NBER PROPOSAL: Consumer Valuation of Size-Related Vehicle Attributes

Vehicle use - especially in cities - generates many external costs (Sultana et al, 2019; Gössling et al., 2022). These include air and water pollution, increased global carbon dioxide concentrations, millions of injuries and fatalities each year, traffic congestion, exacerbating inequalities of access and quality of life (King et al., 2022), and disconnecting communities. Electric vehicles reduce some of these external costs, but may increase others and generate new ones (Rapson and Muehlegger, 2023). Big vehicles generate larger external costs than small ones on most of these metrics (e.g. Anderson and Auffhammer, 2014), and the benefits of electrification are much larger if vehicle buyers would *also* downsize as they electrify.

Yet the market has trended strongly toward larger vehicles; Car and Driver magazine recently dubbed the current period the "Age of the SUV." Explanations for the trend include both market supply- and demand-side drivers, with an additional boost from - ironically - government environmental policies (Ito and Sallee, 2018). Most of the existing literature focuses on supply-side and government policy drivers of vehicle size increases. Estimates of how much consumers actually value size-related vehicle attributes are relatively uncommon and highly variable (Greene et al., 2018).

The proposed research will contribute with new, high-quality estimates of how much and for what reasons consumers value vehicle size. These findings may point the way to new opportunities for vehicle designs that both improve consumer welfare and reach environmental and other societal goals. We ask the following three key questions:

1. How much do consumers value attributes related to vehicle size (i.e. passenger seats, cargo space, towing capacity, ground clearance, vehicle height, four wheel drive, body type, and safety rating) in the United States?
2. How does the valuation of these vehicle attributes vary across consumer market segments?
3. What are possible strategies for vehicle size and weight reduction that optimize - or at least minimize the loss to - consumer welfare?

To answer these questions, we will develop a stated preference choice experiment to be deployed as part of a larger survey about household vehicle holdings and choices, and responses will be collected from a nationally-representative sample of 10,000 U.S. residents in Summer 2024. A survey panel company will invite and compensate respondents, and quota sampling will be used to ensure demographic and regional sample representativeness.

The experiment will include the following eight attributes of interest, with number of modeled levels indicated in parentheses: vehicle height (2), ground clearance (2), cargo space (3), passenger space (2), safety rating (3), towing capacity (2), four-wheel drive (2), and body type (3). These vehicle attributes were chosen because they are often bundled with vehicle size and weight, and we hypothesize that they encompass what consumers truly value about large vehicles. The choice experiment will also include the attribute of vehicle price so that we can obtain estimates of consumer willingness to pay for each of the eight size-related attributes.

Due to the relatively large number of attributes and levels in our study, a full factorial choice experiment design is not practical. We propose instead to employ a D-efficient design (Walker et al. 2018; Rose & Bliemer, 2009), which will allow us to use the data to obtain high-quality estimates of consumer willingness to pay for each of these size-related vehicle attributes. The D-efficient choice experiment design aims to minimize the standard error of the estimated parameters, allowing for more precise estimation with fewer choice occasions. To further reduce survey respondent burden, we propose to use a heterogenous blocking design, where each respondent is only asked a subset of the full D-efficient choice experiment question set.

Prior to administering the stated choice experiment in the large national sample, a pilot study will be administered. The pilot study will be fielded with approximately 50 respondents, and used to obtain the priors required to generate the D-efficient design for the full experiment, as well as help to address any shortcomings in other aspects of the survey design. Stated choice experiments designed with informative priors can further improve the efficiency of the model estimates (Rose & Bliemer, 2009).

The analysis of the stated choice data will be based on the random utility model (RUM) framework in the form of a mixed logit model. The mixed logit model will allow us to infer consumer preferences and substitution effects in addition to calculating willingness to pay (WTP) measures. In addition to obtaining overall WTP estimates, we plan to estimate how WTP for size-related vehicle attributes differs based on key demographic characteristics such as life stage and age, as well as between those who own sedans, SUVs, and trucks.

The proposed stated choice experiment is part of a larger survey on household vehicle holdings in the US, which this research team is currently developing. The full survey takes the following form. Following some demographic screening questions for quota-sampling, respondents will be asked to provide information on their current household vehicle holdings. Then, respondents will go through the choice experiment, where they will be asked to choose between vehicle options with varying attributes numerous times. The stated choice experiment will be placed early in the survey because evaluating tradeoffs can lead to cognitive fatigue. After the stated choice experiment module, respondents will be asked to provide information related to their experience with electric vehicles, other transportation choices and attitudes. The survey will close with a few additional demographic questions that were not asked upfront.

