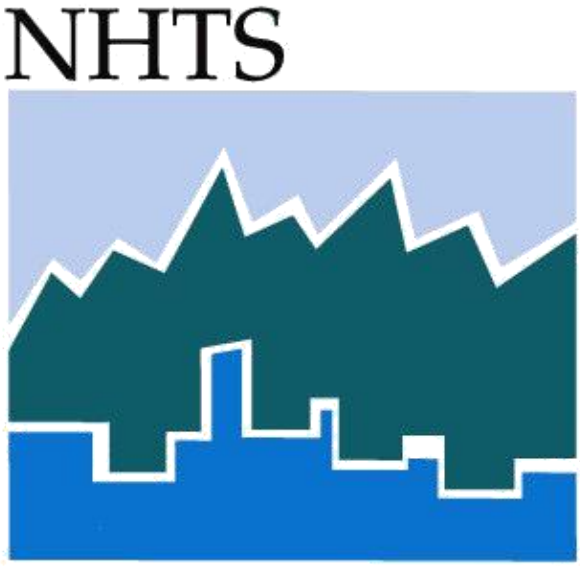

National Household Travel Survey

Compendium of Uses

January 2021–December 2021

Foreword

This compendium contains various uses and applications of the National Household Travel Survey (NHTS) data referenced in transportation planning and research from January 2021 through December 2021. The articles and reports in this compendium cover a diverse range of topics in the areas of transportation, health, safety, environment, and engineering and were published in various journals, including but not limited to the *Transportation Research Record*, the *Journal of Transport Geography*, and the *Journal of Transport & Health*. Several papers were also submitted by researchers and graduate students for presentation and publication to the Transportation Research Board's (TRB's) 100th Annual Meeting and can be found in the *2021 TRB Annual Meeting Compendium of Papers*. Source material was also identified through Google Scholar™ and Google Alerts™ using "National Household Travel Survey" and "NHTS" keyword and search engine terms.

These selected articles and reports were grouped into 12 categories using the subject areas and index terms identified in each abstract as well as category titles used in previous NHTS compendium databases. The following categories, broken out by report chapter, were used in this version of the compendium:

1. Bicycle and pedestrian studies.
2. Energy consumption.
3. Environment.
4. Health.
5. Policy and mobility.
6. Special population groups.
7. Survey, data synthesis, and other applications.
8. Traffic safety.
9. Transit planning.
10. Travel behavior.
11. Trend analysis and market segmentation.
12. Emerging travel modes.

This compendium includes a short description of each article and report along with the title, author(s), abstract, subject areas, and availability.

Please note that the 2021 compendium consists of 454 research articles and reports. It is updated on an ongoing basis with newly published papers that cite NHTS data. For information about adding a research paper to the NHTS compendium, please contact Daniel Jenkins at Daniel.Jenkins@dot.gov.

Search and documentation support was provided by Layla Sun (MacroSys), who also categorized the paper abstracts.

Table of Contents

Chapter 1. Bicycle and Pedestrian Studies

1.1 Title: Are Walking and Cycling Good for All? Tracking Differences in Associations Among Active Travel, Socioeconomics, Gentrification, and Self-reported Health

Author(s): Barajas, J. and Braun, L.

Abstract: While the health benefits of walking and cycling have been well established, questions remain about whether these benefits hold in varying socioeconomic contexts, including across demographic groups and in the context of neighborhood change. This study examines this relationship, identifying the association between cycling or walking and self-reported health, whether socioeconomic status moderates the association between cycling or walking and health, and whether gentrification influences potential moderating effects using the 2017 National Household Travel Survey, a representative sample of the U.S. population. People who had cycled in the past week and each additional walking trip was associated with higher odds of reporting better health. Socioeconomic status moderated the positive associations between active transportation and health in a few key cases. Cycling was not as strongly associated with health for black cyclists or employed cyclists, while women had smaller benefits from each additional walking trip compared to men. Gentrification was an insignificant moderating factor in most cases. Findings suggest planning efforts that continue to support programs that promote cycling and walking are crucial tools in the public health toolbox, but infrastructure investments must be attentive to inequities across neighborhoods.

Subject Areas: Bicycling; Walking; Socioeconomic status; Gentrification; Health

Availability: Barajas, J. and Braun, L. (2021). *Are Walking and Cycling Good for All? Tracking Differences in Associations Among Active Travel, Socioeconomics, Gentrification, and Self-reported Health*. Transportation Research Board 100th Annual Meeting—A Virtual Event, Washington, DC. https://annualmeeting.mytrb.org/OnlineProgram/Details/15626

1.2 Title: Provo Named a Silver-level Bicycle Friendly Community

Author(s): Pugmire, G.

Abstract: Blog.

Subject Areas: Provo; Bicycle; Trails; Community; Bicycle-friendly community; Policy

Availability: Pugmire, G. (2021). "Provo Named a Silver-level Bicycle Friendly Community." *Daily Herald.* https://www.heraldextra.com/news/local/central/provo/provo-named-a-silver-level-bicycle-friendly-community/article_a349e680-a82a-5583-ac0c-9a10e703aa25.html

1.3 Title: Review of Contextual Elements Affecting Bicyclist Safety

Author(s): Dai, B. and Dadashova, B.

Abstract: One of the significant health concerns associated with bicycling is roadway crashes; the number of crashes involving bicyclists has been increasing in recent years. As a result of the increased movement of bicyclists and safety concerns, States and cities have been implementing countermeasures such as installing an increasing number of on-street bikeway facilities to accommodate the bicyclists. However, there is a lack of guidance about understanding the contextual factors that affect bicyclist safety. There is a need to identify the list of contextual factors affecting bicyclist safety and mobility to ensure that the most effective actions are taken to create a safer cycling environment. The objective of this paper is to identify the list of contextual elements affecting bicyclist safety. We used a narrative review approach to identify and review the relevant literature to identify the contextual factors that affect bicyclist safety. We established search terms (i.e., keywords) and criteria for identifying the relevant literature based on the PRISMA approach. As a result, 52 out of 693 studies were included in the review. The results indicate that the following groups or categories of contextual factors affect the bicyclist safety: built environment and infrastructure, bicyclist exposure, demographic and socioeconomic factors, behavioral factors, and temporal factors. Each category includes a number of factors that can affect both bicyclist crash frequency and severity. We conclude this study with the overview of the paper, main findings, and future concerns (i.e., research opportunities).

Subject Areas: Bicyclist safety; Contextual elements; Built environment and infrastructure; Safety in numbers; Socioeconomic factors and equity; Driver behavior

Availability: Dai, B. and Dadashova, B. (2021). "Review of Contextual Elements Affecting Bicyclist Safety." *Journal of Transport & Health*, *20*. https://doi.org/10.1016/j.jth.2021.101013

1.4 Title: Exploration of the Contributing Factors to the Walking and Biking Travel Frequency using Multi-Level Joint Models with Endogeneity

Author(s): Singh, M., Cheng, W., Gopalakrishnan, R., Li, B., and Cao, M.

Abstract: The enormous advantages of active transportation lead the transportation research focus toward enhancing the walking and biking trips. The present study contributes to the current literature by determining the influential factors to the walking and biking travel frequency based on data obtained from the National Household Travel Survey (NHTS) California add-on survey. The study features some highlights. First, bivariate models were used to account for the common unobserved heterogeneity shared by the same persons and/or houses for the number of walking and biking trips. Second, endogeneity was explicitly considered due to the strong interdependency between walking and biking trips. Third, the bivariate normal distribution was applied to both household and person levels of random effects. Fourth, both variable importance ranking and correlation analyses were employed to determine the features to be fed into the models, which are different for each of the joint models. Fifth, to efficiently estimate the model parameters, a fast Bayesian inference approach, Integrated Nested Laplace Approximation (INLA) was used. Finally, distinct evaluation metrics were utilized for a comprehensive understanding of the model performance. The results illustrated that the models developed with endogeneity performed better than the those without endogeneity being included. Four influential variables, including mode to work by bicycle, public transit usage, count of household members, and multiple race responses, tend to have significantly significant impacts on walking and biking trips.

Subject Areas: Influential factors; Walk and bicycle trips; Bivariate models; Endogeneity; Bayesian inference approach

Availability: Singh, M., Cheng, W., Gopalakrishnan, R., Li, B., and Cao, M. (2021). *Exploration of the Contributing Factors to the Walking and Biking Travel Frequency using Multi-Level Joint Models with Endogeneity*. Transportation Research Board 100th Annual Meeting—A Virtual Event, Washington, DC. https://annualmeeting.mytrb.org/OnlineProgram/Details/15859

1.5 Title: Online Discussion Tackles Lack of Micromobility Use Among Women

Author(s): Washington (Brain).

Abstract: Blog.

Subject Areas: Micromobility; Gender; Diversity

Availability: Bicycle Retailer and Industry News. (2021). "Online Discussion Tackles Lack of Micromobility Use Among Women." *Bicycle Retailer and Industry News*, Boulder, CO. https://www.bicycleretailer.com/industry-news/2021/02/25/online-discussion-tackles-disproportionate-use-micromobility-among-men-and#.YHhPguhKiUl

1.6 Title: Generalized Model for Mapping Bicycle Ridership with Crowdsourced Data

Author(s): Nelson, T., Roy, A., Ferster, C., Fischer, J., Brum-Bastos, V., Laberee, K., Yu, H., and Winters, M.

Abstract: Fitness apps, such as Strava, are a growing source of data for mapping bicycling ridership due to large samples and high resolution. To overcome bias introduced by data generated from only fitness app users, researchers build statistical models that predict total bicycling by integrating Strava data with official counts and geographic data. However, studies conducted on single cities provide limited insight on best practices for modeling bicycling with Strava as generalizability is difficult to assess. Our goal is to develop a generalized approach to modeling bicycling ridership using Strava data. In doing so we enable detailed mapping that is more inclusive of all bicyclists and will support more equitable decision-making across cities. We used Strava data, official counts, and geographic data to model average annual daily bicycling (AADB) in five cities: Boulder, Ottawa, Phoenix, San Francisco, and Victoria. Using a machine learning approach, LASSO, we identify variables important for predicting ridership in all cities, and independently in each city. Using the LASSO-selected variables as predictors in Poisson regression, we built generalized and city-specific models and compared accuracy. Our results indicate generalized prediction of bicycling ridership on a road segment in concert with Strava data should include the following variables: number of Strava riders, percentage of Strava trips categorized as commuting, bicycling safety, and income. Inclusion of city-specific variables increased model performance, as the R2 for generalized and city-specific models ranged from 0.08–0.80 and 0.68–0.92, respectively. However, model accuracy was influenced most by the official count data used for model training. For best results, official count data should capture diverse street conditions, including low ridership areas. Counts collected continuously over a long time period, rather than at peak periods, may also improve modeling. Modeling bicycling from Strava and geographic data enables mapping of bicycling ridership that is more inclusive of all bicyclists and better able to support decision-making.

Subject Areas: Bias-correction; LASSO; Big data; Bicycling ridership; Exposure; Strava

Availability: Nelson, T., Roy, A., Ferster, C., Fischer, J., Brum-Bastos, V., Laberee, K., Yu, H., and Winters, M. (2021). "Generalized Model for Mapping Bicycle Ridership with Crowdsourced Data." *Transportation Research Part C: Emerging Technologies*, *125*. https://doi.org/10.1016/j.trc.2021.102981

1.7 Title: Mobility Patterns Before, During, and Anticipated After the COVID-19 Pandemic: An Opportunity to Nurture Bicycling

Author(s): Ehsani, J.P., Michael, J.P., Duren, M.L., Mui, Y., and Porter, K.M.P.

Abstract: Introduction: The purpose of this study is to quantify the immediate and anticipated effect of the COVID-19 pandemic on local travel in the United States.

Methods: A national survey of a representative sample of U.S. adults was conducted using the Harris Poll panel. The online survey was conducted from June 17 to 29, 2020. Respondents reported the frequency of travel before the pandemic, during the pandemic, and anticipated travel when normal activities resume for walking, bicycling, personal vehicle use, and public transit. Analyses were conducted in July and August 2020.

Results: During the pandemic, local travel significantly decreased (−10.36%, 95% CI= −16.26, −4.02) relative to prepandemic levels. Within travel modes, significant decreases were reported for public transit, personal vehicle use, and walking. There was no change in reported bicycle use during the pandemic period relative to prepandemic levels. When normal activities resume, respondents anticipated a significant increase in bicycling (24.54%, 95% CI=3.24, 50.24). Anticipated travel using personal vehicles, public transit, and walking were not significantly different from the prepandemic levels.

Conclusions: Unlike the other local travel modes, bicycling did not decrease during the pandemic and is anticipated to significantly increase. Investment in bicycle-safe infrastructure could sustain the anticipated increase in bicycling.

Subject Areas: Bicycling; COVID-19; Local travel

Availability: Ehsani, J.P., Michael, J.P., Duren, M.L., Mui, Y., and Porter, K.M.P. (2021). "Mobility Patterns Before, During, and Anticipated After the COVID-19 Pandemic: An Opportunity to Nurture Bicycling." *American Journal of Preventive Medicine*. https://doi.org/10.1016/j.amepre.2021.01.011

1.8 Title: Foot Notes: A Podcast About Walkability and Race

Author(s): Linke, L.

Abstract: The prevailing approach to researching, designing, and implementing walkability focuses almost exclusively on the built environment. This approach operates under the assumption that "good design" is objective, neutral, and universal. This is simply not true. Walking is deeply personal, political, social, and cultural. Our experience of walking through public space is determined just as much by the identities we inhabit as by the space itself. This original podcast series utilizes a sociocultural approach to examine the intersection of walkability and race, and specifically the experiences of Black pedestrians in the United States.

Subject Areas: Walkability; Race; Pedestrians

Availability: Linke, L. (2021). *Foot Notes: A Podcast About Walkability and Race*. Master's Thesis, Tufts University, Medford, MA.
https://search.proquest.com/openview/a2f77eba7608c3785d2e38f411c8b514/1?pq-origsite=gscholar&cbl=18750&diss=y

1.9 Title: Who is Biking for? Urban Bikeshare Networks' Responses to the COVID-19 Pandemic, Disparities in Bikeshare Access, and a Way Forward

Author(s): Tiako, M.J.N. and Stokesb, D.C.

Abstract: Black, Latinx, and indigenous people have contracted the SARS-CoV-2 virus and died of COVID-19 at higher rates than white people. Individuals rated public transit, taxis, and ride-hailing as the modes of transportation putting them at greatest risk of COVID-19 infection. Cycling may thus be an attractive alternative for commuting. Amid the increase in bikeshare usage during the early months of the pandemic, bikeshare companies made changes to membership requirements to increase accessibility, targeting especially essential workers. Essential workers in the United States are disproportionately Black and Latinx, underpaid, and reliant on public transit to commute to work. We document changes made by bikeshare companies, including benefits to various groups of essential workers, and we discuss such changes in the context of longstanding racial disparities in bikeshare access. While well intended, the arbitrary delineation in eligibility for such benefits by class of essential workers unwittingly curtailed access for many who may have benefited most. Given that equity in bikeshare is an important tool to improve access to safe transportation, critical changes in the distribution, accessibility, and usability of bikeshare networks is essential. Bikeshare companies, city planners, and policymakers should collaborate with community-based bike advocates to implement changes, as vocalized by those most in need of alternative forms of transportation.

Subject Areas: Cycling; Bikeshare; COVID-19; Health equity; Urban design; Public health

Availability: Tiako, M.J.N. and Stokesb, D.C. (2021). "Who is Biking for? Urban Bikeshare Networks' Responses to the COVID-19 Pandemic, Disparities in Bikeshare Access, and a Way Forward." *Yale Journal of Biology and Medicine*, *94*(1), pp. 159–164. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7995947/#R29

1.10 Title: ALF-Score: Network-Based Walkability

Author(s): Alfosool, A.M.S., Chen, Y., and Fuller, D.

Abstract: Walkability is a term that describes aspects of the built and social environment. Previous studies have shown that different operationalizations of walkability are associated with physical activity and health. Walkability can be subjective and although multiple operational definitions and walkability measurement exist, there is no single agreed upon conceptual definition. Despite lack of consensus of a walkability definition, typical operational definitions include measures of population density, destinations, and the road network. Network science approaches such centralities and network embedding are missing from existing methods, yet they are integral parts of our mobility and should be an important part of how walkability is measured. Furthermore, most walkability measures have a one-size-fits-all approach and do not take into account individual user's characteristics or walking preferences. To address some limitations of previous works, we developed the Active Living Feature Score (ALF-Score). ALF-Score is a network-based walkability measure that incorporates the road network structures as a core component. It also utilizes user data to build high-confidence ground truth that are used in conjunction with our machine learning pipeline to generate models capable of estimating walkability scores that address existing gaps in the walkability literature. We find, relying on road structure alone, we are able to train our models to estimate walkability scores with an accuracy of over 86% while maintaining a consistency of over 98% over collected user data. Our proposed approach outperforms existing measures by providing a walkability data at a much higher resolution as well as a user-derived result.

Subject Areas: Global positioning systems; Information systems applications; Spatial-temporal systems; Spatial behavior; Road networks; Crowd-sourced data

Availability: Alfosool, A.M.S., Chen, Y., and Fuller, D. (2021). "ALF-Score: Network-Based Walkability." *OSF Preprints*. https://osf.io/tcgqp

1.11 Title: Bike-share Equity in the Time of Coronavirus

Author(s): Cobbs, C.

Abstract: Blog.

Subject Areas: Bike-share; COVID-19; Equity

Availability: Cobbs, C. (2021). "Bike-share Equity in the Time of Coronavirus." *StreetBlog Chicago*. https://chi.streetsblog.org/2021/04/20/bike-share-equity-in-the-time-of-coronavirus/

1.12 Title: The CanBikeCO Mini Pilot: Preliminary Results and Lessons Learned

Author(s): Shankari, K., Boyce, L., Hintz, E., and Duvall, A.

Abstract: In fall 2020, the Colorado Energy Office, as part of the State of Colorado's "Can Do Colorado" initiative, initiated a project aimed at encouraging energy-efficient transportation during the COVID-19 pandemic. The initial mini-pilot provided e-bikes to 13 low-income households under an individual ownership model. This report assesses the impact of providing this additional mobility option on the travel behavior of participants. It also outlines the lessons learned from deploying a continuous monitoring platform to track the travel behavior. These lessons will influence the evaluation component for the full pilot, which will cover multiple geographic regions, start in summer 2021, and run for 2 years.

The continuous data collection was enabled by a customized version of the open-source emission platform, called *CanBikeCO*, configured with a behavioral gamification feature. The Colorado Energy Office used this system to collect a unique data set consisting of 3 months of partially automated travel diaries, combining sensed and surveyed data and linked with demographic information, from 12 participants. The data collection process worked well overall: users generally liked the app, appreciated the game, and did not complain about battery life. The long tracking period introduced behavioral challenges in user engagement, which we plan to address using repeated patterns and automated status checks for the full pilot.

The analysis results, based on the subset of trips with user-reported labels (68%), indicate that the e-bike was the dominant commute mode share (31%), in sharp contrast to the census bicycle commute mode share (<1%). E-bike trips primarily replaced single-occupancy vehicle (SOV) trips (28%), followed closely by walking (24%) and regular bike (20%). The nonmotorized mode replacement corresponds to lower travel time and increased productivity enabled by the program. The emissions impact analysis of the program, computed using trip-level energy intensity factors, indicates savings of 1,367 lbs. of CO_2. Although the results are strongly positive, the narrow demographic profile of study participants, their limited mobility alternatives, and nonuniform labeling indicate caution in broader interpretation.

These preliminary results do suggest that such programs, supported by real-time education and support from program managers, can simultaneously meet equity and sustainability goals. The planned full pilot, addressing the data collection challenges and broadening the geographic scope, will provide additional insights into the generality of this approach.

Subject Areas: Low-income household; Trave behavior; E-bike; Emission; Equity; Sustainability

Availability: Shankari, K., Boyce, L., Hintz, E., and Duvall, A. (2021). *The CanBikeCO Mini Pilot: Preliminary Results and Lessons Learned*. National Renewable Energy Laboratory, Golden, CO. https://www.nrel.gov/docs/fy21osti/79657.pdf

1.13 Title: Mayor Thompson Declares May 2021 “Bike Month” in Broadview

Author(s): Ormsby, D.

Abstract: Blog.

Subject Areas: Bike; Health; Environment; Community

Availability: Ormsby, D. (2021). “Mayor Thompson Declares May 2021 ‘Bike Month’ in Broadview.” *Patch*. https://patch.com/illinois/westside/mayor-thompson-declares-may-2021-bike-month-broadview

1.14 Title: Bike Commuting Almost Doubles Over Past Two Decades, According to Report

Author(s): BRAIN Staff.

Abstract: Blog.

Subject Areas: Bike commuting; State ranking

Availability: BRAIN Staff. (2021). "Bike Commuting Almost Doubles Over Past Two Decades, According to Report." *Bicycle Retailer and Industry News*, Boulder, CO. https://www.bicycleretailer.com/studies-reports/2021/05/20/bike-commuting-almost-doubles-over-past-two-decades-according-report#.YL_MQflKiUk

1.15 Title: How Various Levels of the Built and Social Environments Affect Walking and Bicycling Trips Generated from Households: Evidence from Florida

Author(s): Mahmoudi, J. and Zhang, L.

Abstract: Based on principles of the ecological model, this study probes the relationship between nonmotorized travel and built/social environment factors at multiple levels of influence. Mixed-effects models are developed to analyze walking and bicycling trips generated from households in Florida. The results indicate that nonmotorized trips are associated with built environment factors at various levels including at the neighborhood, county, and metropolitan area levels. Increased walking/bicycling trips are correlated with increased compactness, mixed-use development, pedestrian friendliness of streets, intersection density, and transit service frequency within the neighborhood and county. Additionally, more walking trips are associated with improved street connectivity throughout the entire metropolitan area. The analysis further suggests that at various levels of influence, the key social environment factor determining the extent of nonmotorized trips generated from households is vehicle ownership. These findings can assist decision-makers aiming to increase nonmotorized trips in evaluating interventions that involve changes to the built and/or social environment, and in arriving at more potent solutions.

Subject Areas: Mixed-effects models; Walking and bicycling trips; Built environment factors

Availability: Mahmoudi, J. and Zhang, L. (2021). "How Various Levels of the Built and Social Environments Affect Walking and Bicycling Trips Generated from Households: Evidence from Florida." *International Conference on Transportation and Development 2021 (Virtual Conference)*. https://doi.org/10.1061/9780784483541.004

1.16 Title: Buffalo Has Always Been A Bike City: A Brief History Part 2

Author(s): Hassan, T.

Abstract: Blog.

Subject Areas: Street design; Emission; Electric mobility device; Bicycling; Buffalo history; Environment; GObike Buffalo; Urban sprawl

Availability: Hassan, T. (2021). "Buffalo Has Always Been A Bike City: A Brief History Part 2." *Buffalo Rising*. https://www.buffalorising.com/2021/06/buffalo-has-always-been-a-bike-city-a-brief-history-part-2/

1.17 Title: Urban Bicycle Infrastructure and Gentrification: A Quantitative Assessment of 46 American Cities

Author(s): Morrison, G.

Abstract: In recent years, cities across the United States have expanded their bicycle infrastructure. In some instances, community members and local politicians have criticized these developments and noted a link between bicycle lanes and gentrification. In response, recent studies have assessed the quantitative associations between bicycle infrastructure and gentrification in a few large cities. Their results have been mixed but generally support residents' claims of linkages between gentrification and bike infrastructure. However, research is often limited to a handful of large central cities, mostly in the United States. This thesis assessed the associations between gentrification and bicycle infrastructure such as bike lanes and off-street trails and paths in 46 large American cities. Specifically, it used contemporary municipal bicycle infrastructure data aggregated to the census tract level. It conducted multivariate regression analyses to identify the cross-sectional associations between gentrification and other socio-economic indicators and the presence of bike infrastructure. It compared these associations by city size and geographic region. It found substantial evidence that gentrifying tracts had higher rates of cycling infrastructure relative to disadvantaged, non-gentrifying tracts. This trend was less pronounced in America's largest 5 cities, and there was substantial regional variation in both infrastructure coverage and relative levels when comparing gentrifying, non-gentrifying, and advantaged tracts.

