusion model considers that consumers may be heterogeneous in their adoption of new technology, with "innovators" seeking to act first, and "imitators" following in response to social norms. The authors demonstrate the application of an innovation diffusion model to AV adoption using stated preference data from the Chicago metropolitan area. The results show that the expected market penetration of AVs would eventually reach 70% and that the likelihood of adoption is influenced by socioeconomic factors, attitudes, and respondents travel habits, such as whether they are frequent long-distance travelers. The method and findings are valuable for improving our understanding of how quickly and how pervasively AVs may enter the market.

The *third paper* by Nair et al. titled "An Application of a Rank Ordered Probit Modeling Approach to Understanding Level of Interest in Autonomous Vehicles" presents an econometric approach for use in analyzing rank-ordered choice data. Whereas in standard choice data, the respondents indicate a single preferred alternative, in rank-ordered data, the respondents indicate their relative preference for each alternative, ranking them first, second, third and so forth. In the past, rank-ordered data have seen limited use in travel-demand models, in part because the standard rank-ordered logit (ROL) model has been shown to produce unstable coefficients. The rank-ordered probit (ROP) model presented in this paper overcomes that limitation, as well as estimation challenges observed in past ROP models. The authors demonstrate the use of this ROP model using an application to different autonomous vehicle (AV) deployment schemes covering both private ownership and shared fleets. Given uncertainty about which AV deployment schemes will emerge, rank-ordered models may provide a useful tool for understanding traveler preferences when a traveler's first choice is unavailable.

The *fourth paper* titled "Inviting Travelers to the Smorgasbord of Sustainable Urban Transport: Evidence from a MaaS Field Trial" focuses on the Mobility as a Service concept (MaaS). MaaS approach meets the individual traveler's mobility needs in an easy-to-access and tailor-made service package. This is expected to enable the travelers to choose and combine the most appropriate transport option for their trips which may decrease the need of owning a car. Strömberg and her colleagues present analyses and discussion regarding who the potential MaaS customer is, their expectations and their behavior. The paper focuses on UbiGo, a service that was implemented, tested and evaluated in Gothenburg, Sweden for a 6-month period. UbiGo offered transport services for each traveler through a subscription system, and comprised of any combination of public transit, taxi, bike/car sharing and car rentals. Individuals accessed the system through a smartphone app. The researchers analyzed respondent interviews, and based on individuals' statements regarding their expectations, reasons, behavioral change and reflections regarding travel, they identify four subgroups of participants: (1) car shedders; (2) car accessors; (3) simplifiers, and (4) economizers. The paper reports the unique reasons, expectations and behavior change pertaining to each specific group. In general, all subgroups drove less and walked more while using the system. There were also changes to pre-trip planning, trip chaining, destinations and travel durations. While using the system, users re-evaluated their choices, options and perceptions of convenience, and in general shifted to more sustainable transport options. The paper concludes with an emphasis on the need of a larger vision where local policies are integrated into the service, and the system connects to city governance and planning more strongly.

The *fifth paper*, by Friedrich, Hartl and Magg is titled "A Modeling Approach for Matching Ridesharing Trips within Macroscopic Travel Demand Models". Due in part to emergence of smartphone-based ride matching apps, ridesharing may become an increasingly important mode of urban travel. Ridesharing can take multiple forms, including the case where the driver is making a trip anyway and aims to add a passenger for a fee, and the case (such as currently operated by major Transportation Network Companies) where the driver operates as a taxi driver who would not otherwise be on the road. This research is concerned primarily with the former, where there is a need to match the trips of the drivers with those of potential passengers. It presents an algorithm that converts the path of a driver's trip into a sequence of zones, and identifies passenger trips between those zones that can be matched to the driver's trip. This algorithm would serve as an added component to a travel demand model that would help identify the market for and impacts of such a ridesharing system.

Collectively, the selected papers offer methods for modeling the demand for new technologies in the transportation field and provide insights into their potential impacts on human behavior and travel outcomes.

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