Informing research or policy issues of interest to DOT

The US government has committed to reducing transportation emissions through the transition to electric vehicles. The prevalence of large vehicles makes this transition more challenging, for three reasons. First, larger vehicles require more energy to operate. For an electric vehicle, this means either larger batteries, which are expensive and heavy, or shorter driving range between charges, which makes the vehicle less attractive. Second, the electrification of larger vehicles is likely to exacerbate non-emission externalities, specifically through reduced public safety and increased non-exhaust pollution from tire wear - both a result of increased vehicle weight from large batteries. Third, large batteries require more mining of critical minerals and associated social and environmental consequences (Riofrancos et al., 2023).

While the US transition to an electric vehicle fleet provides us an opportunity to rethink the vehicle fleet makeup, prior research has found that large vehicle owners, particularly SUV owners, are less willing to

substitute other body types in the context of adopting an electric vehicle (Forsythe et al. 2023). Given the popularity of SUVs today, SUV consumer buy-in to electric vehicles is crucial. However, as mentioned above, an eSUV dominant market is likely to increase external costs.

In sum, most external costs of vehicle use increase with vehicle size - regardless of whether the vehicle is gasoline or electricity-powered. In an effort to increase the efficiency of emission reductions, and to avoid unwanted consequences of vehicle electrification, many scholars have recommended that the sheer size and weight of the vehicle fleet be reduced (notably, Shaffer et al., 2021). Currently, there is a lack of understanding of how large these welfare losses would be, or by what vehicle attributes the loss would occur, since size and weight are often bundled with - and therefore a proxy for - vehicle attributes that consumers value.

This research aims to generate a clearer picture of how consumers value vehicle weight- and size-related attributes, providing a better understanding of consumers' willingness to substitute across these vehicle attributes. This information then can be used to better design and deploy strategies for vehicle size and weight reduction that optimize - or at least minimize the loss to - consumer welfare.

Research Team Composition

Drs. Deborah Salon and Ram Pendyala will lead the proposed research, with assistance from doctoral student Nicole Corcoran. Bios for each are below.

Deborah Salon is Associate Professor, School of Geographical Sciences and Urban Planning and Associate Director, TOMNET University Transportation Center, Arizona State University. Salon has more than 25 years of experience conducting research related to cars and car dependence. She began her career at the Environmental Defense Fund, researching new policy designs to reduce greenhouse gas emissions from light-duty vehicles. She subsequently authored reports on transport policy for the International Energy Agency, the Pew Center for Climate Change, and the California Air Resources Board, among others. Important for this project, Salon has extensive experience with survey design and implementation, advanced econometric data analysis, management of large datasets, and successful project management. Before joining ASU, Salon completed a postdoctoral fellowship at Columbia University's Earth Institute and held a research faculty position at the Institute of Transportation Studies at the University of California at Davis. She holds a PhD in applied economics from the University of California at Davis and a Bachelor's in physics from Carleton College in Northfield, MN.

Ram M. Pendyala is Professor of Transportation Systems, School of Sustainable Engineering and the Built Environment and Director, TOMNET University Transportation Center, Arizona State University. TOMNET is dedicated to advancing the state of the practice in transportation modeling. Pendyala has published more than 200 refereed articles and conducted more than $15 million in sponsored research for a variety of public and private organizations. Important for this project, he teaches courses and conducts research in travel survey methods and the application of advanced econometric and statistical methods for transportation data analysis. Pendyala holds a PhD and MS in Civil Engineering with a focus in transportation systems from the University of California at Davis and a Bachelor's in Civil Engineering from the Indian Institute of Technology-Madras in Chennai, India.

Nicole Corcoran is an Urban Planning PhD Student in the School of Geographical Sciences and Urban Planning at Arizona State University. Nicole has a Bachelors of Science and Masters of Science in Industrial and Systems Engineering from the University of Iowa. Prior to arriving at ASU, she held research roles at the National Advanced Driving Simulator and the Injury Prevention Research Center, where she worked on a range of projects related to road safety and autonomous vehicle development. Nicole is currently a research assistant at TOMNET University Transportation Center, and recently received the TOMNET student of the year award.

Conflict of Interest

No members of the research team have any existing or expected financial or other conflicts of interest to report.

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