Subject Areas: Gentrification; Displacement; Bike; Bike lanes; Bike infrastructure

Availability: Morrison, G. (2021). *Urban Bicycle Infrastructure and Gentrification: A Quantitative Assessment of 46 American Cities*. Bachelor's Thesis, University of Chicago, Chicago, IL. http://dx.doi.org/10.6082/uchicago.2927

1.18 Title: Abstracting Mobility Flows from Bike-Sharing Systems

Author(s): Kon, F., Ferreira, É.C., de Souza, H.A., Duarte, F., Santi, P., and Ratti, C.

Abstract: Bicycling has grown significantly in the past 10 years. In some regions, the implementation of large-scale bike-sharing systems and improved cycling infrastructure are two of the factors enabling this growth. An increase in non-motorized modes of transportation makes our cities more human, decreases pollution, traffic, and improves quality of life. In many cities around the world, urban planners and policymakers are looking at cycling as a sustainable way of improving urban mobility. Although bike-sharing systems generate abundant data about their users' travel habits, most cities still rely on traditional tools and methods for planning and policy-making. Recent technological advances enable the collection and analysis of large amounts of data about urban mobility, which can serve as a solid basis for evidence-based policy-making. In this paper, we introduce a novel analytical method that can be used to process millions of bike-sharing trips and analyze bike-sharing mobility, abstracting relevant mobility flows across specific urban areas. Backed by a visualization platform, this method provides a comprehensive set of analytical tools to support public authorities in making data-driven policy and planning decisions. This paper illustrates the use of the method with a case study of the Greater Boston bike-sharing system and, as a result, presents new findings about that particular system. Finally, an assessment with expert users showed that this method and tool were considered very useful, relatively easy to use and that they intend to adopt the tool in the near future.

Subject Areas: Bike-sharing; Mobility; Data science; Visualization; Open-source software; Application case study

Availability: Kon, F., Ferreira, É.C., de Souza, H.A., Duarte, F., Santi, P., and Ratti, C. (2021). "Abstracting Mobility Flows from Bike-Sharing Systems." *Public Transport*. https://doi.org/10.1007/s12469-020-00259-5

1.19 Title: Planning Car-lite Neighborhoods: Does Bikesharing Reduce Auto-Dependence?

Author(s): Basu, R. and Ferreira, J.

Abstract: Bike enthusiasts argue that bikesharing programs can be an important element of sustainable mobility planning in the urban cores of large metropolitan areas. However, the objective long-term impact of bikesharing on reducing auto-dependence is not well-examined, as prior studies have tended to rely on self-reported subjective mode substitution effects. We use a unique longitudinal dataset containing millions of geo-referenced vehicle registrations and odometer readings in Massachusetts over a six-year period - the Massachusetts Vehicle Census - to examine the causal impact of bikesharing on various metrics of auto-dependence in the inner core of Metro Boston. The difference-in-differences (DiD) framework is extended to accommodate spatial spillover effects with the inclusion of a spatial autoregressive lag leading to the spatial DiD (SpDiD) model. We also account for seasonal variation in bikeshare operations, where several stations are shut down for the winter months, by setting up a dynamic treatment definition. We find that a new bikeshare station reduces vehicle ownership per household by 2.2%, vehicle miles traveled per person by 3.3%, and per-capita vehicular GHG emissions by 2.9%. We also find strong evidence to support the use of bikesharing as a first/last-mile connector to mass transit. Auto-dependence reductions are around 10% (more than thrice as high as average) where bikeshare connections to transit stations are less than one kilometer long. Finally, we find that vehicle ownership reductions are almost immediate and last up to a year, while vehicle use and emission reductions are lagged over 1.5 years. These sizeable and measurable auto-substitution effects do support some of the claims of bikesharing advocates. These findings are especially important in the post-COVID-19 era, as cities strive to counter the pandemic-inspired safety skepticism about non-car travel.

Subject Areas: Bikesharing; Difference-in-differences; Spatial autocorrelation; Vehicle ownership; Vehicle miles traveled; Vehicle emissions

Availability: Basu, R. and Ferreira, J. (2021). "Planning Car-lite Neighborhoods: Does Bikesharing Reduce Auto-Dependence?" *Transportation Research Part D: Transport and Environment*, *92*. https://doi.org/10.1016/j.trd.2021.102721

1.20 Title: Breaking Down Race-Related Barriers to Recreational Cycling: Experiences from Diverse Cycling Groups

Author(s): Bopp, M., Mama, S.K., Wilson, O.W., and Elliott, L.D.

Abstract: Cycling offers many health-related, environmental, and economic benefits, although rates of participation are low among ethnic minorities. Studying individuals who have successfully adopted the behavior can provide insight on addressing factors that could influence participation in the activity. This qualitative study aimed to examine experiences and perceptions of a diverse group of recreational cyclists. An online survey with open-ended questions was distributed to members of minority cycling clubs. Questions addressed norms, barriers, supports, and stereotypes surrounding cycling. Responses were coded within a social-ecological framework and common themes identified using thematic content analysis. Participants (N = 33) were mostly middle-aged adults and predominantly African American, male, and college educated. Concerning norms around cycling, the most frequent response addressed race-related stereotypes; income was also noted to be a theme, related to disposable income necessary to participate in cycling, as well as sex. Participants responded that cycling clubs could play a role in demonstrating the diversity of participation in cycling. This study provides new insights into the experiences, attitudes, and beliefs of ethnic minority cyclists. The main themes that were identified were related to social and cultural norms surrounding participation in this activity and have implications for further promotion of cycling among diverse populations.

Subject Areas: Physical activity; Cycling; Ethnic minority; Cultural; Social

Availability: Bopp, M., Mama, S.K., Wilson, O.W., and Elliott, L.D. (2021). "Breaking Down Race-Related Barriers to Recreational Cycling: Experiences from Diverse Cycling Groups." *World Leisure Journal*. https://doi.org/10.1080/16078055.2021.1937304

1.21 Title: Assessment of Bicycle Detection Confirmation and Countdown Devices

Author(s): Monsere, C., Kothuri, S., Hurwitz, D., Cobb, D., and Jashami, H.

Abstract: This research examined alternate designs for bicycle detection feedback confirmation devices. The research used quantitative data from a video review and responses from surveys to study how the information provided by the confirmation and feedback device affects the overall cycling experience. An online survey was conducted to determine comprehension rates of blue light feedback systems and countdown timers. The findings from the online survey (1,048 responses) revealed that the comprehension of the blue light detection confirmation devices by themselves was generally poor. Comprehension improved when a supplemental sign explaining the blue light was added. The countdown timer elicited high comprehension. Following the online survey, blue light detection confirmation systems were installed at six intersections far side and one nearside. A bicycle signal countdown timer was installed at one intersection. Video has recorded and analyzed and intercept surveys were conducted. A total of 2,428 persons on bicycle were analyzed and 234 intercepted persons were surveyed. Findings from the far-side installations suggest that the design where the blue light was embedded in the sign was more visible to cyclists and observed by higher proportions of cyclists in the field. Findings from the near-side location were limited due to the single location. Results from the countdown timer indicate high comprehension rates. At all locations, cyclists indicated that the devices improved their waiting experience. There were changes to bicycle compliance and waiting location, but they were site-specific. Observations at the nearside locations were conducted during the COVID-19 pandemic.

Subject Areas: Traffic control devices; Bicycle detection; Traffic operations; Blue light; Countdown signal

Availability: Monsere, C., Kothuri, S., Hurwitz, D., Cobb, D., and Jashami, H. (2021). *Assessment of Bicycle Detection Confirmation and Countdown Devices*. Final Report, Oregon Department of Transportation, Salem, OR.
https://www.oregon.gov/odot/Programs/ResearchDocuments/SPR825_FinalReport.pdf

1.22 Title: Electric Vehicles Will Not Save Our Cities, But Electric Bikes Might

Author(s): Gotta, J.

Abstract: Blog.

Subject Areas: Electric bikes; Walking and biking; Infrastructure; Green energy transition; Battery

Availability: Gotta, J. (2021). "Electric Vehicles Will Not Save Our Cities, But Electric Bikes Might." *Propmodo, Inc.* https://www.propmodo.com/electric-vehicles-will-not-save-our-cities-but-electric-bikes-might/

1.23 Title: The Power of the Neighborhood: Perceived Normative Behaviors Moderate Individual Predictors of Walking and Biking to School

Author(s): Ross, A. and Wilson, K.

Abstract: Introduction: Parent attitudes and perceptions of convenience are primary determinants of children's mode of school travel. Parents may favor the use of active transportation to school, such as walking or biking, if supportive neighborhood normative behaviors are present.

Methods: A series of logistic regressions with marginal effects were conducted to investigate whether seeing others, talking or waving, seeing kids walk alone, or seeing kids walk with adults along the way to school modified the impact of parent attitudes and reported ease of driving a car on active school travel among parents of children in grades K–6 (N = 390) in Phoenix, AZ (USA).

Results: The likelihood of using active transportation to school was positively associated with favorable parent attitudes, and the odds of using active travel modes differed less than 10 percent with the presence of neighborhood normative behaviors and low or high attitudes. As reported ease of driving increased, the likelihood of using active transportation to school decreased. The presence of neighborhood norms did not change the negative trajectory, but differences existed when ease of driving was low compared to high. The probability of using active transportation to school when ease of driving was low compared to high was greater when participants saw others (29.3 percent to, 32.8 percent from), talked/waved to others (11.0 percent to, 0 percent from), saw kids walking alone (28.6 percent to, 35.7 percent from), and saw kids walking with adults (27.8 percent to, 51.5 percent from).

Conclusions: Echoing prior work, parent attitudes and perceptions of convenience of driving remain influential determinants of children'' active school travel behavior. This study provides preliminary evidence on the influences of psychosocial support within the neighborhood to promote active transportation to school. The impact of supportive normative behaviors during the school journey should be considered in active transportation to school interventions, particularly in conjunction with efforts to change parent perceptions of ease of driving.

Subject Areas: Active transportation to school; Neighborhood; Parent attitudes; Driving convenience; Normative behaviors

Availability: Ross, A. and Wilson, K. (2021). "The Power of the Neighborhood: Perceived Normative Behaviors Moderate Individual Predictors of Walking and Biking to School." *Journal of Transport & Health*, *22.* https://doi.org/10.1016/j.jth.2021.101236

1.24 Title: Biking Where Black: Connecting Transportation Planning and Infrastructure to Disproportionate Policing

Author(s): Barajas, J.M.

Abstract: This study asks whether deficiencies in transportation are associated with disproportionate policing in Chicago using the case of cycling. I examine how the number of bicycle citations issued per street segment are influenced by the availability of bicycle facilities and street characteristics, controlling for crash incidence, police presence, and neighborhood characteristics. Tickets were issued 8 times more often per capita in majority Black tracts and 3 times more often in majority Latino tracts compared to majority White tracts. More tickets were issued on major streets, but up to 85 percent fewer were issued when those streets had bike facilities, which were less prevalent in Black and Latino neighborhoods. Tickets were not associated with bicycle injury-crashes and inversely associated with vehicle injury-crashes. Infrastructure inequities compound the effects of racially biased policing in the context of transportation safety strategies. Remedies include the removal of traffic enforcement from safe systems strategies and equitable investment in cycling.

Subject Areas: Cycling; Policing; Mobility justice; Infrastructure; Safety

Availability: Barajas, J.M. (2021). "Biking Where Black: Connecting Transportation Planning and Infrastructure to Disproportionate Policing." *Transportation Research Part D: Transport and Environment*, *99.* https://doi.org/10.1016/j.trd.2021.103027

1.25 Title: Purpose-Based Walking Trips by Duration, Distance, and Select Characteristics, 2017 National Household Travel Survey

Author(s): Watson, K.B., Whitfield, G.P., Bricka, S., and Carlson, S.A.

Abstract: Background: New or enhanced activity-friendly routes to everyday destinations is an evidence-based approach for increasing physical activity. Although national estimates for some infrastructure features surrounding where one lives and the types of nearby destinations are available, less is known about the places where individuals walk.

Methods: A total of 5 types of walking trips (N = 54,034) were defined by whether they began or ended at home (home based [HB]) and trip purpose (HB work, HB shopping, HB social/recreation, HB other, and not HB trip) (2017 National Household Travel Survey). Differences and trends by subgroups in the proportion of each purpose-oriented trip were tested using pairwise comparisons and polynomial contrasts.

Results: About 14% percent of U.S. adults reported ≥1 walking trip on a given day. About 64 percent of trips were HB trips. There were few differences in prevalence for each purpose by subgroup. For example, prevalence of trips that were not HB decreased significantly with increasing age and increased with increasing education and household income.

Conclusions: Given age-related and socioeconomic differences in walking trips by purpose, planners and other professionals may want to consider trip origin and destination purposes when prioritizing investments for the creation of activity-friendly routes to everyday destinations where people live, work, and play.

Subject Areas: Active transport; Epidemiology; Surveillance

Availability: Watson, K.B., Whitfield, G.P., Bricka, S., and Carlson, S.A. (2021). "Purpose-Based Walking Trips by Duration, Distance, and Select Characteristics, 2017 National Household Travel Survey." *Journal of Physical Activity & Health*, *18*(S1), pp. 86–93. https://doi.org/10.1123/jpah.2021-0096

1.26 Title: Analyzing Barriers to Integrating Bike Share with Green Transportation Modes and the Trail System in Greater Cincinnati, Ohio

Author(s): Rogers, III, W.P.

Abstract: Bicycles have become more than recreational equipment and bike-share has given people an even more convenient and relatively affordable way to take both recreational and utilitarian trips. The benefits that bike-share offers to help address inequity in accessibility increase when it is used as a solution to the first-/last-mile (FLM) issue with respect to public transit (Shaheen and Chan, 2016; Zou et al., 2020). Even though barriers to FLM, such as the distribution of stations and trips between bike-share and transit, safety, weather, etc., have been frequently studied (Venter, 2020), few studies incorporate people's individual-level perceptions of their barriers and/or the integration of multiuse paths into the network of bike-share and public transit. This paper uses a survey that was conducted in the eight counties of the Ohio-Kentucky-Indiana region of Greater Cincinnati to examine individual-level perceptions of integrating bike-share and public transit with a focus on barriers to using multiuse paths. The survey, which was designed and implemented by our research team, addressed three major research questions: (1) what are people's major barriers to using or using more frequently multiuse paths to solve the FLM issue? (2) to what extent does the built environment around people's residential location affect their integration level? (3) which improvements would mostly likely encourage people to integrate green modes (e.g., cycling, walking, and riding transit) more often? Statistical comparison and geographical mapping were employed to investigate two groups defined as "Integration" (those who have taken two green modes together in one journey) and "No Integration" (those who have not). The major barrier to integrating multiuse paths into the usage of the green transportation system was their lack of connection to transit and bike-share. Results revealed that more than half of all respondents in both groups would use multiuse paths or do so more often if an integrated green transportation system could be provided or improved. Geographical mapping results of 400-meter catchment areas around green transportation facilities based on respondents' residential locations indicate that a person's living environment is spatially related to their integration level: The more connected green transportation facilities they are near, the more likely they are to integrate them. These findings suggest the potential for incorporating multiuse paths to address the FLM issue. The results from phone interviews based on the survey contribute even more evidence that decreasing the distance between active transportation networks will lower the impact of barriers on people who have to incorporate them into their daily lives. If these green modes are planned and designed as a well-connected system from the start, most people, especially those who have been already using green modes, will be more likely to use them. This implies that better coordination should take place among local government, transit agencies bike-sharing programs, and trail management organizations in planning and implementing plans and investing in relevant facilities. Specifically, building and connecting more multiuse paths to transit stops will provide bike-sharing riders easier and safer access to jobs, healthcare, and more.

Subject Areas: Active transportation; Multimodal transportation; Bike-share; Multiuse paths; Transit

Availability: Rogers, III, WP. (2021). *Analyzing Barriers to Integrating Bike Share with Green Transportation Modes and the Trail System in Greater Cincinnati, Ohio*. Master's Thesis, University of Cincinnati, Cincinnati, OH.
http://rave.ohiolink.edu/etdc/view?acc_num=ucin1626456265307731

1.27 Title: A Thousand Bike-Commuting Huskies … and Counting

Author(s): Subak, S.

Abstract: Blog.

Subject Areas: Bike; Bike commuting to school; Bike parking facilities; Safe Routes to School Program; Infrastructure

Availability: Subak, S. (2021). "A Thousand Bike-Commuting Huskies … and Counting." *Wednesday Journal of Oak Park and River Forest*. https://www.oakpark.com/2021/12/14/a-thousand-bike-commuting-huskies-and-counting/

1.28 Title: Are Cycling and Walking Good for All? Tracking Differences in Associations Among Active Travel, Socioeconomics, Gentrification, and Self-Reported Health

Author(s): Barajas, J.M. and Braun, L.M.

Abstract: Introduction: While the health benefits of cycling and walking have been well established, questions remain about whether these benefits hold in varying socioeconomic contexts, including across demographic groups and in the context of neighborhood change. This study examines this relationship, identifying associations between cycling or walking and self-reported health, whether socioeconomic status moderates these associations, and whether gentrification influences the potential moderating effects.

Methods: This study uses the 2017 U.S. National Household Travel Survey, subset to adults who lived in central cities (n = 91,541). Weighted logistic regression models with interaction terms were fit to estimate self-reported health status separately for cycling and walking. Gentrification was measured using an indicator based on previous research using U.S. Census data.

Results: Cycling in the previous week and each additional walking trip were associated with higher odds of reporting better health. Socioeconomic status moderated the positive associations between active transportation and health for a few variables. Cyclists of color had smaller health effects from cycling for utilitarian trips, while race and ethnicity had only a marginal moderating effect on the association between walking and health. Gentrification was an insignificant moderating factor in general.

Conclusions: Findings suggest planning efforts that continue to support programs that promote cycling and walking are crucial tools in the public health toolbox. The health gains from active transportation might be experienced in a variety of neighborhood contexts. Nevertheless, infrastructure investments and policy must be attentive to inequities across neighborhoods.

Subject Areas: Bicycling; Walking; Gentrification; Self-reported health; Equity

Availability: Barajas, J.M. and Braun, L.M. (2021). "Are Cycling and Walking Good for All? Tracking Differences in Associations Among Active Travel, Socioeconomics, Gentrification, and Self-Reported Health." *Journal of Transport & Health*, *23*.
https://doi.org/10.1016/j.jth.2021.101246

1.29 Title: Factors Influencing Dock-Less E-Bike-Share Mode Substitution: Evidence from Sacramento, California

Author(s): Fukushige, T., Fitch, D.T., and Handy, S.

Abstract: Dock-less e-bike-share use is likely to reduce vehicle miles traveled (VMT) and related greenhouse emissions—if it substitutes for car use. If the major mode shift comes from public transit, owned bike, or walking, the benefits will be more limited. The goal of this paper is to identify the factors influencing mode substitution, defined here as the mode that is replaced when bike-share is used. The analysis shows that the dominant mode substitution for trips of less than 1 mile for most trip purposes is walking. Long trips and non-commute trips that start at non-commercial locations are likely to represent car substitution, and some groups, such as women, non-membership holders, and those who have a private car, are more likely to report car substitution for any trip purpose. These results provide guidance for designing bike-share operations and policies to enhance car substitution.

Subject Areas: Dock-less e-bike-share; Mode substitution; Bayesian multinomial logistic regression; Sacramento

Availability: Fukushige, T., Fitch, D.T., and Handy, S. (2021). "Factors Influencing Dock-Less E-Bike-Share Mode Substitution: Evidence from Sacramento, California." *Transportation Research Part D: Transport and Environment*, *99*. https://doi.org/10.1016/j.trd.2021.102990

1.30 Title: Investors Double Down on Rad Power Bikes with $154 Million Investment, Making it the Most Funded Electric Bike Company in the World

Author(s): Rad Power Bikes.

Abstract: Blog.

Subject Areas: Electric bike; Direct-to-consumer; Global climate crisis

Availability: Rad Power Bikes. (2021). "Investors Double Down on Rad Power Bikes with $154 Million Investment, Making it the Most Funded Electric Bike Company in the World." *PRNewswire*. https://www.prnewswire.com/news-releases/investors-double-down-on-rad-power-bikes-with-154-million-investment-making-it-the-most-funded-electric-bike-company-in-the-world-301410624.html

1.31 Title: Understanding Factors Influencing Shared E-Scooter Usage and Its Impact on Auto Mode Substitution

Author(s): Guo, Y. and Zhang, Y.

Abstract: Shared e-scooter is a fairly new transportation mode that emerged in late 2017. Since then, it has gained popularity around the world; however, it also has spiraled into disarray in many cities due to the lack of e-scooter regulations and improper parking and riding behaviors. Limited understanding of shared e-scooters restrains policymakers from developing more effective regulations and promoting this sustainable transportation mode. This study takes a step toward understanding e-scooter user behaviors by investigating factors that influence e-scooter-sharing usage and auto mode substitution. Survey data were collected from shared e-scooter users, and random parameter models were applied to explore the factors influencing e-scooter-sharing usage and mode substitution. Factors considered in models include sociodemographic information, user behaviors, trip purposes, and health indicators. Model results identify several factors that significantly influence shared e-scooter usage, including user gender, helmet use, exposure to shared e-scooters, ownership of an e-scooter, riding locations, opinions on speed limits, and trip purposes. Contributing factors for auto substitution suggest that shared e-scooters potentially are competing with TNC/taxi, lower cost, and social/entertainment trip purpose, and user households with multiple vehicles contribute to private vehicle substitution. Research outcomes suggest that shared e-scooters could play a significant role in urban transportation sustainability. Insights related to better practices for e-scooter regulations and planning are discussed to help cities improve shared e-scooter program performance and make it a more sustainable transportation mode.

Subject Areas: Shared e-scooter; User behaviors; Regulations and planning; Sustainability

Availability: Guo, Y. and Zhang, Y. (2021). "Understanding Factors Influencing Shared E-Scooter Usage and Its Impact on Auto Mode Substitution." *Transportation Research Part D: Transport and Environment*, *99*. https://doi.org/10.1016/j.trd.2021.102991

1.32 Title: Op-Ed: Why Government Should Invest in E-Bikes

Author(s): Duren, M. and Kennedy, R.D.

Abstract: Blog.

Subject Areas: E-bikes; Government investment; Cycling infrastructure; Health benefits; Trip distance; Affordability

Availability: Duren, M. and Kennedy, R.D. (2021). "Op-Ed: Why Government Should Invest in E-Bikes." *Streetsblog USA*. https://usa.streetsblog.org/2021/11/15/op-ed-why-government-should-invest-in-e-bikes/

1.33 Title: E-Bike Buyers Would Get New Tax Credit Under Budget Plan as Lawmakers Seek Ways to Curb Climate Change

Author(s): Duncan, I.

Abstract: Blog.

Subject Areas: E-bike; Active transportation; Infrastructure; Bike safety; Tax credits; Emission reduction

Availability: Duncan, I. (2021). "E-Bike Buyers Would Get New Tax Credit Under Budget Plan as Lawmakers Seek Ways to Curb Climate Change." *The Washington Post.* https://www.washingtonpost.com/transportation/2021/09/18/ebikes-reconciliation-carbon-emissions/

1.34 Title: OPINION: E-Bikes Could Become a Weapon Against Climate Change

Author(s): Stout, J.

Abstract: Blog.

Subject Areas: E-bike; Climate; Infrastructure; Daily trips

Availability: Stout, J. (2021). "OPINION: E-Bikes Could Become a Weapon Against Climate Change." *Streetsblog USA.* https://usa.streetsblog.org/2021/09/30/opinion-e-bikes-could-become-a-weapon-against-climate-change/

Chapter 2. Energy Consumption

2.1. Title: Feedbacks Among Electric Vehicle Adoption, Charging, and the Cost and Installation of Rooftop Solar Photovoltaics

Author(s): Kaufmann, R.K., Newberry, D., Xin, C., and Gopal, S.

Abstract: Identifying feedback loops in consumer behaviours is important to develop policies to accentuate desired behaviour. Here, we use Granger causality to provide empirical evidence for feedback loops among four important components of a low-carbon economy. One loop includes the cost of installing rooftop solar (Cost) and the installation of rooftop solar (photovoltaics, PV); this loop is probably generated by learning by doing and reductions in the levelized cost of electricity. The second includes the purchase of electric vehicles (EV) and the installation of rooftop solar that is probably created by environmental complementarity. Finally, we address whether installing charging stations enhances the purchase of electric vehicles and vice versa; there is no evidence for a causal relation in either direction. Together, these results indicate ways to modify existing policy in ways that could trigger the Cost↔PV↔EV feedback loops and accelerate the transition to carbon-free technologies.

Subject Areas: Economics; Energy and society; Environmental sciences; Environmental social sciences

Availability: Kaufmann, R.K., Newberry, D., Xin, C., and Gopal, S. (2021). "Feedbacks Among Electric Vehicle Adoption, Charging, and the Cost and Installation of Rooftop Solar Photovoltaics." *Nature Energy*, *6*, pp. 143–149. https://doi.org/10.1038/s41560-020-00746-w

2.2. Title: Drivers Who Spend Too Much on Fuel Efficiency

Author(s): Levinson, A. and Sager, L.

Abstract: Minimum standards for automobile fuel economy were first set in the United States in the 1970s and have since spread to Europe, Asia, and now Latin America. Regulators claim the rules save car buyers money on average, implying a market imperfection or behavioural anomaly. This column presents new evidence that those averages mask enormous variation. While some drivers could likely save money by spending more upfront for efficient cars, many others overspend for efficient cars they rarely use. Demographics, not economics, determine car choices.

Subject Areas: Cars; Fuel savings; Electric vehicles; Behavioural economics

Availability: Levinson, A. and Sager, L. (2021). "Drivers Who Spend Too Much on Fuel Efficiency." *VoxEU.org*. https://voxeu.org/article/drivers-who-spend-too-much-fuel-efficiency

2.3. Title: Decentralized Stochastic Programming for Optimal Vehicle-to-Grid Operation in Smart Grid with Renewable Generation

Author(s): Wang, Y., Liang, H., and Dinavahi, V.

Abstract: This paper presents a decentralized stochastic programming operation scheme for a vehicle-to-grid system in a smart grid, which includes a series of equipment with random power generation and demands. For households with electric devices, renewable solar power generation, energy storage systems, and electric vehicles, we consider utility operating expenses, including power loss and energy consumption cost as the objective function. For customers, we consider the cost of electricity, including battery degradation. To investigate the uncertainty of the devices, a bottom-up approach is proposed to develop a random device usage model for analyzing customers' uncertain behaviour. Besides, a random renewable power generation model and an electric vehicle random driving model are implemented. The proposed approach is implemented with OpenMP to simulate the decentralized process on a multi-core central processing unit (CPU) while reducing the computational burden. A case study based on the IEEE 33-bus distribution system with different scenarios is used to evaluate the performance of the proposed approach. The simulation results show that by introducing an optimal household operation schedule, the expense of distribution system utility company can be reduced in which both customers and operators can benefit from the optimization of the system schedules.

Subject Areas: Decentralized stochastic programming; Vehicle-to-grid system; Renewable solar power generation; Utility operating expenses

Availability: Wang, Y., Liang, H., and Dinavahi, V. (2021). "Decentralized Stochastic Programming for Optimal Vehicle-to-Grid Operation in Smart Grid with Renewable Generation." *IET Renewable Power Generation*, *15*, pp. 746–757.
https://ietresearch.onlinelibrary.wiley.com/doi/pdfdirect/10.1049/rpg2.12064

2.4. Title: Personal Vehicle Electrification and Charging Solutions for High-Energy Days

Author(s): Wei, W., Ramakrishnan, S., Needell, Z.A., and Trancik, J.E.

Abstract: Questions remain on the effectiveness of different proposals for battery electric vehicle (BEV) charging and other supporting infrastructure. Here we investigate options for charging BEVs and supplementing them with long-range vehicles, including on the infrequent high-energy days that can otherwise impede personal vehicle electrification. We examine travel activities and their energy requirements—in Seattle and U.S.-wide—to identify strategies that fit existing lifestyles. We find that home charging on- or off-street is pivotal in all strategies and that highway fast charging and/or supplementary vehicles can be impactful additions. For example, home charging can support the year-round energy requirements of approximately 10% of Seattle vehicles, assuming a lower-cost BEV, but adding occasional highway fast charging or supplementary vehicles on four days per year raises this value to nearly 40%. Infrequent supplementary vehicles may be needed even as battery technology improves. Our results outline potential solutions for nations, cities, companies and communities seeking to support widespread vehicle electrification despite the challenge of high-energy days.

Subject Areas: Energy infrastructure; Energy modeling; Energy policy

Availability: Wei, W., Ramakrishnan, S., Needell, Z.A., and Trancik, J.E. (2021). "Personal Vehicle Electrification and Charging Solutions for High-Energy Days." *Nature Energy*, *6*, pp. 105–114. https://doi.org/10.1038/s41560-020-00752-y

2.5. Title: Investigating Distribution Systems Impacts with Clustered Technology Penetration and Customer Load Patterns

Author(s): MacMackin, N., Miller, L., and Carriveau, R.

Abstract: Electric vehicles (EVs), photovoltaics, heat pumps, and energy storage are changing the demands placed on electricity systems and can pose significant challenges for system operators and distribution companies. Furthermore, clustering of behaviours and technologies throughout different areas of distribution systems can produce broad variation in load curves and impacts on the network. This paper investigates local clustering impacts in a utility service area as a case study to develop methods and gain insights which can be applied to other datasets. Through clustering the variation in technology penetration rates across distribution transformers is revealed, a level of granular variability which has not been well-quantified in past literature. A second clustering framework is the applied to transformer load profiles to identify a small but diversely representative set of novel archetypical local loads. These profiles provide a summary of the dataset variability, showing how simple modeling can begin to illustrate the impacts of future technology penetration across different regions of the system. The results of the case study demonstrate that home EV charging will significantly increase peak residential transformer loading (up to 19% with 25% EV penetration), potentially drastically decreasing their useful life. Results also produced insights into possible mitigation strategies. By taking advantage of alternate charging opportunities (like workplace) the load can be spread across transformers, reducing growth in local residential and aggregate peaks by 2–8%. Energy storage is found to be more effective on residential transformers than business ones, promoting deferral of capacity investment, while simultaneously matching local and regional grid requirements for demand smoothing. In contrast, photovoltaics are found most effective at lowering new and baseline peak demands when on commercial and industrial transformers, particularly for small businesses where moderate penetration scenarios for EVs and PVs showed peak demand actually declining by 1–9%. The data analysis and clustering techniques developed through this case study can provide valuable insight into large datasets for policy development and potentially revelatory illustration of the varying effects of new technology within evolving networks.

Subject Areas: Distribution networks; Load profiles; Technology penetration; Electric vehicles; Energy transition

Availability: MacMackin, N., Miller, L., and Carriveau, R. (2021). “Investigating Distribution Systems Impacts with Clustered Technology Penetration and Customer Load Patterns.” *International Journal of Electrical Power & Energy Systems*, *128*. https://doi.org/10.1016/j.ijepes.2020.106758

2.6. Title: Characterization of Interaction Between Electric Vehicles and Smart Grid

Author(s): Zhang, Y., He, Y., Su, F., Wang, X., and Zhang, D.

Abstract: With the development of smart distribution technology in the future, electric vehicle users can not only charge reasonably based on peak-valley price, but they can also discharge electricity into the power grid to realize their economic benefit when it's necessary and thus promote peak load shifting. According to the characteristic that future electric vehicles can discharge, this paper studies the interactive characteristics between electric vehicles and smart grid. In this paper, the example shows that the charging and discharging behaviour of EV users will bring significant fluctuation effect to the power grid load, and the reasonable Time of use (TOU) strategy can stimulate EV users to conduct reasonable charging and discharging so as to smooth the peak and valley difference of some power grid.

Subject Areas: Electric vehicles; Smart grid; Charging behavior; Time of use strategy

Availability: Zhang, Y., He, Y., Su, F., Wang, X., and Zhang, D. (2021). "Characterization of Interaction Between Electric Vehicles and Smart Grid." *E3S Web of Conferences*, *237*. https://doi.org/10.1051/e3sconf/202123702004

2.7. Title: Resiliency Impacts of Plug-in Electric Vehicles in a Smart Grid

Author(s): Razeghi, G., Lee, J., and Samuelsen, S.

Abstract: This project assesses the impact of plug-in electric vehicles (PEVs) on the resiliency of the electricity distribution system by: (1) assessing the use of PEVs as a resiliency resource during grid outages (Mobility Services+), (2) assessing and simulating the impact of PEVs on the distribution infrastructure during normal operations, and (3) determining the local environmental impact of clustering PEVs. A previously developed model of a smart grid consisting of two distribution circuits and a distribution substation was modified to enable the use of PEVs in vehicle-to-home (V2H) and vehicle-to-grid (V2G) configurations. Scenarios were simulated in which PEVs were used to serve critical loads in a home or community shelters, and a model was developed to assess the feasibility of using PEVs in grid restoration, which determined the inrush current of the substation transformer to determine the required power and energy for startup. The use of clustered PEVs and scattered PEVs in grid restoration was also considered. During normal operations, the stress on system components from high PEV demand resulted in accelerated aging and possible failure, thereby negatively impacting distribution infrastructure during normal grid operations. Smart charging is required to retain an acceptable level of resiliency. In contrast, during grid outages, this study demonstrated that PEVs can be used as an environmentally friendly resiliency resource to both serve critical loads and facilitate grid restoration with the qualification that implementation requires system upgrades including smart switches, upgraded inverters, energy management systems, and communication links.

Subject Areas: Electric vehicles; Electric power transmission; Smart grids; Disaster resiliency; Power loss; Transformers; Electric power conditioning

Availability: Razeghi, G., Lee, J., and Samuelsen, S. (2021). *Characterization of Interaction Between Electric Vehicles and Smart Grid*. Institute of Transportation Studies, Irvine, CA. https://escholarship.org/uc/item/4j19d5p1

2.8. Title: Optimal Allocation of Electric Vehicles Parking Lots and Optimal Charging and Discharging Scheduling using Hybrid Metaheuristic Algorithms

Author(s): Ahmadi, M., Hosseini, S.H., and Farsadi, M.

Abstract: The issue of simultaneous planning of electric vehicles and distributed generation resources has received more attention from energy researchers in recent years. Scattered renewable sources do not have a certain amount of production and, according to research, follow possible mathematical functions. Renewable energy sources are modeled on wind and solar production, both of which are moderately generated per hour. In this study, using the optimal allocation problem of the electric vehicles parking lots and the optimal operation scheduling of the electric vehicles in a smart distribution network are studied as a novel optimization problem. In the proposed problem, the different factors including the technical and the economic issues are considered for achieving a realistic solution. In terms of technical issues, minimizing network losses, minimizing voltage drop in feeders, as well as supplying all network demand are considered. Also, the total cost of the charging and discharge at the electric vehicles parking lots and the total cost paid for purchasing power from upstream network are given as economic issues in the proposed problem. Moreover, the price-based DRP is considered due to the implementation of the demand side management program. To obtain the optimal solution, a hybrid metaheuristic algorithms (HMA) has been used. The proposed problem is simulated on the standard IEEE 69-bus. It is solved by the proposed HMA and is compared with another heuristic method. The obtained results confirm the accuracy and efficiency of the proposed problem. The obtained results show increased to an acceptable level, the voltage profile was improved and network losses were reduced. Finally, the results curves and tables show the efficiency of the proposed method.

Subject Areas: Optimal allocation; Electric vehicles; Smart distribution network; Hybrid metaheuristic algorithms; Demand side management

Availability: Ahmadi, M., Hosseini, S.H., and Farsadi, M. (2021). "Characterization of Interaction Between Electric Vehicles and Smart Grid." *Journal of Electrical Engineering & Technology*, *16*, pp. 759–770. https://doi.org/10.1007/s42835-020-00634-z

2.9. Title: Low Energy: Estimating Electric Vehicle Electricity Use

Author(s): Burlig, F., Bushnell, J., Rapson, D., and Wolfram, C.D.

Abstract: We provide the first at-scale estimate of electric vehicle (EV) home charging. Previous estimates are either based on surveys that reach conflicting conclusions, or are extrapolated from a small, unrepresentative sample of households with dedicated EV meters. We combine billions of hourly electricity meter measurements with address-level EV registration records from California households. The average EV increases overall household load by 2.9 kilowatt-hours per day, less than half the amount assumed by state regulators. Our results imply that EVs travel 5,300 miles per year, under half of the U.S. fleet average. This raises questions about transportation electrification for climate policy.

Subject Areas: Electric vehicles; Home charging; Climate

Availability: Burlig, F., Bushnell, J., Rapson, D., and Wolfram, C.D. (2021). *Low Energy: Estimating Electric Vehicle Electricity Use*. Working Paper No. w28451, National Bureau of Economic Research, Cambridge, MA. https://ssrn.com/abstract=3781338

2.10. Title: Impacts of Electric Vehicle Deployment on the Electricity Sector in A Highly Urbanised Environment

Author(s): Wang, L., Nian, V., Li, H., and Yuan, J.

Abstract: The developments in electric vehicles (EVs) are driven by the need for cleaner and more efficient road transport, but vehicle charging poses significant challenges to the electric grid and electricity sector planning. These challenges are further amplified in the case of a highly urbanised and densely populated small island state, like Singapore, with limited space and options for electricity sector planning. In response, this study aims to evaluate the impacts of a large-scale EV deployment on the electricity sector from a whole-system perspective with focus on investments in the power sector for EV adoption, assuming minimum deployment of advanced "smart-grid" and "vehicle-to-grid" technologies. Findings suggest that a small-scale deployment of EVs below 20% replacement can be economically manageable. A large-scale of deployment of EVs would inevitably bring a notable impact to the electricity sector regardless the state of advanced technology development. From the perspective of integrated planning, cities, especially those with high vehicle density, should continue to exercise caution with EV deployment. A large-scale deployment should be pursued after a "stress-test" of the power system infrastructure from both the technical and economic perspectives.

Subject Areas: Electric vehicle; Charging demand; Electricity sector planning; Power infrastructure investment; Urban transport environment

Availability: Wang, L., Nian, V., Li, H., and Yuan, J. (2021). "Impacts of Electric Vehicle Deployment on the Electricity Sector in A Highly Urbanised Environment." *Journal of Cleaner Production*, *295*. https://doi.org/10.1016/j.jclepro.2021.126386

2.11. Title: Overload Risk Evaluation of DNs with High Proportion EVs Based on Adaptive Net-based Fuzzy Inference System

Author(s): Ma, W., Wang, F., Zhang, J., and Jin, Q.

Abstract: Owing to the deepening of power reform and innovation of distribution networks (DNs), it is of significantly importance to make the load forecast accurately considering the new elements accessed to DNs, such as electric vehicles (EVs). Considering the impact of the charging load of large-scale EVs to DNs, this paper proposes a dynamic probabilistic method of forecasting EV charging load based on the temporal and spatial characteristics of EVs. Then, through simulating the historical charging load data of typical days, an adaptive net-based fuzzy inference system (ANFIS) is built to forecast the charging load of EVs utilizing the subtractive clustering method. Finally, on the basis of the trained ANFIS, the evaluation of the overload risk level of nodes EVs accessed to is realized. Simulation tests verify the superiority of the proposed method of forecasting the EV charging load and evaluating the overload risk level of nodes in DNs.

Subject Areas: Large-scale electric vehicle; Distribution network; Temporal and spatial characteristics; Adaptive net-based fuzzy inference system; Charging load forecast; Overload risk level

Availability: Ma, W., Wang, F., Zhang, J., and Jin, Q. (2020). "Overload Risk Evaluation of DNs with High Proportion EVs Based on Adaptive Net-based Fuzzy Inference System." *2020 IEEE 4th Conference on Energy Internet and Energy System Integration (EI2)*, pp. 2936–2941, Wuhan, China. https://doi.org/10.1109/EI250167.2020.9346905

2.12. Title: PV-Powered Electric Vehicle Charging Stations: Preliminary Requirements and Feasibility Conditions

Author(s): Cheikh-Mohamad, S., Sechilariu, M., Locment, F., and Krim, Y.

Abstract: Environmental benefits lie in halting direct air pollution and reducing greenhouse gas emissions. In contrast to thermal vehicles, electric vehicles (EV) have zero tailpipe emissions, but their contribution in reducing global air pollution is highly dependent on the energy source they have been charged with. Thus, the energy system depicted in this paper is a photovoltaic (PV)-powered EV charging station based on a DC microgrid and includes stationary storage and public grid connection as power source backups. The goal is to identify the preliminary requirements and feasibility conditions for PV-powered EV charging stations leading to PV benefits growth. Simulation results of different scenarios prove that slow charging with long park time could increase PV benefits for EVs and may reduce the charging price, therefore, EV users should be more willing to stay at charging stations. Whereas, for fast charging, EV users should accept the high charging price since it depends on the public energy grid. Energy system distribution and EV's energy distribution are well presented.

Subject Areas: Charging station; Electric vehicle; Energy distribution; Feasibility conditions; Photovoltaic energy; Power flow management; Microgrid

Availability: Cheikh-Mohamad, S., Sechilariu, M., Locment, F., and Krim, Y. (2021). "PV-Powered Electric Vehicle Charging Stations: Preliminary Requirements and Feasibility Conditions." *Applied Sciences*, *11*(4). https://doi.org/10.3390/app11041770

2.13. Title: The Hidden Costs of Energy and Mobility: A Global Meta-Analysis and Research Synthesis of Electricity and Transport Externalities

Author(s): Sovacool, B.K., Kim, J., and Yang, M.

Abstract: What is the range and scope of externalities associated with electricity supply, energy efficiency, and transport? What research methods and techniques of valuation does the community use to monetize these externalities? What policy implications arise in terms of better governing energy and mobility systems? To answer these questions, this study offers a comprehensive and global research synthesis of externalities for energy and mobility. It synthesizes data from 139 studies with 704 distinct estimates to examine the hidden social and environmental costs. The mean external cost for electricity supply is 7.15¢/kWh. When correlating this with the actual amount of electricity generated per year, the amount is $11.644 trillion. This likely exceeds both the reported revenues for electricity sales, oil and gas production as well as the levelized costs of energy. The mean external cost for mobility is 17.8¢/km. Using differentiated estimations of the externalities associated with aviation, road travel for passengers and freight, rail, and coastal water/marine modes of travel, transport's global externalities amount to another $13.018 trillion. When combined, this $24.662 trillion in externalities for energy and transport is equivalent to 28.7% of global Gross Domestic Product. Energy efficiency or demand response by contrast has net positive externalities of approximately 7.8¢/kWh. When put into the context of global efficiency and demand management efforts, this approaches an annual positive value of $312 billion. The fundamental policy question is whether we want global markets that manipulate the presence of externalities to their advantage, or a policy regime that attempts to internalize them.

Subject Areas: Externalities; Social costs of energy; Energy markets; Market failure; Climate change; Air pollution; Traffic congestion

Availability: Sovacool, B.K., Kim, J., and Yang, M. (2021). "The Hidden Costs of Energy and Mobility: A Global Meta-Analysis and Research Synthesis of Electricity and Transport Externalities." *Energy Research & Social Science*, *72*. https://doi.org/10.1016/j.erss.2020.101885

2.14. Title: Transportation Electrification in North Carolina

Author(s): Smith, C.

Abstract: Increased electric vehicle (EV) adoption across all vehicle classes is critical if North Carolina is to meet its transportation electrification and climate goals. On-road vehicles are the leading source of greenhouse gas and criteria pollutant emissions in the state and emissions from commercial vehicles in particular disproportionately harm marginalized communities.

North Carolina's EV market has been trending in a positive direction since 2015, and while sales were down 3 percent nationwide between 2019 and 2020, North Carolina passenger EV sales grew by 5 percent. North Carolina has a strong policy framework under the North Carolina Zero Emission Vehicle (ZEV) Plan and the ZEV bus and truck memorandum of understanding (MOU) that it can use to spur investment in manufacturing, create clean jobs, and rapidly electrify both public and privately owned vehicles throughout the State. It also has $64 million in unspent Volkswagen Settlement funds that State agencies can deploy to facilitate the transition to EVs. Stakeholders in North Carolina can also draw support from electric cooperatives and utilities like Duke Energy to ensure all North Carolinians have access to affordable charging infrastructure and rates that help maximize fuel cost savings associated with driving an EV.

The urgency to invest in the clean economy has never been greater in light of the ongoing COVID-19 pandemic. This brief, "Transportation Electrification in North Carolina," produced by Atlas Public Policy with support from the Southern Alliance for Clean Energy (SACE), provides an overview of the state of the EV market and deployment in North Carolina while also highlighting travel patterns and transit agency statistics, along with snapshots of EV policy and program examples from other States. Statewide transportation electrification roadmaps and funding available through the Volkswagen Settlement have generated momentum in North Carolina and can be harnessed to accelerate the EV market across the State and position it as a regional and national leader.

Subject Areas: Electric vehicle; Zero Emission vehicle; Energy usage; Electric vehicle deployment; Travel pattern

Availability: Smith, C. (2021). *Transportation Electrification in North Carolina*. Atlas Public Policy, Washington, DC. https://atlaspolicy.com/wp-content/uploads/2021/02/Transportation-Electrification-in-North-Carolina.pdf

2.15. Title: Surrogate-Assisted Multi-Objective Probabilistic Optimal Power Flow for Distribution Network with Photovoltaic Generation and Electric Vehicles

Author(s): Srithapon, C., Fuangfoo, P., Ghosh, P.K., Siritaratiwat, A., and Chatthaworn, R.

Abstract: The uncertainties of solar photovoltaics generation, electric vehicle charging demand, and home appliances load are the major challenge of energy management planning in the residential areas. Optimal allocation of battery energy storage systems for distribution networks based on probabilistic power flow (PPF) is an effective solution to deal with these uncertainties. However, the high computational burden is the main obstacle of this method. Therefore, this paper proposes a surrogate-assisted multi-objective probabilistic optimal power flow (POPF) to reduce the expensive computational time. The surrogate model is developed by using a machine learning method namely deep learning which is used for bypassing the deterministic load flow calculation. Zhao's point estimation method combined with Nataf transformation is selected to handle the PPF analysis considering correlated uncertain input variables. The multi-objective POPF problem is solved using the multi-objective differential evolution. The historical data including solar irradiation, ambient temperature, residential load, and electric vehicle (EV) travel distance is calculated in the low voltage distribution system to demonstrate the potential advantages of the proposed method. Numerical results show that the proposed surrogate assisted multi-objective POPF method provides the optimal solution for operating cost, helps to prolong transformer life and reducing environmental impact. Moreover, the results show that the proposed surrogate-assisted optimization framework gives a better solution when comparing with the conventional surrogate-assisted method.

Subject Areas: Battery energy storage system; Carbon emission; Deep learning; Multi-objective differential evolution; Probabilistic power flow; Transformer loss of life

Availability: Srithapon, C., Fuangfoo, P., Ghosh, P.K., Siritaratiwat, A., and Chatthaworn, R. (2021). "Surrogate-Assisted Multi-Objective Probabilistic Optimal Power Flow for Distribution Network with Photovoltaic Generation and Electric Vehicles." *IEEE Access*, *9*, pp. 34395–34414. https://doi.org/10.1109/ACCESS.2021.3061471

2.16. Title: A New Framework for Plug-In Electric Vehicle Charging Models Supported by Solar Photovoltaic Energy Resources

Author(s): Assolami, Y.O., Gaouda, A., and El-Shatshat, R.

Abstract: This article proposes a new framework for modeling plug-in electric vehicle (PEV) charging demand supported by solar photovoltaic (PV) energy resources in a distribution system. The proposed work focuses on modeling the stochastic nature of both PEV loads and PV generation while considering the effect of the temporal–spatial characteristics of the driver's behavior, as well as solar irradiation and temperature. A trip chain, based on the Markov Chain Monte Carlo process, is developed to properly model PEV daily driving activities and the PV uncertainty. Charging facilities are assumed available at home, work, and fast-charging stations, having charging levels of 3.7, 6.6, and 50 kW, respectively. The proposed framework is examined, considering the National Household Travel Survey global data, as well as the city of Buffalo and New York state. The impact of varying the penetration levels of PEV and PV resources is also investigated. This work strengthens the proposed models in the literature by integrating the temporal–spatial characteristics of PEV charging demand into PV stochastic models.

Subject Areas: Markov chain Monte Carlo; National household travel survey; Plug-in electric vehicles; Trip chain

Availability: Assolami, Y.O., Gaouda, A., and El-Shatshat, R. (2021). "A New Framework for Plug-In Electric Vehicle Charging Models Supported by Solar Photovoltaic Energy Resources." *IEEE Canadian Journal of Electrical and Computer Engineering*, *44*(2), pp. 118–129. https://doi.org/10.1109/ICJECE.2020.3008689

2.17. Title: Reducing Probability of Transformer Failure by Managing EV Charging in Residential Parking Lots

Author(s): Soleimani, M., Khoshjahan, M., and Kezunovic, M.

Abstract: The power of electric vehicle (EV) chargers is considerable and high penetration of EVs may lead to overloading and thermal stress for utility transformers. Large buildings usually are connected to the grid through a transformer. By managing EV charging in the building parking lots, the probability of transformer failure may be reduced. We propose a controller to manage the charging of the EVs to reduce the probability of transformer failure without the involvement of distribution grid operator. In order to test the proposed framework, a use case is developed using real and synthesized data from College Station, TX, United States.

Subject Areas: Electric vehicle; Electric transformer; Loss of life; Hazard of failure; Fuzzy control

Availability: Soleimani, M., Khoshjahan, M., and Kezunovic, M. (2021). *Reducing Probability of Transformer Failure by Managing EV Charging in Residential Parking Lots*. Texas A&M University, College Station, TX. https://pscpresume.engr.tamu.edu/wp-content/uploads/2021/03/PES_GM_Final.pdf

2.18. Title: Risk-based Residential Demand Side Response

Author(s): Soleimani, M., Khoshjahan, M., and Kezunovic, M.

Abstract: The advances in communication and utilization of internet of things enable residential dwelling occupants to manage their assets to provide services to the grid through demand response programs. However, it is essential that the comfort of the consumers is not affected and the programs do not require extensive manual management of the controller settings to keep the program attractive for the consumers. In this paper, a risk-based framework that automates management of the demand side response interactions between consumers and distribution system operator is proposed. A Fuzzy logic controller that optimizes time of operation of consumers' energy assets to minimize the risk to the consumers is defined in this paper. A case study is developed in which an unexpected increase in electric vehicles (EV) penetration causing a risk of overloading of distribution transformers is managed in an automated way using a demand side management program that utilizes the controller. The risk-based optimization results in the residential demand side response that successfully mitigates the stress on utility power transformers and yet meets the consumer expectations about the EV charging service availability.

Subject Areas: Demand side management; Risk assessment; Risk management; Fuzzy control; Distribution system operator

Availability: Soleimani, M., Khoshjahan, M., and Kezunovic, M. (2021). "Risk-based Residential Demand Side Response." *CIRED 2021 Conference*, Geneva, Switzerland. https://pscpresume.engr.tamu.edu/wp-content/uploads/2021/03/CIRED2021_V5.pdf

2.19. Title: A Self-Optimizing Scheduling Model for Large-Scale EV Fleets in Microgrids

Author(s): Rezaeimozafar, M., Eskandari, M., and Savkin, A.V.

Abstract: The increasing number of electric vehicles (EVs) demands management solutions to deal with the impacts of EV charging on the efficiency of distribution grids. Many suggested methods are derived from analysis on laboratory-scale systems with declared data, which cannot be implemented for real networks. In this article, a two-step scheduling model is developed that effectively guides a large-scale EV fleet in microgrids without demanding a dynamic monetary scheme. The first step corresponds to prediction-based day-ahead optimal scheduling for large scale EVs, which minimizes the costs of electricity supply and EVs battery degradation. To avoid dimensional problems in calculations, an improved K-means clustering algorithm is presented to divide vehicles into different clusters. In the second step, online coordination is deployed based on an effective scoring system to encourage drivers to follow the first-step provided model. The proposed model is analyzed on a grid-connected microgrid with photovoltaic system integration. The problem (real) data are derived based on an estimate of the development process on the Ontario energy network over the next 10 years. Results show that the introduced model can guarantee the accurate deployment of optimal charging/discharging schedules in large-scale systems.

Subject Areas: Microgrids; Vehicles; Clustering algorithms; Batteries; Vehicle-to-grid; Optimal scheduling; Computational modeling; Scoring system

Availability: Rezaeimozafar, M., Eskandari, M., and Savkin, A.V. (2021). “A Self-Optimizing Scheduling Model for Large-Scale EV Fleets in Microgrids.” *IEEE Transactions on Industrial Informatics*. https://doi.org/10.1109/TII.2021.3064368

2.20. Title: Apartments Rarely Come with Access to Charging Stations. But Electric Vehicles Need Them

Author(s): Davis, L.

Abstract: Blog.

Subject Areas: Electric vehicles; Homeowners; Renters; Decarbonization; Energy transition

Availability: Davis, L. (2021). "Apartments Rarely Come with Access to Charging Stations. But Electric Vehicles Need Them." *The Conversation*. https://theconversation.com/apartments-rarely-come-with-access-to-charging-stations-but-electric-vehicles-need-them-100296

2.21. Title: Residential Energy Management Strategy Considering the Usage of Storage Facilities and Electric Vehicles

Author(s): Muthiah-Nakarajan, V., Cherukuri, S.H.C., Saravanan, B., and Palanisamy, K.

Abstract: This article presents a different type of home energy management algorithm for a residence consisting of solar PV, battery storage units, electric vehicles with different driving profiles, and critical and noncritical loads. The primary objective of the proposed methodology is to reduce the overall power purchase from the utility. In order to achieve the said objectives, a combination of the rule-based approach proposed by the authors and a heuristic optimization is used. Hence, it can be said that the proposed strategy consists of two layers, of which the first part of the algorithm schedules the noncritical loads using electric springs and the second part of the strategy controls battery storage units and electric vehicles. The novelty of the proposed work lies in using electric springs and battery storage units and exploring the virtual energy storage capabilities of electric vehicles so as to make the residential complexes more autonomous and less dependent on the utility. The robustness of the proposed strategy is tested on a residence and from the obtained results it can be said that the presented algorithm can save an electricity bill of about 53% to the consumer.

Subject Areas: Electric springs; Home energy management; Electric vehicles; Battery energy storage; Utility grid

Availability: Muthiah-Nakarajan, V., Cherukuri, S.H.C., Saravanan, B., and Palanisamy, K. (2021). "Residential Energy Management Strategy Considering the Usage of Storage Facilities and Electric Vehicles." *Sustainable Energy Technologies and Assessments*, *45*. https://doi.org/10.1016/j.seta.2021.101167

2.22. Title: Strategically Targeting Plug-In Electric Vehicle Rebates and Outreach Using "EV Convert" Characteristics

Author(s): Williams, B.D.H. and Anderson, J.B.

Abstract: To expand markets for plug-in electric vehicles (EVs) beyond enthusiastic early adopters, investments must be strategic. This research characterizes a segment of EV adoption that points the way toward the mainstream: EV consumers with low or no initial interest in EVs, or "EV Converts." Logistic regression is utilized to profile EV Convert demographic, household, and regional characteristics; vehicle-transaction details; and purchase motivations—based on 2016–2017 survey data characterizing 5447 rebated California EV consumers. Explanatory factors are rank-ordered—separately for battery EVs (BEVs) and plug-in hybrid EVs (PHEVs), to inform targeted outreach and incentive design. EV Converts tend to have relatively "lower" values on factors that might have otherwise "pre-converted" them to EV interest: hours researching EVs online; motivation from environmental impacts and carpool-lane access; and solar ownership. PHEV Converts more closely resemble new-car buyers than other EV adopters, and BEV Converts actually tend to be younger and less-frequently white/Caucasian than new-car buyers. BEV Converts also tend to: lack workplace charging, be moderately motivated by energy independence, and reside in Southern California or the Central Valley. Predictors that not only help target consumers, but also help convert them, include rebates for BEV consumers and, modestly, fuel-cost savings for PHEV consumers.

Subject Areas: Electric vehicle; Adopter characteristics; Consumer segment; Outreach strategy; Incentive design

Availability: Williams, B.D.H. and Anderson, J.B. (2021). "Strategically Targeting Plug-In Electric Vehicle Rebates and Outreach Using 'EV Convert' Characteristics." *Energies*, *14*(7). https://doi.org/10.3390/en14071899

2.23. Title: Infrastructure Optimization of In-Motion Charging Networks for Electric Vehicles Using Agent-Based Modeling

Author(s): Willey, L. and Salmon, J.

Abstract: As the market share of electric vehicles increases, the associated charging infrastructure must be further developed to meet the growing demand for charging. While stationary plug-in methods have been the traditional approach to satisfying this demand, in-motion charging technologies have the potential to eliminate the inconvenience of long charging wait times and the high cost of large batteries. In this research, an agent-based model is developed to simulate vehicle charging demand and then validated against real traffic data. Driver behavior is estimated from travel survey data, and a method is introduced to estimate route-planning decisions in the presence of multiple charging options. The model is technology agnostic, allowing for its application to any kind of in-motion charging technology (i.e., inductive, conductive, and capacitive). A genetic algorithm is used to optimize the location of roadways with dynamic charging capabilities in the presence of the existing charging infrastructure. Both major highways and arterial roads were considered as potential candidates for dynamic charger installation. Results are presented for a case study in Salt Lake County, Utah.

Subject Areas: Vehicle dynamics; Batteries; Electric vehicles; Statistics; Sociology; Mathematical model; State of charge

Availability: Willey, L. and Salmon, J. (2021). "Infrastructure Optimization of In-Motion Charging Networks for Electric Vehicles Using Agent-Based Modeling." *IEEE Transactions on Intelligent Vehicles*. https://doi.org/10.1109/TIV.2021.3064549

2.24. Title: Distributed Energy Resources based Microgrid: Review of Architecture, Control, and Reliability

Author(s): Muhtadi, A., Pandit, D., Nguyen, N., and Mitra, J.

Abstract: To accomplish feasible large-scale integration of distributed energy resources (DER) into the existing grid system, microgrid implementation has proven to be the most effective. This paper reviews the vital aspects of DER based microgrid and presents simulations to investigate the impacts of DER sources, electric vehicles (EV), and energy storage system (ESS) on practicable architectures resilient operation. The focus is primarily on the concept and definition of microgrid, comparison of control strategies (primary, secondary and tertiary strategies), energy management strategies, power quality issues associated with DER based microgrid, and state-of-the-art entities such as ESS and EV's applications towards microgrid reliability. Following discussion on the different attributes of DER sources based microgrid, simulations are performed to verify the results of the past works on the effects of solar, wind energy sources, ESS, and EVs on the microgrid frequency response. Additional simulations are conducted to assess the influences of DERs, ESS, EVs and their operational strategies on the microgrid reliability aspects.

Subject Areas: Distributed energy resources; Electric vehicle; Energy storage system; Frequency response; Microgrid; Power quality; Reliability

Availability: Muhtadi, A., Pandit, D., Nguyen, N., and Mitra, J. (2021). "Distributed Energy Resources based Microgrid: Review of Architecture, Control, and Reliability." *IEEE Transactions on Industry Applications*, *57*(3). https://doi.org/10.1109/TIA.2021.3065329

2.25. Title: A Centralized Optimization Approach for Bidirectional PEV Impacts Analysis in a Commercial Building-Integrated Microgrid

Author(s): Yusuf, J., Hasan, A.S.M.J., Enriquez-Contreras, L.F., and Ula, S.

Abstract: Building sector is the largest energy user in the United States. Conventional building energy studies mostly involve Heating, Ventilation, and Air Conditioning (HVAC) and lighting energy consumptions. Recent additions of solar Photovoltaics (PV) along with other Distributed Energy Resources (DER), particularly Plug-in Electric Vehicles (PEV) have added a new dimension to this problem and made it more complex. This paper presents an avant-garde framework for selecting the best charging/discharging level of PEV for a commercial building-integrated microgrid. A typical commercial building is used as a microgrid testbed incorporating all the DERs presented in a smart building. A Mixed Integer Linear Programming (MILP) problem is formulated to optimize the energy and demand cost associated with this building operation. The cost function is solved in conjunction with real data and modified to assess the bidirectional PEV impacts on the flexible building loads that are contributing factors in making energy usage decisions. Finally, the impacts of optimized DERs are investigated on a Distribution System (DS) to show the necessity of a holistic approach for selecting the suitable PEV strategies. The results show that bidirectional fast PEV activities can provide higher cost reduction and less voltage deviation in comparison to slow PEV activities.

Subject Areas: Building energy cost reduction; Distributed energy resources; Distribution system; Plug-in electric vehicles; Microgrid; Mixed integer linear programming optimization

Availability: Yusuf, J., Hasan, A.S.M.J., Enriquez-Contreras, L.F., and Ula, S. (2021). *A Centralized Optimization Approach for Bidirectional PEV Impacts Analysis in a Commercial Building-Integrated Microgrid*. arXiv preprint, arXiv:2104.03498 [eess.SY]. https://arxiv.org/abs/2104.03498

2.26. Title: Why It's Time to Rethink EV Range

Author(s): Electric Vehicles.

Abstract: Blog.

Subject Areas: Driving range; Electric vehicle charging

Availability: Electric Vehicles. (2021). "Why It's Time to Rethink EV Range." *Online EV*. https://www.onlineev.com/why-its-time-to-rethink-ev-range/

2.27. Title: The Value of Consumer Acceptance of Controlled Electric Vehicle Charging in a Decarbonizing Grid: The Case of California

Author(s): Tarroja, B. and Hittinger, E.

Abstract: Plug-in electric vehicles charged with zero-carbon electricity are important for decarbonizing regional energy systems. Flexible charging of these vehicles aids with grid integration of wind and solar generation but may require drivers to provide information about their travel patterns and allow grid operators to control the charging of their vehicles. Limited acceptance of flexible charging can potentially limit greenhouse gas emissions reductions from electric vehicle deployment. Therefore, here we assess how varying the extent of consumer acceptance of flexible charging affects electric vehicle greenhouse gas emissions reductions in a highly decarbonized California grid (>70% zero-carbon), a region with mandated zero-emission vehicle deployment and electricity decarbonization targets. We quantify the monetary value of flexible charging based on the reduction in stationary storage required to achieve a given zero-carbon penetration as flexible charging is adopted. We find that increased participation in smart charging and vehicle-to-grid increases zero-carbon generation uptake by up to 5.2% and 11.1%, respectively. The value of smart charging only reaches $87 per vehicle-year while that for vehicle-to-grid can reach $2,850 per vehicle-year. Non-monetary incentives may be needed to increase smart charging participation. These results can inform future analyses on the supply and demand for participation in flexible charging programs.

Subject Areas: Electric vehicles; Smart charging; Greenhouse gas emissions; Consumer behavior

Availability: Tarroja, B. and Hittinger, E. (2021). "The Value of Consumer Acceptance of Controlled Electric Vehicle Charging in a Decarbonizing Grid: The Case of California." *Energy*. https://doi.org/10.1016/j.energy.2021.120691

2.28. Title: Variability of the Value of Vehicle-to-Grid Across Vehicle and Time in Future California Grid

Author(s): Wang, M.

Abstract: Electric vehicles (EVs) are gaining momentum across the globe as a strategy to combat climate change, however, uncontrolled charging of EVs can create pressure on electricity grid. Along with smart charging (V1G), Vehicle-to-grid (V2G) technology presents an opportunity for a new way of vehicle grid integration that enables EVs to send electricity back to the grid, creating the potential for EVs to provide grid services including electricity generation as well as regulation up and regulation down capacity. This study aims to quantify the economic value of V2G in the 2025 and 2030 California grid using an EV simulation model and a grid Unit Commitment Economic Dispatch model. Scenarios on different renewable penetration and battery cost are included to account for uncertainty in future energy and battery development. Results show a V2G-enabled EVs can generate an average of $32–$48 more total annual net revenue than V1G, most profits come from EVs providing electricity and a small amount from regulation down capacity. From 2020 to 2030, the economic value of V1G and V2G increased, the result also shows a tradeoff exists between renewable deployment and V2G value. V2G can generate a moderate amount of economic benefit given access to electricity and ancillary service wholesale market, which need further policy support and third-party business cases.

Subject Areas: Electric vehicles; Vehicle-to-grid; Smart charging; Revenue

Availability: Wang, M. (2021). *Variability of the Value of Vehicle-to-Grid Across Vehicle and Time in Future California Grid*. Master's Thesis, University of Michigan, Ann Arbor, MI. https://deepblue.lib.umich.edu/handle/2027.42/167344

2.29. Title: Spatial Load Prediction Considering Spatiotemporal Distribution of Electric Vehicle Charging Load

Author(s): Gao, X., Wei, L., Wang, B., Chen, G., and Wu, X.

Abstract: In view of the influence of large-scale electric vehicle access to the distribution network on spatial load prediction, this paper proposes a spatial load prediction method for urban distribution network considering the spatial and temporal distribution of electric vehicle charging load. Firstly, electric vehicles are classified according to charging mode and travel characteristics of various types of vehicles. Secondly, the probability distribution function is fitted to the travel rules of electric vehicles according to the travel survey and statistical data of residents. Then, the model of electric vehicle travel chain is constructed, and the charging load in different regions and different times is calculated by Monte Carlo method. Finally, based on the actual data of a certain area, the predicted spatial load values of different functional communities in one day are obtained, which can provide reference for future urban distribution network planning.

Subject Areas: Electric vehicles; Distribution network; Spatial load prediction; Charging; Travel chain

Availability: Gao, X., Wei, L., Wang, B., Chen, G., and Wu, X. (2021). "Spatial Load Prediction Considering Spatiotemporal Distribution of Electric Vehicle Charging Load." *E3S Web of Conferences*, *256*. https://doi.org/10.1051/e3sconf/202125601001

2.30. Title: Optimal Load Management of Smart Homes considering PVs and Comfort of Residents

Author(s): Alyami, S.

Abstract: Demand side management (DSM) can be utilized in smart homes to reduce peak load and enhance the utilization of renewables. Detailed modeling of individual components and the comfort of residents are considered in this study to formulate an optimization model for DSM in the residential sector. Each household contains fixed and shiftable loads along with an electric vehicle (EV) and a storage unit. A public photovoltaics (PV) park is also considered, which can provide subsidized electricity to the residents. The input data from consumers is minimized to make the model easy to use for different types of consumers. For example, information of EV return time is used to schedule dishwashers and to set the indoor temperature of the rooms. Similarly, noisy equipment cannot be operated during sleeping time. The performance of the proposed model is evaluated for both weekdays and holidays. In addition, the impact of the presence of EVs and local storage on the operation cost of the smart home network is also analyzed.

Subject Areas: Consumer comfort; Controllable loads; Smart home; Photovoltaic systems; Schedules; Demand side management; Computational modeling; Simulation; Electric vehicles

Availability: Alyami, S. (2021). "Optimal Load Management of Smart Homes considering PVs and Comfort of Residents." *IEEE Transactions on Intelligent Transportation Systems*, pp. 1–12. https://doi.org/10.1109/IREC51415.2021.9427867

2.31. Title: The Fastest Way to Get More People to Buy Electric Vehicles

Author(s): Nilsen, E.

Abstract: Blog.

Subject Areas: Electric vehicles; Charging station; Home charging; Infrastructure

Availability: Nilsen, E. (2021). "The Fastest Way to Get More People to Buy Electric Vehicles." *Vox*. https://www.vox.com/22463219/electric-vehicles-charging-station-infrastructure

2.32. Title: Charging Navigation Strategy of Electric Vehicles Considering Time-of-Use Pricing

Author(s): Huang, J., Wang, X., Wang, Y., Ma, Z., Chen, X., and Zhang, H.

Abstract: This paper proposes a charging navigation strategy of electric vehicles (EVs) considering time-of-use (TOU) pricing, which takes into consideration both the charging demand of EV users and the revenue of EV charging station (EVCS) operators. Firstly, a spatial-temporal distribution of EVs in a day is given by a traffic simulation method. Then, by considering the impact of TOU price on charging navigation, an EV strategy including charging probability, charging energy, and charging station selection is proposed to minimize the costs of EVs. Based on the EV strategy, the optimal TOU charging price is formulated by EVCS operators to maximize the revenue under the given pricing rule. The simulation results show that the proposed method is not only beneficial to EVs and EVCSs, but also can effectively reduce the peak-valley difference of load profile and achieve the goal of peak load shifting.

Subject Areas: Charging navigation; Time-of-use charging price; Electric vehicles; Charging station; Traffic simulation

Availability: Huang, J., Wang, X., Wang, Y., Ma, Z., Chen, X., and Zhang, H. (2021). "Charging Navigation Strategy of Electric Vehicles Considering Time-of-Use Pricing." *2021 6th Asia Conference on Power and Electrical Engineering (ACPEE)*, pp. 715–720. https://doi.org/10.1109/ACPEE51499.2021.9436864

2.33. Title: Inverse Optimization with Kernel Regression: Application to the Power Forecasting and Bidding of a Fleet of Electric Vehicles

Author(s): Fernández-Blanco, R., Morales, J.M., Pineda, S., and Porras, Á.

Abstract: This paper considers an aggregator of Electric Vehicles (EVs) who aims to learn the aggregate power of his/her fleet while also participating in the electricity market. The proposed approach is based on a data-driven inverse optimization (IO) method, which is highly nonlinear. To overcome such a caveat, we use a two-step estimation procedure which requires solving two convex programs. Both programs depend on penalty parameters that can be adjusted by using grid search. In addition, we propose the use of kernel regression to account for the nonlinear relationship between the behavior of the pool of EVs and the explanatory variables, i.e., the past electricity prices and EV fleet's driving patterns. Unlike any other forecasting method, the proposed IO framework also allows the aggregator to derive a bid/offer curve, i.e., the tuple of price-quantity to be submitted to the electricity market, according to the market rules. We show the benefits of the proposed method against the machine-learning techniques that are reported to exhibit the best forecasting performance for this application in the technical literature.

Subject Areas: Inverse optimization; Kernel regression; Forecasting; Electric vehicles

Availability: Fernández-Blanco, R., Morales, J.M., Pineda, S., and Porras, Á. (2021). "Inverse Optimization with Kernel Regression: Application to the Power Forecasting and Bidding of a Fleet of Electric Vehicles." *Computers & Operations Research*, *134*. https://doi.org/10.1016/j.cor.2021.105405

2.34. Title: Estimating the Deep Decarbonization Benefits of the Electric Mobility Transition: A Review of Managed Charging Strategies and Second-Life Battery Uses

Author(s): Dean, M.D. and Kockelman, K.M.

Abstract: Emissions-reduction pathways in transportation are often characterized as a "three-legged stool," where vehicle efficiency, fuel carbon content, and vehicle miles traveled (VMT) contribute to lower emissions. The electric mobility (e-mobility) transition provides fast savings, since plug-in electric vehicles (PEVs) are nearly three times more energy efficient than internal combustion engines (ICEs), and most nations' power grids are lowering their carbon intensity irrespective of any further climate policy. The transportation sector's greenhouse gas (GHG) savings via electrification are subject to many variables, such as power plant feedstocks, vehicle charging locations and schedules, vehicle size and weight, driver behavior, and annual mileage, which are described in existing literature. Savings will also depend on emerging innovations, such as managed charging (MC) strategies and second-life battery use in energy storage systems (B2U-ESS). This paper's review of MC strategies and B2U-ESS applications estimates additional GHG savings to be up to 33% if chargers are widely available for MC-enabled passenger cars and up to 100% if B2U-ESS abates peaker plants over its second-use lifetime. In this way, an e-mobility transition can deliver additional lifetime decarbonization benefits, both on- and off-road, long term.

Subject Areas: Electric mobility; Decarbonization; Greenhouse gas savings; Managed charging; Second-life battery use

Availability: Dean, M.D. and Kockelman, K.M. (2021). "Estimating the Deep Decarbonization Benefits of the Electric Mobility Transition: A Review of Managed Charging Strategies and Second-Life Battery Uses." *International Conference on Transportation and Development 2021 (Virtual Conference)*. https://doi.org/10.1061/9780784483541.003

2.35. Title: Tesla Miles Traveled

Author(s): Callaway, D. and Fowlie, M.

Abstract: Blog.

Subject Areas: Emissions market; Gasoline; Transportation

Availability: Callaway, D. and Fowlie, M. (2021). "Tesla Miles Traveled." *Energy Institute Blog, UC Berkeley*. https://energyathaas.wordpress.com/2021/06/21/tesla-miles-traveled/

2.36. Title: Analyzing the Travel and Charging Behavior of Electric Vehicles – A Data-driven Approach

Author(s): Baghali, S., Hasan, S., and Guo, Z.

Abstract: The increasing market penetration of electric vehicles (EVs) may pose significant electricity demand on power systems. This electricity demand is affected by the inherent uncertainties of EVs' travel behavior that makes forecasting the daily charging demand (CD) very challenging. In this project, we use the National Household Travel Survey (NHTS) data to form sequences of trips and develop machine learning models to predict the parameters of the next trip of the drivers, including trip start time, end time, and distance. These parameters are later used to model the temporal charging behavior of EVs. The simulation results show that the proposed modeling can effectively estimate the daily CD pattern based on travel behavior of EVs, and simple machine learning techniques can forecast the travel parameters with acceptable accuracy.

Subject Areas: Electrical vehicles; Travel behavior; Charging demand; Machine learning

Availability: Baghali, S., Hasan, S., and Guo, Z. (2021). "Analyzing the Travel and Charging Behavior of Electric Vehicles – A Data-driven Approach." *2021 IEEE Kansas Power and Energy Conference (KPEC)*, pp. 1–5. https://doi.org/10.1109/KPEC51835.2021.9446240

2.37. Title: Impacts Analysis of Electric Vehicles Integration to the Residential Distribution Grid

Author(s): Yusuf, J., Hasan, A.S.M.J., and Ula, S.

Abstract: The proliferation of Electric Vehicles (EVs) can cause vulnerability to the electric grid. This paper analyzes the EV integration impacts on the distribution grid that mainly consists of residential loads. The EV uncertainties are addressed by a comprehensive model using arrival time and miles traveled. The penetration of EV is modeled based on the maximum permissible number of customers that can be connected to each node of a representative residential feeder. The temporal power consumption of EVs is calculated by using their daily trip and capacity information which are measured by utilizing specific EV models. An IEEE 123 bus feeder is used for power flow simulation and the demonstration of different case studies. Results from the customer-oriented modeling presented here show that wide voltage deviations occur at local nodes with higher penetration of EVs and it also depends on the distance of the nodes from the substation. The coincidental peak can cause large voltage unbalance at the closer nodes and hourly voltage profiles can vary significantly based on this. While voltage deviation increases with higher EV penetration at the distant nodes, the closer nodes demonstrate insignificant change in voltage deviation for different levels of penetrations. The synergy between EV and grid modeling and the in-depth statistical analysis of voltage distribution at the local nodes are needed by the grid operators for higher EV integration in the future.

Subject Areas: Distribution grid; Electric vehicles charging; Grid integration; Residential load; Substations; Uncertainty; Power measurement; Power demand; Statistical analysis; Stochastic processes

Availability: Yusuf, J., Hasan, A.S.M.J., and Ula, S. (2021). "Impacts Analysis of Electric Vehicles Integration to the Residential Distribution Grid." *2021 IEEE Kansas Power and Energy Conference (KPEC)*, pp. 1–6. https://doi.org/10.1109/KPEC51835.2021.9446249

2.38. Title: Assessment of Light-Duty Plug-in Electric Vehicles in the United States, 2010 – 2020

Author(s): Gohlke, D. and Zhou, Y.

Abstract: This report examines properties of plug-in electric vehicles (PEVs) sold in the United States from 2010 to 2020, exploring vehicle sales, miles driven, electricity consumption, petroleum reduction, vehicle manufacturing, and battery production, among other factors. Over 1.7 million PEVs have been sold, driving 52 billion miles on electricity since 2010, thereby reducing national gasoline consumption by 0.42% in 2020 and 1.9 billion gallons cumulatively through 2020. In 2020, PEVs used 4.4 terawatt-hours of electricity to drive 13.7 billion miles, offsetting 500 million gallons of gasoline. Since 2010, 68% of PEVs sold in the United States have been assembled domestically, and 77 gigawatt-hours of lithium-ion batteries have been installed in vehicles to date.

Subject Areas: Plug-in electric vehicles; Electric vehicle miles traveled; Energy consumption; Gasoline consumption; Emission reduction; Vehicle production

Availability: Gohlke, D. and Zhou, Y. (2021). *Assessment of Light-Duty Plug-in Electric Vehicles in the United States, 2010 – 2020*. Energy System Division, Argonne National Laboratory, Lemont, IL. https://publications.anl.gov/anlpubs/2021/06/167626.pdf

2.39. Title: Impact on Voltage Quality and Transformer Aging of Residential Prosumer Ownership of Plug-in Electric Vehicles: Assessment and Solutions

Author(s): Assolami, Y.O., Gaouda, A., and El-shatshat, R.

Abstract: The effects of climate change have resulted in the increased deployment of plug-in electric vehicles (PEVs), solar photovoltaics (PVs), and energy storage systems penetration levels in the residential sector. The integration of these resources with accurate stochastic models is expected to affect the assessment of the electrical distribution system (EDS) assets. This study proposes a new framework for evaluating and enhancing voltage quality, distribution transformer (DT) overload and aging, while considering residential prosumer ownership of PEVs. The proposed work develops a probabilistic power flow in order to investigate the impact of the stochastic nature of PEVs, PVs, and conventional load. In this work, the residential premises are modeled for supply through a detailed secondary distribution system which is integrated as a part of the EDS. This paper enhances the existing research through the inclusion of PEV spatial-temporal (SAT) charging activities into the assessment models of DT overload and aging, voltage imbalance, and voltage deviation. The proposed framework provides a more realistic life expectancy for DTs compared with a simplified model in the literature. The results indicate that the use of the proposed SAT-based approach has reduced DT lifetime to 6.30 years from 7.92 years for the same PEV penetration level.

Subject Areas: Plug-in electric vehicles; Residential prosumer; Electrical distribution system; Voltage imbalance; Transformer aging

Availability: Assolami, Y.O., Gaouda, A., and El-shatshat, R. (2021). "Impact on Voltage Quality and Transformer Aging of Residential Prosumer Ownership of Plug-in Electric Vehicles: Assessment and Solutions." *IEEE Transactions on Transportation Electrification*. https://doi.org/10.1109/TTE.2021.3089460

2.40. Title: Urban Cells: Extending the Energy Hub Concept to Facilitate Sector and Spatial Coupling

Author(s): Perera, A.T.D., Javanroodi, K., Wang, Y., and Hong, T.

Abstract: The rapid growth of urban areas and concerns over climate change make it vital to improve the energy sustainability of cities. Understanding the complex interactions within different sectors (sectoral) and localities (spatial) of cities plays a crucial role in improving efficiency and sustainability, which is extremely challenging due to the complex urban morphology. State-of-the-art energy concepts do not facilitate a detailed consideration of both sectoral and spatial coupling that energy infrastructure maintains at the urban scale. This has become a significant challenge when designing interconnected urban energy infrastructure. The Urban Cell concept is introduced to address this bottleneck. A novel computational model using a modular approach is introduced to create an interconnected urban infrastructure, including the energy, building, and transportation sectors. Optimal sizing of the distributed energy system (including renewables, energy storage, and dispatchable sources) and optimal urban morphology is determined within a modular unit. A game-theoretic approach is used to model the interactions between urban cells (modular units). The study revealed that the urban cell concept can reduce the net present value of the interconnected energy infrastructure by 37% while increasing the installed renewable energy capacity by 25%. This demonstrates the benefit potential of urban cells and the importance of considering interactions between different sectors and different parts within a city. The Urban Cell concept can be used to present the complex interactions maintained within a city.

Subject Areas: Distributed generation; Sector coupling; Multi-agent systems; Urban cells; Interconnected energy infrastructure; Urban systems

Availability: Perera, A.T.D., Javanroodi, K., Wang, Y., and Hong, T. (2021). "Urban Cells: Extending the Energy Hub Concept to Facilitate Sector and Spatial Coupling." *Advances in Applied Energy*, *3*. https://doi.org/10.1016/j.adapen.2021.100046

2.41. Title: The Promise of Energy-Efficient Battery-Powered Urban Aircraft

Author(s): Sripad, S. and Viswanathan, V.

Abstract: Improvements in rechargeable batteries are enabling several electric urban air mobility (UAM) aircraft designs with up to 300 miles of range with payload equivalents of up to 7 passengers. We find that novel UAM aircraft consume between 130 Wh/passenger-mile up to ~1,200 Wh/passenger-mile depending on the design and utilization, relative to an expected consumption of over 220 Wh/passenger-mi for terrestrial electric vehicles and 1,000 Wh/passenger-mile for combustion engine vehicles. We also find that several UAM aircraft designs are approaching technological viability with current Li-ion batteries, based on the specific power-and-energy while rechargeability and lifetime performance remain uncertain. These aspects highlight the technological readiness of a new segment of transportation.

Subject Areas: Electric aviation; Energy efficiency; Transport electrification; Urban air mobility

Availability: Sripad, S. and Viswanathan, V. (2021). *The Promise of Energy-Efficient Battery-Powered Urban Aircraft*. arXiv preprint, arXiv:2106.09513 [eess.SY].
https://arxiv.org/abs/2106.09513

2.42. Title: Multi-objective Optimal Dispatching of Electric Vehicle Cluster Considering User Demand Response

Author(s): Li, T., Tao, S., He, K., Fan, H., Zhang, Y., and Sun, Y.

Abstract: In view of the load fluctuation caused by large-scale access of electric vehicles to the power grid, this paper proposes an electric vehicle cluster dispatching strategy considering demand response, which uses Vehicle to Grid (V2G) technology to control the charging and discharging behavior and provide auxiliary services for the power system. Firstly, the V2G model of EV is established according to the travel demand and regular characteristics of EV users. Secondly, combined with the regional daily load curve and time-of-use price, the multi-objective optimal dispatching model of EV cluster charging and discharging is established to stabilize the load fluctuation of power grid and increase the profit of EV users. Considering the demand of electric vehicles and the operation constraints of distribution network, the Pareto optimal solution is obtained by genetic algorithm. The case study results show that the optimization strategy can use peak-valley time-of-use electricity prices to guide the orderly charging and discharging of electric vehicles while meeting user needs, so as to achieve load peak-shaving and valley-filling. After increasing the V2G response subsidy under the tiered electricity price mode, when dispatching with the maximum profit of the user, the grid-side peak-to-valley ratio can be reduced by 2.99%, and the variance can be reduced by 9.52%, achieving the multi-objective optimization of V2G participation in power response.

Subject Areas: Vehicle-to-grid; Analytical models; Fluctuations; Electric vehicles; Load management; Dispatching; Power grids; Demand response; Multi-objective optimization

Availability: Li, T., Tao, S., He, K., Fan, H., Zhang, Y., and Sun, Y. (2021). "Multi-objective Optimal Dispatching of Electric Vehicle Cluster Considering User Demand Response." *2021 IEEE 4th International Conference on Electronics Technology (ICET)*, pp. 1003–1008. https://doi.org/10.1109/ICET51757.2021.9450945

2.43. Title: Combined Optimal Planning and Operation of a Fast EV-Charging Station Integrated with Solar PV and ESS

Author(s): Nishimwe H., L.F. and Yoon, S.-G.

Abstract: Sufficient and convenient fast-charging facilities are crucial for the effective integration of electric vehicles. To construct enough fast electric vehicle-charging stations, station owners need to earn a reasonable profit. This paper proposed an optimization framework for profit maximization, which determined the combined planning and operation of the charging station considering the vehicle arrival pattern, intermittent solar photovoltaic generation, and energy storage system management. In a planning horizon, the proposed optimization framework finds an optimal configuration of a grid-connected charging station. Besides, during the operation horizon, it determines an optimal power scheduling in the charging station. We formulated an optimization framework to maximize the expected profit of the station. Four types of costs were considered during the planning period: the investment cost, operational cost, maintenance cost, and penalties. The penalties arose from vehicle customers' dissatisfaction associated with waiting time in queues and rejection by the station. The simulation results showed the optimal investment configuration and daily power scheduling in the charging station in various environments such as the downtown, highway, and public stations. Furthermore, it was shown that the optimal configuration was different according to the environments. In addition, the effectiveness of solar photovoltaic, energy storage system, and queue management was demonstrated in terms of the optimal solution through a sensitivity analysis.

Subject Areas: Electric vehicle; Energy storage system; Charging station; Optimization; Power scheduling; Queueing system; Solar photovoltaic

Availability: Nishimwe H., L.F. and Yoon, S.-G. (2021). "Combined Optimal Planning and Operation of a Fast EV-Charging Station Integrated with Solar PV and ESS." *Energies 2021*, *14*(11). https://doi.org/10.3390/en14113152

2.44. Title: Electric Vehicle Charging and Rural Distribution Systems

Author(s): Goolsby, R.T.

Abstract: Rural electric distribution systems, compared to their suburban and urban counterparts, are characterized by longer, radial feeders with fewer consumers per mile. These feeders are limited in length more by voltage drop than thermal capacity. Corrective action must be taken when peak demand results in insufficient end-of-line voltage. Today, most energy consumed by the transportation sector is delivered via fossil fuels. Electrification of the transportation sector has the potential to increase peak demand on feeders that have historically seen little to no load growth. Likewise, additional energy sales without a corresponding peak demand increase are possible. Since it is the utility's responsibility to ensure adequate voltage is provided to each consumer, and most economical to deliver additional energy via existing capacity, both "on-peak" and "off-peak" charging of electric vehicles require consideration. An electrical model of Ohio rural electric system is combined with estimates of future electric vehicle adoption and existing transportation data. Residential energy consumption collected hourly via the owner's Advanced Metering Infrastructure (AMI) is modified to represent on-peak electric vehicle charging. The existing system load profile and load factor are reviewed, and off-peak time-of-use periods identified.

Subject Areas: Plug-in electric vehicles; Substations; Limiting; Load forecasting; Loading; Transportation; System improvement; Time-of-use; Advanced metering infrastructure; Demand; Distribution

Availability: Goolsby, R.T. (2021). "Electric Vehicle Charging and Rural Distribution Systems." *2021 IEEE Rural Electric Power Conference (REPC)*, pp. 1–5. https://doi.org/10.1109/REPC48665.2021.00007

2.45. Title: Vehicle-to-Vehicle Inductive Charge Transfer Feasibility and Public Health Implications

Author(s): Dutta, P.

Abstract: There has been an increased push away from the traditional combustion-engine powered vehicle due to environmental, health, and political concerns. As a result, alternative methods of transportation such as electric vehicles (EVs) have gaining popularity in the market. However, the EVs are not penetrating the market as quickly as expected, due in part to a combination of range, charge anxiety, and their financial costs. EVs cannot travel far due to limited driving range and require longer charge times than combustion-engine powered vehicles to recharge. Coupled with a lacking infrastructure for charging, the feasibility of an all-electric transportation market is still not possible.

We propose a novel system in which we study and characterize the feasibility of increasing the effective driving range of a battery electric vehicle by utilizing inductive charge transfer to create an ad-hoc charging network where vehicles can "share" charge with one another. The application of wireless charge transfer from vehicle-to-vehicle (V2V) is the first of its kind and does not require any changes to current metropolitan infrastructures. Through the use of computer networking and communications algorithms, we analyze real-world commuter and taxi data to determine the potential effectiveness of such a system. We propose a participation and incentive mechanism to encourage participation in this network that enables the system to be functional. To illustrate proof of principle for V2V charging at traffic lights, we simulate a simplified model in which vehicles only exchange charge at traffic lights without coordination with other vehicles. Using a greedy heuristic, vehicles only exchange charge if they happen to meet another vehicle that has charge to share. The heuristic is greedy since decisions are made at each iteration with longer optimality not being considered. We are able to demonstrate an increase in effective driving range of EVs using these simplistic assumptions.

In this thesis, we develop and quantify a complete simulation framework, which allows EVs to operate using charge sharing. We analyze data from the United States Department of Transportation, New York City Taxi and Limousine Commission, and Regional New York City data sources to understand the cumulative driving distance distributions for passenger/commuter vehicles and taxicabs in large metropolitan areas such as New York City. We show that the driving distributions can best be represented as heavy-tail distribution functions with most commuter vehicles not requiring additional charge during a typical day's usage of their vehicle as compared to taxicabs, which regularly travel more than 100 miles during a 12-hour shift.

We develop and parameterize several variables for input into our simulation framework including driving distance, charge exchange heuristics, models for determining pricing of charge units, traffic density, and geographic location. The inclusion of these parameters helps to build a framework that can be utilized for any metropolitan area to determine the feasibility of EVs.

We have performed extensive evaluation of our model using real data. Our current simulations indicate that we can increase the effective distance that an electric vehicle travels by a factor of at least 2.5. This increased driving range makes EVs a more feasible mode of transportation for fleet

vehicles such as taxicabs that rely heavily on commuting long cumulative distances. We have identified areas for future improvement to add further parameters to make the model even more sensitive.

Finally, we focus on the application of our charge sharing framework in a real-world application for utilizing this methodology for the New York City bus system. In partnership with the New York City MTA, we launched a feasibility study of converting the currently majority hybrid bus fleet into a complete electric bus fleet with charging available at bus stops during scheduled bus stops. Unlike the earlier charge sharing framework, this simulation focuses on discrete distances that are traveled by the bus before having an opportunity to charge at the next bus stop. In this scenario, a large source of variability is the amount of time that the bus is able to stop at a bus stop for charging since this is determined by the amount of time needed to successfully embark and disembark the passengers at the given bus stop. This particular variability impacts how much charge the bus is able to gain during any given stop.

We conclude with a list of opportunities for future work in expanding the model with additional parameters and conclusions of our work. Further, we identify areas of further research that outline the potential positive and negative outcomes from a charge sharing system that can be extended to various other applications including micro-mobility applications such as electric scooters and bicycles.

Subject Areas: Environmental health; Motor vehicles; Exhaust gas; Electric vehicles; Public transit

Availability: Dutta, P. (2021). *Vehicle-to-Vehicle Inductive Charge Transfer Feasibility and Public Health Implications*. Doctoral Dissertation, Columbia University, New York, NY. https://academiccommons.columbia.edu/doi/10.7916/d8-2bb8-0180

2.46. Title: Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains

Author(s): Burnham, A., Gohlke, D., Rush, L., Stephens, T., Zhou, Y., Delucchi, M.A., Birky, A., Hunter, C., Lin, Z., Ou, S., Xie, F., Proctor, C., Wiryadinata, S., Liu, N., and Boloor, M.

Abstract: In order to accurately compare the costs of two vehicles, the total cost of ownership (TCO) should consist of all costs related to both purchasing and operating the vehicle. This TCO analysis builds on previous work to provide a comprehensive perspective of all relevant vehicle costs of ownership. In this report, we present what we believe to be the most comprehensive explicit financial analysis of the costs that will be incurred by a vehicle owner. This study considers vehicle cost and depreciation, financing, fuel costs, insurance costs, maintenance and repair costs, taxes and fees, and other operational costs to formulate a holistic total cost of ownership and operation of multiple different vehicles. For each of these cost parameters that together constitute a comprehensive TCO, extensive literature review and data analysis were performed to find representative values in order to build a holistic TCO for vehicles of all size classes. The light- and heavy-duty vehicles selected for analysis in this report are representative of those that are on the road today and expected to be available in the future.

Previous analyses of TCO, particularly those dealing with alternative fuel vehicles (AFVs), have often focused on the purchase cost and the fuel cost. While these are two of the most important factors making up the cost of the vehicle, we find sizeable variations in other operational costs across powertrains, size classes, and usage parameters. We use vehicles modeled in Autonomie to estimate vehicle costs and fuel economy along with fuel price projections from the Energy Information Administration (EIA), and focus on developing internally consistent estimates for other relevant cost parameters. Important additive analyses in xviii this study include systematic analysis of vehicle depreciation, in-depth examination of insurance premium costs, comprehensive maintenance and repair estimates, analysis of all relevant taxes and fees, and considerations of specific costs applicable to commercial vehicles. This study, which considers these additional cost components, provides a more holistic and comprehensive perspective of TCO for a wider range of vehicle sizes, types, and vocations than have previously been analyzed.

Subject Areas: Total cost of ownership; Financial analysis

Availability: Burnham, A., Gohlke, D., Rush, L., Stephens, T., Zhou, Y., Delucchi, M.A., Birky, A., Hunter, C., Lin, Z., Ou, S., Xie, F., Proctor, C., Wiryadinata, S., Liu, N., and Boloor, M. (2021). *Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains*. U.S. Department of Energy Office of Scientific and Technical Information, Washington, DC. https://www.osti.gov/biblio/1780970

2.47. Title: Application of Flexible Ramping Products with Allocation Rates in Microgrid Utilizing Electric Vehicles

Author(s): Kim, D., Kwon, K., and Kim, M.

Abstract: Microgrids account for a relatively high proportion of renewable energy utilization. Therefore, an operation method that ensures flexible resources to cope with the variability and uncertainty in renewable energy is indispensable for microgrid operators (MGOs). Here, we focus on the necessity of an optimal generation scheduling model for MGOs by considering flexible resources—namely, flexible ramping products (FRPs). We propose a microgrid scheduling model including a method of utilizing electric vehicles (EVs) as a flexible resource and an operation method to secure FRPs in microgrids by applying allocation indices. The states and available capacities of EVs during each period are estimated using a Markov chain. The net load scenarios, which are considered as the target for the supply–demand balancing in the proposed method, are generated considering the uncertainty in forecasting load and renewable energy. The effectiveness and merits of the proposed model are validated through experiments on a microgrid test system that allows transactions between utilities through the tie-line. The results confirm that the proposed optimal generation scheduling model affords a reduction in microgrid operating costs and enables the stabilization of variability.

Subject Areas: Microgrid; Electric vehicle; Flexible ramping product; Optimal generation scheduling; Allocation rate

Availability: Kim, D., Kwon, K., and Kim, M. (2021). "Application of Flexible Ramping Products with Allocation Rates in Microgrid Utilizing Electric Vehicles." *International Journal of Electrical Power & Energy Systems*, *133*. https://doi.org/10.1016/j.ijepes.2021.107340

2.48. Title: The Promise of EV-Aware Multi-Period OPF Problem: Cost and Emission Benefits

Author(s): Kayacık, S.E., Kocuk, B., and Yüksel, T.

Abstract: In this paper, we study the Multi-period optimal power flow problem (MOPF) with electric vehicles (EV) under emission considerations. We integrate three different real-world datasets: household electricity consumption, marginal emission factors, and EV driving profiles. We present a systematic solution approach based on second-order cone programming to find globally optimal solutions for the resulting nonconvex optimization problem. To the best of our knowledge, our paper is the first to propose such a comprehensive model integrating multiple real datasets and a promising solution method for the EV-aware MOPF problem. Our computational experiments on various instances with up to 2,000 buses demonstrate that our solution approach leads to high-quality feasible solutions with provably small optimality gaps. In addition, we show the importance of coordinated EV charging to achieve significant emission savings and reductions in cost. In turn, our findings can provide insights to decision makers on how to incentivize EV drivers depending on the trade-off between cost and emission.

Subject Areas: Multi-period optimal power flow problem; Second-order cone programming; Integration of electric vehicles to power grid

Availability: Kayacık, S.E., Kocuk, B., and Yüksel, T. (2021). *The Promise of EV-Aware Multi-Period OPF Problem: Cost and Emission Benefits*. arXiv preprint, arXiv:2107.03868 [math.OC]. https://arxiv.org/abs/2107.03868

2.49. Title: A Hybrid Robust-Stochastic Framework for Strategic Scheduling of Integrated Wind Farm and Plug-In Hybrid Electric Vehicle Fleets

Author(s): Zeynali, S., Nasiri, N., Marzband, M., and Ravadanegh, S.N.

Abstract: This paper focuses on cooperative scheduling of the integrated plug-in hybrid electric vehicle fleets and wind farm system (IWPHEVS) in the day-ahead wholesale market (DWM), as well as its effects on the market outcomes and price, as a price-maker player. In this regard, a multi-objective two-stage bi-level hybrid stochastic-robust offering/bidding and scheduling strategy is developed. The upper-level problem, which is that of the IWPHEVS operator, encompasses two objectives—namely, cost and emission. The cost objective comprises operational costs and the cost of power that is purchased in DWM. Additionally, the plug-in hybrid electric vehicles (PHEVs) are congregated into distinct fleets through k-means clustering. To inscribe PHEVs' battery erosion, a comprehensive battery erosion model is comprehended, which is linearized by semi-integer variables. The uncertain datasets, such as vehicle fleets' arrival/departure timings and their traveled miles, are represented as scenarios according to their empirical distribution, which is acquired from the National Household Travel Survey (NHTS). On the flip side, the wind power, which is a more unpredictable parameter, is designed as a robust optimization (RO) set, as it is apt to enhance the reliability issues regarding wind volatilities. The lower level embodies the wholesale market operator that has the objective of maximizing social welfare. Conclusively, different case studies of dump, smart, and multi-objective charging are meticulously investigated to testify the potency of the proposed method. Based on the obtained findings on the proposed smart multi-objective framework, the IWPHEVS as a price-maker player, can manipulate locational marginal price as much as 4.4 percent, while the emissions can be curtailed by 40 percent.

Subject Areas: Transportation electrification; Bi-level optimization; Battery degradation; Smart charging; K-means clustering; Hybrid stochastic robust optimization

Availability: Zeynali, S., Nasiri, N., Marzband, M., and Ravadanegh, S.N. (2021). "A Hybrid Robust-Stochastic Framework for Strategic Scheduling of Integrated Wind Farm and Plug-In Hybrid Electric Vehicle Fleets." *Applied Energy*, *300*.
https://doi.org/10.1016/j.apenergy.2021.117432

2.50. Title: Electrification of Personal Vehicle Travels in Cities—Quantifying the Public Charging Demand

Author(s): Thingvad, A., Andersen, P.B., Unterluggauer, T., Træholt, C., and Marinelli, M.

Abstract: Charging electric vehicles is regarded as trivial with chargers installed on private property, which could accommodate the demand of 78 percent of the Danish cars. Hence, the owners would rarely need to charge outside the household. Car owners in the cities often do not have this option and must rely on the public charging infrastructure. In this work, we quantify the need, in terms of energy demand, for public chargers on a national level and in the largest Danish cities as a function of car ownership, driving distance, and household parking condition. We assess the potential of destination charging at existing shared parking facilities next to the household and the workplace to reduce the public charging demand to be up to 87 percent. EVs with 300 km range are able to complete the daily driving distance without range extending charging in 98.4 percent of the days. The analysis relies on driving and ownership data based on the Danish national transport survey. Further, we identify suitable/optimal locations for the necessary public chargers based on the total amount of parking time spent by a car at different destinations and the duration of a stay. We generalize the relationship between publicly available information such as population density and city size and the parameters that determine the public charging demand. The systematic approach enables others to estimate the demand in time and space for other cities or countries.

Subject Areas: Electric vehicles; Charging infrastructure

Availability: Thingvad, A., Andersen, P.B., Unterluggauer, T., Træholt, C., and Marinelli, M. (2021). "Electrification of Personal Vehicle Travels in Cities—Quantifying the Public Charging Demand." *eTransportation*, *9*. https://doi.org/10.1016/j.etran.2021.100125

2.51. Title: It's Not Easy Being "Green": Lessons from Norway's Experience with Incentives for Electric Vehicle Infrastructure

Author(s): Springel, K.

Abstract: Governments around the world are planning to accelerate their efforts to decarbonize and electrify their transportation sector. In this article, I describe the key role charging stations play in electric vehicle (EV) markets and discuss how a lack of charging infrastructure can pose a barrier to EV adoption. Then I discuss Norway's experience with incentives for charging infrastructure and consumer subsidies. I conclude by highlighting key lessons from Norway and their implications for designing effective policies to support EV adoption.

Subject Areas: Charging infrastructure; Electric vehicle; Consumer subsidies; Norway

Availability: Springel, K. (2021). "It's Not Easy Being 'Green': Lessons from Norway's Experience with Incentives for Electric Vehicle Infrastructure." *Review of Environmental Economics and Policy*, *15*(2). https://www.journals.uchicago.edu/doi/abs/10.1086/715549

2.52. Title: How Argonne Research Is Illuminating How Energy Costs Vary Nationwide

Author(s): Argonne National Laboratory.

Abstract: Blog.

Subject Areas: Fuel spending; Machine learning; Household income; Transportation burden; Clean vehicle adoption

Availability: Argonne National Laboratory. (2021). "How Argonne Research Is Illuminating How Energy Costs Vary Nationwide." *Newswise*. https://www.newswise.com/doescience/how-argonne-research-is-illuminating-how-energy-costs-vary-nationwide/?article_id=755031

2.53. Title: Gasoline Superusers

Author(s): Metz, M., London, J., and Rösler, P.

Abstract: American drivers are highly unequal in their gasoline use. The top 10 percent of drivers in terms of gasoline consumption ("gasoline superusers") burn 32 percent of gasoline—more than the bottom 60 percent of drivers combined.

This report demonstrates that converting gasoline superusers to electric vehicles (EVs) at an accelerated rate is necessary to achieve Biden administration carbon reduction targets. Therefore, EV incentive policies should be changed to focus on reducing gasoline consumption rather than simply selling EVs. The report concludes that gasoline displacement incentives are a more effective and equitable tool to reduce gasoline use than flat EV incentives and that superusers should be prioritized in EV charging policy and EV marketing and education initiatives.

Subject Areas: Gasoline usage; Vehicle preference; Demographics; Electric vehicles; Incentive; Charging infrastructure; Marketing

Availability: Metz, M., London, J., and Rösler, P. (2021). *Gasoline Superusers*. Coltura, Seattle, WA. https://www.coltura.org/gasoline-superusers

2.54. Title: Training Electric Vehicle Charging Controllers with Imitation Learning

Author(s): Pilát, M.

Abstract: The problem of coordinating the charging of electric vehicles gains more importance as the number of these vehicles grows. In this paper, we develop a method for the training of controllers for the coordination of EV charging. In contrast to most existing works on this topic, we require the controllers to preserve the privacy of the users, and therefore we do not allow any communication from the controller to any third party.

In order to train the controllers, we use the idea of imitation learning—we first find an optimum solution for a relaxed version of the problem using quadratic optimization and then train the controllers to imitate this solution. We also investigate the effects of regularization of the optimum solution on the performance of the controllers. The method is evaluated on realistic data and shows improved performance and training speed compared to similar controllers trained using evolutionary algorithms.

Subject Areas: Imitation learning; Apprenticeship learning; Neural networks; Electric vehicle charging

Availability: Pilát, M. (2021). *Training Electric Vehicle Charging Controllers with Imitation Learning*. arXiv preprint, arXiv:2107.10111 [cs.LG]. https://arxiv.org/abs/2107.10111

2.55. Title: Household Transportation Energy Affordability by Region and Socioeconomic Factors

Author(s): Zhou, Y., Aeschliman, S., and Gohlke, D.

Abstract: Transportation fuel is an important component of household budgets, as 3.3 percent of total household expenditures are for vehicle fuel nationwide, and over 50 percent of annual household expenditures on energy are for transportation. These average values vary geographically, and higher energy cost burdens are faced by households with lower incomes. Defining transportation energy affordability burden as the percentage of annual household income spent on vehicle fuel, this study aims to quantify affordability as a function of household characteristics and geography. Through analysis at the Census tract level, this study (i) projects annual household vehicle miles traveled (VMT) based on demographic factors using machine-learning techniques, (ii) estimates local differences in vehicle fuel economy and fuel price, and (iii) quantifies resulting transportation energy affordability by Census tract. This study found that the average burden by tract varies from 0.15 to 8 percent. The variation in affordability can be largely explained by income level and vehicle fuel efficiency. Suburban and rural households spend more on transportation energy compared with urban households because of the usage of less fuel-efficient vehicle technologies and higher annual VMT. Lower income groups have a wide distribution of the percentage of income spent on transportation energy, 1.2 to 8 percent, whereas the range for the highest income group ($125,000+) is from 0.15 to 3.9 percent. This detailed transportation energy affordability analysis provides a better understanding of regional variations in household travel behavior, helps to determine where fuel-efficient vehicle technologies are more likely to be used, and improves estimates of vehicle ownership costs.

Subject Areas: Transportation burden; Energy cost; Affordability; Household characteristics; Geography; Vehicle miles traveled; Machine learning

Availability: Zhou, Y., Aeschliman, S., and Gohlke, D. (2021). "Household Transportation Energy Affordability by Region and Socioeconomic Factors." *Transportation Research Record*, *2675*(10), pp. 81–95. https://doi.org/10.1177%2F03611981211010186

2.56. Title: Improved Ant Lion Algorithm for Orderly Charging of Electric Vehicles

Author(s): Peng, X., Chen, C., Zheng, T., Tang, W., Xiong, Z., and Ouyang, G.

Abstract: In order to reduce the instability of power grid caused by disorderly charging of large-scale electric vehicles in the future, an ordered charging optimization model is established, which aims at the minimum peak and valley difference of power grid side and the lowest charge cost of user side. Meanwhile, to solve the objective function efficiently and quickly, ant lion optimization with Levy flight and self-adaptive strategy (LSALO) is proposed for charging the electric vehicle. The introduction of adaptive boundary strategy increases population diversity, and Levy flight is conducive to avoiding local optimization and speeding up global convergence. The simulation results show that compared with particle swarm optimization (PSO) and ant lion optimization (ALO), LSALO has the highest convergence accuracy and optimization accuracy and has strong advantages in the optimization of the orderly charging of electric vehicles.

Subject Areas: Simulation; Sociology; Electric vehicles; Linear programming; Power grids; Power electronics; Statistics

Availability: Peng, X., Chen, C., Zheng, T., Tang, W., Xiong, Z., and Ouyang, G. (2021). "Improved Ant Lion Algorithm for Orderly Charging of Electric Vehicles." *2021 IEEE 12th International Symposium on Power Electronics for Distributed Generation Systems (PEDG)*, pp. 1–7. https://doi.org/10.1109/PEDG51384.2021.9494274

2.57. Title: Charging Up America: Assessing the Growing Need for U.S. Charging Infrastructure Through 2030

Author(s): Bauer, G., Hsu, C., Nicholas, M., and Lutsey, N.

Abstract: Electric vehicles surpassed 10 million cumulative sales globally in late 2020. Announcements from automakers and the U.S. Government regarding manufacturing goals, new vehicle emission standards, incentives, and infrastructure investments suggest the U.S. electric vehicle market could expand dramatically in the years ahead. These developments spur broad questions about how much infrastructure is needed to support electric vehicle growth and the associated costs.

This paper assesses growing home, workplace, and public charging needs through 2030 to support the transition to electric vehicles in the United States. The analysis incorporates local market trends, evolving charging technology and behavior, household characteristics, and home charging availability. It includes charging needs for lower income communities, rural areas, highway corridor charging, and ride-hailing vehicles. The charging analysis is also integrated with bottom-up charging costs to estimate the associated infrastructure investment required to support the electric transition.

Subject Areas: Electric vehicles; Charging; Charging infrastructure; Lower income communities

Availability: Bauer, G., Hsu, C., Nicholas, M., and Lutsey, N. (2021). *Charging Up America: Assessing the Growing Need for U.S. Charging Infrastructure Through 2030*. White Paper, International Council on Clean Transportation, Washington, DC. https://theicct.org/sites/default/files/publications/charging-up-america-jul2021.pdf

2.58. Title: A Review of Data Sources for Electric Vehicle Integration Studies

Author(s): Calearo, L., Marinelli, M., and Ziras, C.

Abstract: The sales of electric vehicles (EVs) are rapidly increasing and their integration in the power system is becoming a crucial issue. However, there is a scarcity of necessary data to derive charging profiles and analyze their impact on the power system. The purpose of this manuscript is to provide a comprehensive review of published data sources that can be useful for EV studies in the context of smart grids and power systems. The manuscript focuses on the last two decades of published data, as this is more complete and reliable in terms of user and vehicle behavior. Data sources are categorized into three classes: surveys, internal combustion engine vehicles and EVs trials, and charger trials. Data from the different sources are summarized, including information regarding how and what kind of data have been collected and their availability. Based on the reviewed sources, five parameters are identified as essential to derive charging profiles: battery capacity, charging power, plug-in state of charge, plug-in/-out time, and charged energy. In order to observe individual behavior, it is important to consider sets of charging sessions per charger; otherwise, important correlations may be neglected. Depending on the source and data availability, in many cases this is not possible. To this end, this manuscript discusses how to use data from various sources to complement missing information and concludes with guidelines and limitations about data usage in EV studies.

Subject Areas: Charging profiles; EV data sources; EV integration

Availability: Calearo, L., Marinelli, M., and Ziras, C. (2021). "A Review of Data Sources for Electric Vehicle Integration Studies." *Renewable and Sustainable Energy Reviews*, *151*. https://doi.org/10.1016/j.rser.2021.111518

2.59. Title: Electric Vehicles Charging Stations' Architectures, Criteria, Power Converters, and Control Strategies in Microgrids

Author(s): Savio Abraham, D., Verma, R., Kanagaraj, L., Giri Thulasi Raman, S.R., Rajamanickam, N., Chokkalingam, B., Marimuthu Sekar, K., and Mihet-Popa, L.

Abstract: The usage of electric vehicles (EV) has been increasing over the last few years due to a rise in fossil fuel prices and the rate of increasing carbon dioxide (CO_2) emissions. EV-charging stations are powered by existing utility power grid systems, increasing the stress on the utility grid and the load demand at the distribution side. DC grid-based EV charging is more efficient than AC distribution because of its higher reliability, power conversion efficiency, simple interfacing with renewable energy sources (RESs), and integration of energy storage units (ESU). RES-generated power storage in local ESU is an alternative solution for managing the utility grid demand. In addition, to maintain the EV charging demand at the microgrid levels, energy management and control strategies must carefully power the EV battery charging unit. In addition, charging stations require dedicated converter topologies and control strategies and need to follow set levels and standards. Based on EV, ESU, and RES accessibility, different types of microgrid architecture and control strategies are used to ensure optimum operation at the EV-charging point. Based on the above-mentioned merits, this review paper presents different RES-connected architecture and control strategies used in EV-charging stations. It highlights the importance of different charging station architectures with current power converter topologies proposed in the literature. In addition, a comparison of microgrid-based charging station architecture with its energy management, control strategies, and charging converter controls are presented. The different levels and types of charging stations used for EV charging, in addition to controls and connectors used, are also discussed. An experiment-based energy management strategy was developed to control power flow among the available sources and charging terminals for the effective utilization of generated renewable power. The main motive of the EMS and its control is to maximize the usage of RES consumption. This review also provides the challenges and opportunities in EV charging and parameters in selecting appropriate charging stations.

Subject Areas: Microgrid; Electric vehicle; Energy management controls; Renewable energy sources; Energy storage unit

Availability: Savio Abraham, D., Verma, R., Kanagaraj, L., Giri Thulasi Raman, S.R., Rajamanickam, N., Chokkalingam, B., Marimuthu Sekar, K., and Mihet-Popa, L. (2021). "Electric Vehicles Charging Stations' Architectures, Criteria, Power Converters, and Control Strategies in Microgrids." *Electronics*, *10*(16). https://doi.org/10.3390/electronics10161895

2.60. Title: City-Wide Modeling of Vehicle-to-Grid Economics to Understand Effects of Battery Performance

Author(s): Gandhi, H.A. and White, A.D.

Abstract: Vehicle-to-grid (V2G) is a promising approach to solve the problem of grid-level intermittent supply and demand mismatch due to renewable energy resources because it uses the existing resource of electric vehicle (EV) batteries as the energy storage medium. EV battery design, together with an impetus on profitability for participating EV owners, is pivotal for V2G success. To better understand what battery device parameters are most important for V2G adoption, we model the economics of V2G process under realistic conditions. Most previous studies that perform V2G economic analysis assume ideal driving conditions, use linear battery degradation models, or only consider V2G for ancillary services. Our model accounts for realistic battery degradation, empirical charging efficiencies, randomness in commute behavior, and historic hourly electricity prices in six cities in the United States. We model user behavior with Bayesian optimization to provide a best-case scenario for V2G. Across all cities, we find that charging rate and efficiency are the most important factors that determine EV users' profits. Surprisingly, EV battery cost and thus degradation due to cycling has little effect. These findings should help focus research on figures of merit that better reflect real usage of batteries in a V2G economy.

Subject Areas: Vehicle-to-grid economics; Electric vehicles; Stochastic modeling; Cost-benefit analysis

Availability: Gandhi, H.A. and White, A.D. (2021). *City-Wide Modeling of Vehicle-to-Grid Economics to Understand Effects of Battery Performance*. arXiv preprint, arXiv:2108.05837 [stat.AP]. https://arxiv.org/abs/2108.05837

2.61. Title: Quantifying the Impact of Driving Style Changes on Light-Duty Vehicle Fuel Consumption

Author(s): Miotti, M., Needell, Z.A., Ramakrishnan, S., Heywood, J., and Trancik, J.E.

Abstract: Modifying driving styles can help to reduce the energy use and emissions of driving without requiring changes to infrastructure or vehicle technology. Here, we evaluate the energy consumption and duration of trips before and after driving style changes. These modifications are made using emissions-friendly driving style heuristics that are easily implementable by drivers and do not require real-time feedback or on-board diagnostics. We use a data-driven approach to apply these heuristics to a representative baseline of U.S. drive cycles. The simulated driving-style improvements provide an average fuel savings per trip of 6 percent, alongside a 1.5 percent increase in trip duration. Decelerating early and reducing highway speeds can each contribute substantially to fuel savings. Accelerating more gradually contributes less. The percentage fuel savings are relatively consistent across locations and vehicle classes. These findings can inform several decision makers, including drivers aiming to reduce fuel consumption, car manufacturers or software developers designing driving style feedback, and policymakers examining emissions savings opportunities.

Subject Areas: Driving style; Eco-driving; Fuel economy; Light-duty vehicle; Greenhouse gas emissions

Availability: Miotti, M., Needell, Z.A., Ramakrishnan, S., Heywood, J., and Trancik, J.E. (2021). "Quantifying the Impact of Driving Style Changes on Light-Duty Vehicle Fuel Consumption." *Transportation Research Part D: Transport and Environment*, *98*. https://doi.org/10.1016/j.trd.2021.102918

2.62. Title: Exploring the Future Energy-Mobility Nexus: The Transportation Energy & Mobility Pathway Options (TEMPO) Model

Author(s): Muratori, M. et al.

Abstract: This paper documents the approaches and methods used in the Transportation Energy & Mobility Pathway Options™ (TEMPO™) model to evaluate passenger and freight demand for transportation and mobility services, project vehicle ownership and technology adoption decisions, and determine transport mode choices to derive scenarios of future energy use and emissions. TEMPO is an all-inclusive transportation demand model that covers the entire United States, with an implicit spatial resolution and an hourly temporal resolution that allows for generating time-resolved energy use profiles to assess multisectoral integration aspects. Key features of the TEMPO model include the ability to perform endogenous out-of-sample forecasting to extrapolate recent emerging trends and analyze impacts of disruptive technological breakthroughs and behavioral changes. TEMPO employs an innovative representation of passenger mobility demand stemming from household-level decisions that determine vehicle adoption, ownership, and use based on sociodemographics (e.g., income, household composition), technology attributes (e.g., travel cost, time), geography (e.g., urban, suburban, rural) and population-specific multiday mobility and travel requirements. This representation enables a more forward-looking perspective on the use of new mobility options and the adoption of alternative fuel vehicles, as well as a more accurate representation of their energy usage profiles than previous modeling approaches. A comparison with the U.S. Energy Information Administration's Annual Energy Outlook showcases the ability of TEMPO to accurately replicate widely accepted projections by representing the key elements of the entire transportation sector at the appropriate level of resolution. TEMPO is intended to generate future scenarios of technology adoption, energy use, and emissions in the transportation sector to compare alternatives, inform decision makers, and assess integration with energy infrastructure and supply systems at an appropriate spatiotemporal resolution.

Subject Areas: Transportation model; Energy projections; Household travel; Vehicle ownership; Alternative fuels; Electric vehicles; Mode choice

Availability: Muratori, M. et al. (2021). "Exploring the Future Energy-Mobility Nexus: The Transportation Energy & Mobility Pathway Options (TEMPO) Model." *Transportation Research Part D: Transport and Environment*, *98*. https://doi.org/10.1016/j.trd.2021.102967

2.63. Title: A Novel Underfill-SOC Based Charging Pricing for Electric Vehicles in Smart Grid

Author(s): Lin, J., Xiao, B., Zhang, H., Yang, X., and Zhao, P.

Abstract: With the advanced communication, computation, control, and manufacturing technologies, electric vehicles have been extensively developed to improve the utilization of clean energy and reduce emissions. Despite the tremendous advantages, the rapidly growthing of deploying electric vehicles will bring new insecurities, such as disorderly charging behaviors, which affect the stability of the smart grid. Although considerable efforts on charging schedules have been developed to improve energy utilization and reduce load fluctuation in the smart grid, the profits of utility company have not been investigated. In addition, most of these schemes also lead to inefficient battery utilization, i.e., electric vehicles usually charge while their batteries still have a lot of energy left. To address these issues, in this paper, a novel underfill-SOC based charging pricing (USoCP) scheme is proposed for electric vehicles in smart grid, which can achieve great battery utilization, as well as guarantee great profits of utility company and load balance of the whole grid. Particularly, via introducing the Logistic function into charging pricing determination, the proposed USoCP scheme can effectively improve the underfill state of charge (underfill-SOC) for battery charging, thereby improving the battery utilization. Meanwhile, to reduce the load fluctuation and guarantee great profits of utility company, a charging price based demand-response model is conducted to determine the effective charging power quantity, and a charging pricing determination model is formalized as an optimization problem to reduce the peak-to-average ratio of power load and guarantee great electricity selling profits of utility company. Finally, a Particle Swarm Optimization (PSO) based solution is proposed to solve the optimization problem and determine the effective charging price for electric vehicles. Via extensive evaluations, the results show that the proposed USoCP scheme can effectively stimulate electric vehicles to charge more energy in each battery charging (i.e., improving the battery utilization), reduce peak power load, as well as guarantee great profits of utility company.

Subject Areas: Smart grid; Electric vehicles; Charging price; Underfill-SOC

Availability: Lin, J., Xiao, B., Zhang, H., Yang, X., and Zhao, P. (2021). "A Novel Underfill-SOC Based Charging Pricing for Electric Vehicles in Smart Grid." *Sustainable Energy, Grids and Networks*, *28*. https://doi.org/10.1016/j.segan.2021.100533

2.64. Title: How Much Do Consumers Value Fuel Cost Savings? Evidence from the Passenger Vehicle Leasing Market

Author(s): Ankney, K. and Leard, B.

Abstract: Vehicle leasing involves a consumer renting a car for an average of 3 years. Given the typical lease length, we show that estimating valuation of leased vehicle fuel costs is fundamentally different from estimating valuation of purchased vehicle fuel costs. We find that new vehicle lessees and buyers both undervalue lifetime fuel costs. But because leasing periods last about 3 years, new vehicle lessees fully value lease-specific fuel costs. Our estimates also imply that leasing companies set residual values, defined as the post-lease expected value of the vehicle, with the expectation that used vehicle buyers undervalue post-lease fuel costs.

Subject Areas: Vehicle leasing; Leased vehicle fuel costs; Purchased vehicle fuel costs

Availability: Ankney, K. and Leard, B. (2021). *How Much Do Consumers Value Fuel Cost Savings? Evidence from the Passenger Vehicle Leasing Market*. Working Paper 21-27, Resources for the Future, Washington, DC. https://media.rff.org/documents/wp_21-27.pdf

2.65. Title: A Simple Multi-Parameter Method for Efficient Charging Scheduling of Electric Vehicles

Author(s): Konstantinidis, G., Kanellos, F.D., and Kalaitzakis, K.

Abstract: In this article, a method for the efficient charging of electric vehicles (EVs) at the parking lot (PL) level, including vehicle-to-grid (V2G) operation and taking into account lifetime of EV batteries, distribution network, and local transformer loading, is proposed. The main targets of the method are to minimize the total charging cost of the PLs hosting the EVs and to satisfy all technical and operation constraints of EVs and PLs. The proposed method exploits particle swarm optimization (PSO) to derive the charging schedule of the EVs. The proposed method is compared with conventional charging strategies, where the EVs are charged with the maximum power of their charging power converter or the average power required to achieve their state-of-charge target, and a conventional charging scheduling method using the aggregated behavior of the plug-in EVs. Real-world data series of electricity price and parking lot activity were used. The results obtained from the study of indicative operation scenarios prove the effectiveness of the proposed method, while no sophisticated computing, measurement, and communication systems are required for its application.

Subject Areas: Electric vehicles; Efficient charging scheduling; Energy management; Particle swarm optimization; Vehicle-to-grid

Availability: Konstantinidis, G., Kanellos, F.D., and Kalaitzakis, K. (2021). "A Simple Multi-Parameter Method for Efficient Charging Scheduling of Electric Vehicles." *Applied System Innovation*, *4*(3). https://doi.org/10.3390/asi4030058

2.66. Title: Comparing Total Cost of Ownership of Battery Electric Vehicles and Internal Combustion Engine Vehicles

Author(s): Liu, Z., Song, J., Kubal, J., Susarla, N., Knehr, K.W., Islam, E., Nelson, P., and Ahmed, S.

Abstract: The technological advance of electrochemical energy storage and the electric powertrain has led to rapid growth in the deployment of electric vehicles. The high cost and the added weight of the batteries have limited the size (energy storage capacity) and, therefore, the driving range of these vehicles. However, consumers are steadily purchasing these vehicles because of the fast acceleration, quiet ride, and high energy efficiency. The higher pack-to-wheel efficiency and the lower energy cost per mile, as well as the lower expense for maintenance and repair, translate to operating savings over conventional vehicles. This paper compares battery electric vehicles with internal combustion engine vehicles based on the total cost of ownership. It is seen that the higher initial cost of electric vehicles can be recovered in as little as 5 years. This is especially true for electric vehicles with shorter driving ranges. Specifically, a vehicle with an electric driving range under 200 miles may achieve cost parity with an equivalent internal combustion engine vehicle in 8 years or less.

Subject Areas: Total cost of ownership; Battery electric vehicle; Electric powertrain; Cost parity; Favorability

Availability: Liu, Z., Song, J., Kubal, J., Susarla, N., Knehr, K.W., Islam, E., Nelson, P., and Ahmed, S. (2021). "Comparing Total Cost of Ownership of Battery Electric Vehicles and Internal Combustion Engine Vehicles." *Energy Policy*, *158*. https://doi.org/10.1016/j.enpol.2021.112564

2.67. Title: Electric Vehicles in Multi-Vehicle Households

Author(s): Davis, L.W.

Abstract: This paper uses U.S. nationally representative data from the 2017 National Household Travel Survey to present a series of facts about electric vehicles in multi-vehicle households. First, as of the time of the survey, 89 percent of households with an electric vehicle also had a gasoline or diesel vehicle in addition to the electric vehicle. Second, 60 percent of households with an electric vehicle also had a gasoline or diesel SUV, truck, or minivan—in most cases with fuel economy below the average for the U.S. vehicle stock. Third, 66 percent of households with an electric vehicle also had a gasoline or diesel vehicle that was driven more miles per year than the electric vehicle. The paper argues that these patterns have implications for the environmental impact of electric vehicles and underscore the importance of better understanding how multi-vehicle households substitute between vehicles. The paper also points out that within-household substitution between electric and gasoline vehicles will tend to increase the price elasticity of demand for gasoline.

Subject Areas: Gasoline consumption; Carbon dioxide emissions; Local pollution; Vehicle miles traveled; Range anxiety; Rebound effect; Gasoline tax; Mileage tax; Fuel economy standards

Availability: Davis, L.W. (2021). *Electric Vehicles in Multi-Vehicle Households*. Energy Institute WP 322R, University of California, Berkeley, CA. https://www.haas.berkeley.edu/wp-content/uploads/WP322.pdf

2.68. Title: Assisting Residential Distribution Grids in Overcoming Large-Scale EV Preconditioning Load

Author(s): Antoun, J., Kabir, M.E., Atallah, R., Moussa, B., Ghafouri, M., and Assi, C.

Abstract: The repercussion of increased electric vehicle (EV) charging demand is notable at the distribution grid, especially during the cold morning while users tend to precondition their vehicles before leaving their premises. Moreover, due to the price declination, a tendency of installing level 2 chargers in residential premises is anticipated, which should stimulate the appearance of a new peak to the residential load profile. Hence, multiple scenarios of preconditioning are simulated, and the corresponding network's quality metrics (e.g., voltage level and power losses) are assessed to analyze the impact. And a remarkable consequence is observed. As a consequence, to mitigate the consequences and manage the new peak load, the optimal reconfiguration of network is implemented, and unfortunately, with a larger number of EVs, this technique fails to attain the minimum voltage level. Therefore, leveraging this high number of EVs, instead of relying on the network reconfiguration, power is assumed to be injected from idle EVs through vehicle-to-grid (V2G) energy transmission. An integer linear program is formed to schedule a set of EVs in participating in V2G, and the outcome indicates that V2G alone could not compensate for the disturbance in the network. Accordingly, a hybrid method of V2G and reconfiguration is proposed and evaluated to assist the network in handling the new peak load, and this hybrid solution reduces power losses in the network by 50 percent on average and maintains the voltage level above the operational threshold of 0.95 p.u.

Subject Areas: Electric vehicles (EVs); Load balancing; Network reconfiguration (NR); Preconditioning; Vehicle-to-grid (V2G); Load modeling; Load management; Electric vehicle charging; Threshold voltage; Pricing; Water heating

Availability: Antoun, J., Kabir, M.E., Atallah, R., Moussa, B., Ghafouri, M., and Assi, C. (2021). "Assisting Residential Distribution Grids in Overcoming Large-Scale EV Preconditioning Load." *IEEE Systems Journal*, pp. 1–12. https://doi.org/10.1109/JSYST.2021.3104185

2.69. Title: Joint Optimal Allocation of Electric Vehicle Charging Stations and Renewable Energy Sources Including CO_2 Emissions

Author(s): de Lima, T.D., Franco, J.F., Lezama, F., Soares, J., and Vale, Z.

Abstract: In the coming years, several transformations in the transport sector are expected, associated with the increase in electric vehicles (EVs). These changes directly impact electrical distribution systems (EDSs), introducing new challenges in their planning and operation. One way to assist in the desired integration of this technology is to allocate EV charging stations (EVCSs). Efforts have been made toward the development of EVCSs, with the ability to recharge the vehicle at a similar time than conventional vehicle filling stations. Besides, EVs can bring environmental benefits by reducing greenhouse gas emissions. However, depending on the energy matrix of the country in which the EVs fleet circulates, there may be indirect emissions of polluting gases. Therefore, the development of this technology must be combined with the growth of renewable generation. Thus, this proposal aims to develop a mathematical model that includes EVs integration in the distribution system. To this end, a mixed-integer linear programming (MILP) model is proposed to solve the allocation problem of EVCSs including renewable energy sources. The model addresses the environmental impact and uncertainties associated with demand (conventional and EVs) and renewable generation. Moreover, an EV charging forecast method is proposed, subject to the uncertainties related to the driver's behavior, the energy required by these vehicles, and the state of charge of the EVs. The proposed model was implemented in the AMPL modeling language and solved via the commercial solver CPLEX. Tests with a 24-node system allow evaluating the proposed method application.

Subject Areas: Allocation of electric vehicle charging stations; Electric vehicle charging stations; EV charging forecast method; Renewable energy sources

Availability: de Lima, T.D., Franco, J.F., Lezama, F., Soares, J., and Vale, Z. (2021). "Joint Optimal Allocation of Electric Vehicle Charging Stations and Renewable Energy Sources Including CO_2 Emissions." *Energy Informatics*, *4*. https://doi.org/10.1186/s42162-021-00157-5

2.70. Title: Planning Integrated Energy Systems Coupling V2G as a Flexible Storage

Author(s): Wei, H., Zhang, Y., Wang, Y., Hua, W., Jing, R., and Zhou, Y.

Abstract: Coupling the vehicle-to-grid (V2G) with integrated energy systems (IES) offers an emerging solution for decarbonization of both energy and transport sectors. To evaluate the feasibility of coupling V2G with IES as a flexible storage, we propose an optimization-based system planning framework embedding V2G into IES. Within this framework, stochastic features of electric vehicles (EV) fleets are simulated. The impacts of V2G on IES design are captured by assessing both economic and environmental benefits via multi-objective optimizations utilizing an improved NSGA-II algorithm. Six case studies considering three cities with different climate conditions, and two functional areas of residential and commercial are performed. The results manifest that Beijing-commercial case could achieve the largest mutual benefits. The EV fleets' charging behavior follows the time-of-use energy tariff in transition seasons while not during winter. Sensitivity analysis indicates the electricity and gas prices have significant impact on the system design. The benefits induced by growing EV penetration would gradually decrease and stabilize when the EV number reaches 300 and the growth of economic and environmental benefits stabilized at 1.3 percent and 1.8 percent, respectively. Overall, this study quantifies the benefits of enabling V2G in IES and generates valuable insights for IES planners, V2G service providers, and relevant policymakers.

Subject Areas: Integrated energy system; Vehicle-to-grid; Electric vehicles; Flexible energy storage; Multi-objective optimization; Feasibility assessment

Availability: Wei, H., Zhang, Y., Wang, Y., Hua, W., Jing, R., and Zhou, Y. (2021). "Planning Integrated Energy Systems Coupling V2G as a Flexible Storage." *Energy*, *239*(B). https://doi.org/10.1016/j.energy.2021.122215

2.71. Title: A Framework for Determining Energy Use in Rural Food Delivery Services: Capturing System Interdependencies Through an Agent-Based Discrete Event Approach

Author(s): Gee, I.M., Faust, K.M., and Webber, M.E.

Abstract: Food e-commerce has seen significant growth over the past decade that accelerated after the onset of the COVID-19 pandemic. Last-mile transportation and logistics are widely considered the most expensive and least efficient portion of the supply chain and have multiple important energy trade-offs, such as cargo capacity and consumer density. Last-mile transportation energy use in rural areas is underrepresented in the literature. This study proposes a hybrid agent-based and discrete event model framework for evaluating the last-mile transportation energy use of van- and car-based food delivery services in a rural community, based on meal-kit and grocery delivery operations, respectively. This framework quantifies last-mile energy use in rural areas and is demonstrated here using a neighborhood outside of Austin, TX, as an analytical testbed. The study focuses on the effects of consumer density, cargo limitations, and vehicle speed. For the conditions examined with this framework, diesel delivery vans use more total energy than passenger cars for the same trip, although a van delivering four orders uses less energy per order than a car delivering one order. However, there are trade-offs between vehicle type and mileage, cargo capacity, route density, and speed that are particularly important for delivery services operating in rural areas. This framework can be used by service providers to assess route-specific trade-offs for each vehicle and gauge which is preferable for given operating conditions or to evaluate the energy, and thus also cost, impact of expanding their services to rural areas.

Subject Areas: Food delivery; Rural; Transportation; Energy; Last-mile; E-commerce

Availability: Gee, I.M., Faust, K.M., and Webber, M.E. (2021). "A Framework for Determining Energy Use in Rural Food Delivery Services: Capturing System Interdependencies Through an Agent-Based Discrete Event Approach." *Environmental Research: Infrastructure and Sustainability*, *1*(3). https://iopscience.iop.org/article/10.1088/2634-4505/ac2b10

2.72. Title: Maximizing Solar and Transportation Synergies

Author(s): Ardani, K., Hunter, C., Johnson, C., and Koebrich, S.

Abstract: This report considers the technological and market pathways that will enable better use of photovoltaic (PV) electricity as fuel for future transportation demand. Most of the pathways identified will require collaborative research and development (R&D) efforts to improve the capabilities of multiple technologies, including PV, energy storage, vehicles, electrolyzers, electrofuels, and infrastructure. For plug-in electric vehicles (PEVs), technologies that enable wide-scale managed and coordinated charging are among the highest priorities for continued research, development, and deployment in the near term. Furthermore, managed and coordinated charging capabilities are foundational for future vehicle-to-grid (V2G) functionality in the long term. For hydrogen fuel cell electric vehicles (FCEVs), the use of PV electricity for electrolysis provides an opportunity to increase PV deployment. For rail, air, and maritime transportation, the feasibility of increased PV use varies in the near term; opportunities for synergies with solar include the electrification of rail, increased reliability from airport microgrids, and switching from heavy fuel oil to clean maritime electrofuels made from PV-based hydrogen. Over the longer term, battery swap stations for electric airplanes and the co-location of solar with hydrogen fueling stations at shipping ports may enable greater synergies between PV and transportation.

Subject Areas: Solar energy; Advanced propulsion systems; Energy storage; Air; Batteries; Charging; Electric vehicle; Fuel cell; Maritime; Photovoltaics; Rail

Availability: Ardani, K., Hunter, C., Johnson, C., and Koebrich, S. (2021). *Maximizing Solar and Transportation Synergies*. Technical Report: NREL/TP-6A20-80779, National Renewable Energy Laboratory, Golden, CO. https://www.osti.gov/biblio/1820101

2.73. Title: The Value of Vehicle-to-Grid in a Decarbonizing California Grid

Author(s): Wang, M. and Craig, M.T.

Abstract: Vehicle-to-grid (V2G) technology could increase electric vehicle (EV) revenues and grid flexibility. Prior analyses have quantified potential V2G revenues, but each has ignored at least one of four factors that could drive future V2G revenues: future grid changes, large EV numbers, V2G interactions with electricity prices, and V2G operational responses to shifts in electricity prices. Our innovation is the capture of all four factors to quantify net revenues of a fleet of V2G-enabled EVs in California through 2030 by co-simulating optimization models for V2G and power system operations. We find V2G-enabled EVs generate an average of $32–$48 more annual net revenues than smart-charging EVs. Declining electricity prices through 2030 due to decarbonization and V2G participation decreases V2G revenues, and ignoring fleet-wide V2G participation significantly overestimates V2G annual net revenues. Overall, these results indicate V2G revenues could be modest and decrease in the future, underscoring the value of our co-optimization framework.

Subject Areas: Vehicle-to-grid; Smart charging; California electric vehicles; Vehicle-grid integration

Availability: Wang, M. and Craig, M.T. (2021). "The Value of Vehicle-to-Grid in a Decarbonizing California Grid." *Journal of Power Sources*, *513*. https://doi.org/10.1016/j.jpowsour.2021.230472

2.74. Title: Tri-Stage Optimal Dispatch for a Microgrid in the Presence of Uncertainties Introduced by EVs and PV

Author(s): Jiao, F., Ji, C., Zou, Y., and Zhang, X.

Abstract: This paper proposes a novel tri-stage online dispatch framework that coordinates the charging behaviors of electrical vehicles (EVs) within an AC/DC hybrid microgrid in the presence of uncertainties. A day-ahead scheduling model is proposed as the first stage to optimize the total operational cost for the next day (24 hours). In the second stage, a receding horizon manner is adopted to adjust the day-ahead scheduling results, which can compensate for unpredictable disturbances. Both the first and second stages are operated with a time scale of 1 hour, which is, however, insufficient in capturing the operations of EVs. Hence, the third stage is introduced with the stochastic model predictive control (SMPC) method in a time scale of 10 minutes to further consider uncertainties of load, PV, EVs. The real-world behavioral data of eight private EVs in Beijing are used to evaluate the performance of our dispatch model. The simulation results show that compared with some traditional online dispatch methods, the total operational cost of the proposed dispatch framework is significantly reduced.

Subject Areas: Microgrid; Electric vehicles; Online dispatch; Model predictive control; Uncertainty model

Availability: Jiao, F., Ji, C., Zou, Y., and Zhang, X. (2021). "Tri-Stage Optimal Dispatch for a Microgrid in the Presence of Uncertainties Introduced by EVs and PV." *Applied Energy*, *304*. https://doi.org/10.1016/j.apenergy.2021.117881

2.75. Title: Modelling Integrated Power and Transportation Sectors Decarbonization with Hydrogen Energy Storage

Author(s): Li, B., Chen, M., Ma, Z., He, G., Dai, W., Liu, D., Zhang, C., and Zhong, H.

Abstract: The deployment of renewable energy sources, power-to-gas (P2G) systems, and zero-emission vehicles provide a synergistic opportunity to accelerate the decarbonization of both power and transportation systems. This study investigates the prospects of implementing hydrogen P2G technology in coupling the power system and the transportation system. A novel coordinated long-term planning model of integrated power and transportation system (IPTS) at the regional scale is proposed to simulate the power system balance and travel demand balance simultaneously, while subject to a series of constraints, such as CO_2 emission constraints. IPTS of Texas was investigated considering various CO_2 emission cap scenarios. Results show unique decarbonization trajectories of the proposed coordinated planning model, in which IPTS prefers to decarbonize the power sector first. When the power system reaches ultra-low carbon intensity, the IPTS then focuses on the road transportation system decarbonization. The results show that with the P2G system, IPTS of Texas could achieve 100 percent CO_2 emission reductions (relative 2018 emissions level) by adding a combination of approximately 143.5 GW of wind, 50 GW of solar PV, and 40 GW of P2G systems with 2.5 percent renewables curtailment. The integration of the P2G system can produce hydrogen by use of surplus RES generation to meet hydrogen demand of fuel cell electric vehicles (FCEVs) and to meet multi-day electricity supply imbalances.

Subject Areas: Power-to-gas technology; Integrated power and transportation system; Fuel cell electric vehicle; Capacity expansion; Smart charging; Generators; Low-carbon economy; Indexes; Hydrogen; Power systems

Availability: Li, B., Chen, M., Ma, Z., He, G., Dai, W., Liu, D., Zhang, C., and Zhong, H. (2021). "Modelling Integrated Power and Transportation Sectors Decarbonization with Hydrogen Energy Storage." *IEEE Transactions on Industry Applications* (Early Access). https://doi.org/10.1109/TIA.2021.3116916

2.76. Title: A Systematic Data-Driven Analysis of Electric Vehicle Electricity Consumption with Wind Power Integration

Author(s): Akil, M., Dokur, E., and Bayindir, R.

Abstract: Real-time charging data of electric vehicles (EVs) cannot be easily shared between service providers, making analysis of the energy profile is difficult of collective EVs. This paper uses a real-time dataset that analyzes real-world charging load profiles of EVs to the nearest 15 minutes for a 1-day period. This dataset includes charging data from 21 EVs at different session times and different locations in a region. The data were systematically expanded to take advantage of the wind turbine (WT) generation power, which is one of the Renewable Energy Sources (RES) in the charge energy consumption of collective EVs in modified bus-2 network of the Roy Billington Test System (RBTS). Instead of assuming that EVs were constantly charging at maximum power in creating a charge-load profile, collective charge-load profiles were simulated based on the actual charging at varying power. Simulation results show that EV charging peak loads can decrease with an onsite WT generation power. Thus, the load balancing was performed due to the wind energy conversion system instead of load shifting in the modeled power system.

Subject Areas: Electric vehicle; Wind power; Actual charging profiles; Load balancing; Demand coordination

Availability: Akil, M., Dokur, E., and Bayindir, R. (2021). "A Systematic Data-Driven Analysis of Electric Vehicle Electricity Consumption with Wind Power Integration." *2021 10th International Conference on Renewable Energy Research and Application (ICRERA)*, pp. 397–401. https://ieeexplore.ieee.org/document/9598483

2.77. Title: Electric Vehicles Charging Management with Monte Carlo Simulation

Author(s): Kilic, E., Akil, M., Bayindir, R., Sebati, A., and Malek, R.

Abstract: The effects of climate change are being felt more and more day by day. Reducing emissions from fossil fuels is among the priority measures to deal with the climate crisis. With the increase in the sales of zero-emission electric vehicles (EV), the number of charging stations for the charging needs of EV will also increase. In order to meet the EV charging need, grid must be operated in a stable, efficient, and uninterrupted manner. In this paper, the charging power required for EVs at home and in public areas was modeled with Monte Carlo Simulation (MCS) over real data, peak load and total load values were calculated. The results showed that the charging need can be met with lower peak load values in public areas instead of charging at home traditionally.

Subject Areas: Electric vehicle; Energy management; Monte Carlo simulation; Charging load

Availability: Kilic, E., Akil, M., Bayindir, R., Sebati, A., and Malek, R. (2021). "Electric Vehicles Charging Management with Monte Carlo Simulation." *2021 10th International Conference on Renewable Energy Research and Application (ICRERA)*, pp. 423–427. https://doi.org/10.1109/ICRERA52334.2021.9598807

2.78. Title: Uncoordinated Charging Profile of EVs Based on an Actual Charging Session Data

Author(s): Akil, M., Kilic, E., Bayindir, R., Sebati, A., and Malek, R.

Abstract: The energy profile of gathered EVs is difficult to determine, as the actual charging data of electric vehicles (EVs) cannot be shared among distribution service providers. In this study, a dataset containing weekday and weekend information over a 1-day period based on actual EV charging sessions in the Perth and Kinross region is used. This dataset contains the start and end times of EVs charging. Based on these data, a total of 5,000 vehicle session data were derived for Monte Carlo Simulation (MCS) at 15-minute intervals. According to the data obtained, uncoordinated (without power reduction, restriction, and timing) AC charge load profiles of bulk EVs with 50 kWh battery capacity and maximum power up to 22 kW in accordance with IEC 61851-1 standards were generated. Accordingly, peak loading and peak loading times of 5,000 EVs in the distribution line in case of uncoordinated charging for Perth and Kinross regions were evaluated for weekdays and weekends. The results found provided information on EV load peak times for distribution service providers in the city of Perth, both weekdays and weekends.

Subject Areas: Monte Carlo simulation; Actual charging sessions; Peak loading; Uncoordinated electric vehicle charging

Availability: Akil, M., Kilic, E., Bayindir, R., Sebati, A., and Malek, R. (2021). "Uncoordinated Charging Profile of EVs Based on an Actual Charging Session Data." *2021 10th International Conference on Renewable Energy Research and Application (ICRERA)*, pp. 459–462. https://doi.org/10.1109/ICRERA52334.2021.9598554

2.79. Title: Modeling and Simulation of EV Unscheduled Charging and Its Impact on Distribution Systems

Author(s): Anselmo, I. and Mahmood, H.

Abstract: The growing deployment of electric vehicles (EVs) in the utility grid raises concerns regarding the current distribution infrastructure's capability to accommodate such a rapidly increasing load demand. This paper presents a methodology for modeling and simulating EV charging demand in residential distribution systems. The modeling approach can be used to study the impact of unscheduled charging and also for energy management studies. Since each driver or a group of drivers has a particular behavior, the daily EV plug-in profile variations are characterized to show the individual driving behavior. This approach is more suitable for energy management studies and charging coordination algorithms. The impact of unscheduled charging is investigated using the IEEE 13-Node Test Feeder with 601 EVs, which represents a 50-percent penetration level. Tesla Model 3 EV is used, and the 13-Node Test Feeder is simulated in the MATLAB software. Statistical studies, using a year's worth of data, show the significant effect of unscheduled charging on the quality of the distribution system operation. Feeders that are impacted the most in terms of violating the voltage limit and current limits are highlighted, and the violation statistics are presented.

Subject Areas: Systems operation; Software algorithms; Voltage; Electric vehicle charging; Software; Automobiles; State of charge

Availability: Anselmo, I. and Mahmood, H. (2021). "Modeling and Simulation of EV Unscheduled Charging and Its Impact on Distribution Systems." *2021 IEEE PES Innovative Smart Grid Technologies Conference—Latin America (ISGT Latin America)*, pp. 1–5. https://doi.org/10.1109/ISGTLatinAmerica52371.2021.9543054

2.80. Title: A Bi-Level Optimization Model for Electric Vehicle Charging Strategy Based on Regional Grid Load Following

Author(s): Yang, X., Niu, D., Sun, L., Ji, Z., Zhou, J., Wang, K., and Siqin, Z.

Abstract: Because a greater proportion of large-scale electric vehicles (EVs) are connected to the grid, their stochastic charging load has a significant impact on the power quality and economic operation of the distribution network. However, a random charging load can be transformed into flexible demand response resources through intelligent control of the EV charging process. Therefore, a bi-level optimization model for EV charging is proposed in this study based on the real-time charging price according to the regional grid load, providing more flexible charging strategies for EVs. First, the framework for a bi-level optimization control strategy for EV charging based on the load is developed. Based on the regional grid load, the charging price of each period is optimized in accordance with the load elasticity coefficient of the real-time charging price. Second, an upper-level EV charging price optimization model and a lower level EV charging load optimization model are established. Third, an optimal control strategy for the scheduling of EV charging is developed, which considers the charging cost of EV users as the objective function and the standard deviation and peak-valley difference of the regional grid load as validation functions. Finally, using a regional power grid in China as the simulation object, the daily operation data of the grid are used to analyze and verify the proposed model. The simulation results demonstrate that the optimized real-time charging price can better respond to the regional grid load, smooth the regional grid load curve, reduce the peak-valley difference, promote clean energy consumption, and further lower the charging cost for EV users.

Subject Areas: Electric vehicle; Real-time charging price; Demand response; Optimal charging strategy; Peak load regulation

Availability: Yang, X., Niu, D., Sun, L., Ji, Z., Zhou, J., Wang, K., and Siqin, Z. (2021). "A Bi-Level Optimization Model for Electric Vehicle Charging Strategy Based on Regional Grid Load Following." *Journal of Cleaner Production*, *325*. https://doi.org/10.1016/j.jclepro.2021.129313

2.81. Title: Modelling Driving and Charging Behaviours of Electric Vehicles Using a Data-Driven Approach Combined with Behavioural Economics Theory

Author(s): Xing, Q., Chen, Z., Zhang, Z., Wang, R., and Zhang, T.

Abstract: With the popularization and promotion of electric vehicles (EVs), their interactions with power grids and traffic networks have increasingly deepened. Accurate modeling of EV behavior can faithfully depict the characteristics of EV driving and charging. However, most existing modeling researchers fail to adopt real-world travel data and consider realistic perceptual decision-making psychology of owners. Thus, this paper proposes a novel behavioral modeling for EVs based on a data-driven approach combined with behavioral economics theory. To characterize the driving behavior of owners using actual data, a systematic data mining and modeling approach is first proposed based on the open source "Didi" traffic travel dataset, which obtains the traffic operation rules and the regenerative behavior characteristics data. According to the subjective perceptual characteristics of social economic man, a Cumulative Prospect Theory-based modeling framework is further developed to quantify the uncertain and stochastic charging decision-making behavior of EV users. Moreover, the user's preferences and attitudes are evaluated by calculating their cumulative prospect value when choosing charging stations. Finally, the most suitable charging station is recommended for EVs with charging requirements. Case studies are conducted within a practical zone in Nanjing, China. The results demonstrate that the traffic travel rules of vehicle owners have typical date types and functional area distribution characteristics. And the travel time and space of private and commercial vehicles are relatively regular, whereas the travel rules of public vehicles are random. Besides, this proposed methodology can not only effectively capture the irrational decision-making characteristics of EV users' charging behavior, but also achieve promising performance in terms of reducing the charging waiting cost. The user's decision-making regarding charging behavior exhibits a higher risk-seeking preference than a risk-aversion preference.

Subject Areas: Electric vehicle; Driving behavior; Charging behavior; Data-driven; Behavioral economics; Didi traffic travel data; Cumulative prospect theory

Availability: Xing, Q., Chen, Z., Zhang, Z., Wang, R., and Zhang, T. (2021). "Modelling Driving and Charging Behaviours of Electric Vehicles Using a Data-Driven Approach Combined with Behavioural Economics Theory." *Journal of Cleaner Production*, *324*. https://doi.org/10.1016/j.jclepro.2021.129243

2.82. Title: Quantifying Energy Flexibility of Commuter Plug-In Electric Vehicles Within a Residence-Office Coupling Virtual Microgrid. Part II: Case Study Setup for Scenario and Sensitivity Analysis

Author(s): Yu, Z., Lu, F., Zou, Y., and Yang, X.

Abstract: Continuing with the model and methods proposed in Part I for the optimal coordination and flexibility evaluation of plug-in electric vehicles (PEVs), we further conducted a case study to assess the energy flexibility of commuter PEVs in a virtual microgrid in Beijing, consisting of distributed RES system, an office, and residences. We first presented a parametric mobility model for generating individual driving profiles of commuter PEVs. The validation results indicated the feasibility of the model in capturing the mobility characteristics of commuter vehicles in Beijing. On that basis, the flexibility of PEVs for different charging schemes and renewable generation portfolios was evaluated. The results indicated that the expansion of charging locations primarily increases the flexibility potential for reducing power ramps, and meanwhile, activating the vehicle-to-building (V2B) function mostly improve the potential for reducing energy and power capacity. By contrast, the charging locations expansion takes priority to the V2B capability. Finally, we further analyzed how the flexibility is influenced by PEV numbers, charging parameters, and reserve levels. The results showed that the daily net load profile of the microgrid could be nearly flattened when the PEV battery storage quota per unit office area reaches 0.18 kWh/m^2 in the studied case.

Subject Areas: Flexibility evaluation; Electric vehicle; Renewable energy; Vehicle-to-building; Flexible energy management; Optimal scheduling

Availability: Yu, Z., Lu, F., Zou, Y., and Yang, X. (2021). "Quantifying Energy Flexibility of Commuter Plug-In Electric Vehicles Within a Residence-Office Coupling Virtual Microgrid. Part II: Case Study Setup for Scenario and Sensitivity Analysis." *Energy and Buildings*, *254*. https://doi.org/10.1016/j.enbuild.2021.111552

2.83. Title: Long-Time Scale Vehicle-to-Grid Scheduling Strategy Considering Psychological Effect Based on Weber-Fechner Law

Author(s): Hou, H., Wang, Y., Chen, Y., Zhao, B., Zhang, L., and Xie, C.

Abstract: Short-time scale charging is a common assumption in current electric vehicle studies. However, this assumption reduces the complexity of charging behavior by ignoring the fact that a large amount of electric vehicles only require to charge once every few days. Furthermore, it can be trapped in local optimization. Therefore, we propose a long-time scale vehicle-to-grid scheduling strategy for electric vehicles considering the psychological effect of range anxiety. The long-time scale vehicle-to-grid scheduling strategy includes two models to optimize the comprehensive benefits of electric vehicles in long-time scale—namely, the day-ahead scheduling model and the real-time optimization model. The day-ahead scheduling model completes long-time scheduling, while the real-time optimization model follows the day-ahead scheduling results to complete real-time optimization. In addition, the psychological effect of range anxiety based on Weber-Fechner law and the scheduling cost of electric vehicle users are quantified in the two models to further quantify the comprehensive benefits of electric vehicles. Finally, two methods are used to deal with the strategy. The rolling horizon optimization method is used to solve the real-time optimization process of the strategy. The non-dominated sorting genetic algorithm is used to deal with the multi-objective problem. Simulation results show that the proposed strategy can make electric vehicles more responsive to participate in the vehicle-to-grid process to improve users' satisfaction and enhance the enthusiasm and participation of receiving scheduling.

Subject Areas: Long-time scale; Psychological effect; Electric vehicle (EV); Vehicle-to-grid (V2G); Rolling horizon

Availability: Hou, H., Wang, Y., Chen, Y., Zhao, B., Zhang, L., and Xie, C. (2021). "Long-Time Scale Vehicle-to-Grid Scheduling Strategy Considering Psychological Effect Based on Weber-Fechner Law." *International Journal of Electrical Power & Energy Systems*, *136*. https://doi.org/10.1016/j.ijepes.2021.107709

2.84. Title: Optimal Distributed Energy Resource Coordination: A Decomposition Method Based on Distribution Locational Marginal Costs

Author(s): Andrianesis, P., Caramanis, M., and Li, N.

Abstract: In this paper, we consider the day-ahead operational planning problem of a radial distribution network hosting distributed energy resources (DERs) including rooftop solar and storage-like loads, such as electric vehicles. We present a novel decomposition method that is based on a centralized AC optimal power flow (AC OPF) problem interacting iteratively with self-dispatching DER problems adapting to real and reactive power distribution locational marginal costs. We illustrate the applicability and tractability of the proposed method on an actual distribution feeder, while modeling the full complexity of spatiotemporal DER capabilities and preferences and accounting for instances of non-exact AC OPF convex relaxations. We show that the proposed method achieves optimal grid-DER coordination, by successively improving feasible AC OPF solutions, and discovers spatiotemporally varying marginal costs in distribution networks that are key to optimal DER scheduling by modeling losses, ampacity, and voltage congestion, and, most importantly, dynamic asset degradation.

Subject Areas: AC optimal power flow; Distributed energy resources; Distribution network; Decomposition method; Spatiotemporal marginal costs; Dynamic asset degradation

Availability: Andrianesis, P., Caramanis, M., and Li, N. (2021). *Optimal Distributed Energy Resource Coordination: A Decomposition Method Based on Distribution Locational Marginal Costs*. arXiv preprint, arXiv:2110.12492 [math.OC]. https://arxiv.org/abs/2110.12492

2.85. Title: Minimizing the Cost of PHEV Usage with Price Sensitive Charging Strategies

Author(s): Zarbouti, D., Koutsi, O., Athanasiadou, G., and Tsoulos, G.

Abstract: Electric cars sales have been rising almost steadily over the past decade. Uncontrolled charging has recently emerged as the main detrimental factor to this otherwise environmentally friendly and paradigm shifting technology due to the incurred impact on the energy grid. In addition, people are usually hesitant in allowing their vehicles to be controlled by external units; therefore, controlled charging strategies that offer users the option to have some control over their vehicles seems to be a sensible choice moving toward a gasoline-free vehicles market. This work investigated two price-sensitive charging strategies that allowed users to control the charging of their vehicle in order to receive cost benefits. These strategies were of a parametric nature; thus, the analysis focused on providing useful rules of thumb to guide users in choosing the most suitable strategy and the relevant parameters according to their driving profiles. The results show that when driving less than 40 km/hour on average and employing a price-sensitive charging strategy with the proposed optimized parameters, electric car users may obtain 30 to 40 percent of the running cost reduction.

Subject Areas: Electric vehicle charging; Energy price; Vehicle-to-grid (V2G)

Availability: Zarbouti, D., Koutsi, O., Athanasiadou, G., and Tsoulos, G. (2021). "Minimizing the Cost of PHEV Usage with Price Sensitive Charging Strategies." *Electricity*, *2*(4), pp. 459–470. https://doi.org/10.3390/electricity2040027

2.86. Title: A Medium- and Long-Term Orderly Charging Load Planning Method for Electric Vehicles in Residential Areas

Author(s): Xiao, Z., Zhou, Y., Cao, J., and Xu, R.

Abstract: Due to the large number of electric vehicles (EVs) connected to the distribution network of residential areas (RAs), community charging has become a major constraint. The planning of the distribution network in RAs needs to consider the orderly charging load of EVs. In the current study, an orderly charging planning method for the charging posts and distribution network of RAs was proposed. First, a charging load forecasting model based on the travel characteristics, charging time, and ownership of EVs in RAs was established. Then, a hierarchical orderly charging optimization method, including a distribution network layer and EV access node layer, was devised. The upper layer optimizes the distribution network. The objective function is the minimum variance of the overall load in the RA, and the constraint conditions satisfy the overall charging load demand and the capacity of the distributed network. The lower layer optimizes the EV access nodes. The objective function is the minimum variance of the node access load, and the constraint conditions are to meet the regional charging load demand and the optimal power balance demand transmitted from the upper layer to the lower layer. A nonlinear optimization algorithm is employed to solve these objective functions. An IEEE 33 node example was used to obtain the orderly charging power load curves for weekdays and weekends in RAs, and the simulation results prove the effectiveness of the proposed method.

Subject Areas: Electric vehicles; Residential areas; Orderly charging; Hierarchical optimization; Nonlinear optimization algorithm

Availability: Xiao, Z., Zhou, Y., Cao, J., and Xu, R. (2021). "A Medium- and Long-Term Orderly Charging Load Planning Method for Electric Vehicles in Residential Areas." *World Electric Vehicle Journal*, *12*(4). https://doi.org/10.3390/wevj12040216

2.87. Title: Infrastructure Enabled and Electrified Automation: Charging Facility Planning for Cleaner Smart Mobility

Author(s): Azin, B., Yang, X., Marković, N., and Liu, M.

Abstract: Due to higher energy efficiency and lower emissions, electric vehicles (EVs) have become attractive transportation means in developing cleaner mobility systems. Moreover, many future automated vehicles (AVs) can be electrified. Hence, the existing market will experience a drastic growth in automated electric vehicles (AEVs). For infrastructure enabled automation (IEA), charging facility planning is required to accommodate the increasing AEV charging demand. The planning process must also account for their impact on the power grid. This study presents an integrated demand coverage optimization model over a coupled power-transportation (CPT) network. This model aims to pinpoint candidate locations of AEV charging stations that would serve the most charging demand in the transportation network, considering the upcoming technologies in AEV also will affect the charging behavior that can influence the charging system. Besides, power grid limitations at each charging station are considered for the minimal power cost of the network. The developed model is applied to Utah state road network to determine the optimal charging station locations.

Subject Areas: Automated electric vehicles; Charging station; Range anxiety; Traffic demand; Power flow; Land use

Availability: Azin, B., Yang, X., Marković, N., and Liu, M. (2021). "Infrastructure Enabled and Electrified Automation: Charging Facility Planning for Cleaner Smart Mobility." *Transportation Research Part D: Transport and Environment*, *101*. https://doi.org/10.1016/j.trd.2021.103079

2.88. Title: Effect of Electric Vehicles Charging Loads on Realistic Residential Distribution System in Aqaba-Jordan

Author(s): Obeidat, M.A., Almutairi, A., Alyami, S., Dahoud, R., Mansour, A.M., Aldaoudeyeh, A.-M., and Hrayshat, E.S.

Abstract: In recent years, air pollution and climate change issues have pushed people worldwide to switch to using electric vehicles (EVs) instead of gas-driven vehicles. Unfortunately, most distribution system facilities are neither designed nor well prepared to accommodate these new types of loads, which are characterized by random and uncertain behavior. Therefore, this paper provides a comprehensive investigation of EVs' effect on a realistic distribution system. It provides a technical evaluation and analysis of a real distribution system's load and voltage drop in the presence of EVs under different charging strategies. In addition, this investigation presents a new methodology for managing EV loads under a dynamic response strategy in response to the distribution system's critical hours. The proposed methodology is applied to a real distribution network, using the Monte Carlo method and the CYME program. Random driver behavior is taken into account in addition to various factors that affect EV load parameters. Overall, the results show that the distribution system is significantly affected by the addition of EV charging loads, which create a severe risk to feeder limits and voltage drop. However, a significant reduction in the impact of EVs can be achieved if a proper dynamic demand response program is implemented. We hope that the outcomes of this investigation will provide decision makers and planners with prior knowledge about the expected impact of using EVs and, consequently, enable them to take the proper actions needed to manage such load.

Subject Areas: Electric vehicle; Charging load; Distribution system; Low-voltage network; Probabilistic model

Availability: Obeidat, M.A., Almutairi, A., Alyami, S., Dahoud, R., Mansour, A.M., Aldaoudeyeh, A.-M., and Hrayshat, E.S. (2021). "Effect of Electric Vehicles Charging Loads on Realistic Residential Distribution System in Aqaba-Jordan." *World Electric Vehicle Journal*, *12*(4). https://doi.org/10.3390/wevj12040218

2.89. Title: Future Automotive Systems Technology Simulator (FASTSim) Validation Report: 2021

Author(s): Baker, C., Moniot, M., Brooker, A., Wang, L., Wood, E., and Gonder, J.

Abstract: The National Renewable Energy Laboratory's Future Automotive Systems Technology Simulator (FASTSim) captures the most important factors influencing vehicle power demands and performs large-scale fuel efficiency calculations very quickly. These features make FASTSim well suited to evaluate a representative distribution of real-world fuel efficiency over a large quantity of in-use driving profiles, which have become increasingly available in recent years owing to incorporation of Global Positioning System data collection into various travel surveys and studies. In addition, by being open-source, computationally lightweight, freely available, and free from expensive third-party software requirements, analyses conducted using FASTSim may be easily replicated and critiqued in an open forum. This is highly desirable for situations in which technical experts seek to reach consensus over questions about what vehicle development plans or public interest strategies could maximize fuel savings and minimize adverse environmental impacts with an evolving vehicle fleet. While FASTSim continues to be refined and improved on an ongoing basis, this report compiles available runs using versions of the tool from the past few years to provide illustrative comparisons of the model results against measured data.

Subject Areas: Advanced propulsion systems; Future Automotive Systems Technology Simulator; Modeling; Powertrain; Validation; Vehicle

Availability: Baker, C., Moniot, M., Brooker, A., Wang, L., Wood, E., and Gonder, J. (2021). *Future Automotive Systems Technology Simulator (FASTSim) Validation Report: 2021*. National Renewable Energy Laboratory, Golden, CO. https://www.osti.gov/biblio/1828851

2.90. Title: Vermont Transportation Energy Profile: 2021

Author(s): Dowds, J. and Rowangould, D.

Abstract: Slightly more than one-third of the total energy consumed in Vermont is used for transportation. Transportation energy is overwhelmingly derived from fossil fuels, with more than 95 percent in the form of gasoline and diesel fuel. Transportation is also the largest source of greenhouse gas (GHG) emissions in the State, accounting for 39.1 percent of GHGs in 2017.

Consequently, the 2016 Vermont Comprehensive Energy Plan (CEP) included three goals and nine supporting objectives related to reducing transportation sector energy consumption and GHG emissions. The 2021 Vermont Transportation Energy Profile ("the Profile") is the fifth installment of a biannual reporting series that evaluates the State's progress toward achieving these transportation sector targets.

Subject Areas: Energy consumption; Transportation energy; Comprehensive Energy Plan; Travel behavior; Vehicle fleet; Greenhouse gas emission

Availability: Dowds, J. and Rowangould, D. (2021). *Vermont Transportation Energy Profile: 2021*. Transportation Research Center at the University of Vermont and Vermont Agency of Transportation, Burlington, VT.
https://vtrans.vermont.gov/sites/aot/files/planning/documents/planning/2021%20Vermont%20Transportation%20Energy%20Profile.pdf

2.91. Title: Optimal Sizing and Placement of Multiple Photovoltaics Considering Electric Vehicles Charging Stations

Author(s): Ali, A., Mahmoud, K., Shaaban, M.F., and Lehtonen, M.

Abstract: Due to the fluctuated generation of photovoltaic (PV) and stochastic charging and discharging schemes of electric vehicles (EVs), risky operational issues are observed in the medium-voltage distribution systems. Expected issues are excessive energy losses, voltage drop and voltage rise, and disruptions of operational boundaries in power distribution systems. To tackle these issues, we propose an optimization planning model in this paper for optimally allocating PV to accommodate EV charging stations in distribution systems. The proposed planning approach has the ability to determine the best PV locations and sizes to reduce the electrical energy losses in the distribution system, considering voltage and power flow boundaries. Consequently, the allocation problem of PV is created as a double-layer optimization model, which is solved by the gravitational search algorithm. To indicate the effectiveness of the proposed allocation approach of PV, different simulations are performed in the IEEE 69-bus distribution system. The computed results demonstrate that the proposed planning approach can optimally allocate multiple PV units while satisfying the EV charging requirements.

Subject Areas: Distribution systems; Energy losses; Photovoltaic; Planning problem; Electric vehicles charging; Computational modeling; Stochastic processes; Power distribution; Search problems

Availability: Ali, A., Mahmoud, K., Shaaban, M.F., and Lehtonen, M. (2021). "Optimal Sizing and Placement of Multiple Photovoltaics Considering Electric Vehicles Charging Stations." *2021 International Conference on Electromechanical and Energy Systems (SIELMEN)*, pp. 358–362. https://doi.org/10.1109/SIELMEN53755.2021.9600359

2.92. Title: Shapley Value Method and Stochastic Dantzig–Wolfe Decomposition for Decentralized Scheduling of Multimicrogrid

Author(s): Singh, A., Sethi, B.K., Singh, D., and Misra, R.K.

Abstract: The decentralized economic scheduling of multimicrogrid is an important aspect in the operational planning of microgrids (MGs). This article proposes an approach to maximize economic benefit among MGs through cooperative scheduling. The cooperative scheduling is achieved via price signals so that MGs are encouraged to share power among themselves for economic benefit. An MG operator generates a time-variable tariff based on energy trading status so that the parking lot operator and distributed battery energy storage system aggregator participate with flexibility in the MG's energy management. The Shapley value method is used for generating fair price signals. The stochastic Dantzig–Wolfe decomposition is used to solve the resulting optimization problem in a decentralized manner. The uncertainties related to load demand and renewable energy sources are captured using scenario-based methods, whereas the uncertainty associated with plug-in hybrid electric vehicles is modeled using copula theory–based estimation. The simulation studies and comparison with the existing methods establish that the proposed approach effectively reduces the total energy cost in a decentralized manner with the minimum amount of information exchange.

Subject Areas: Dantzig–Wolfe decomposition (DWD); Distributed battery energy storage system (D-BESS); Distributed generation (DG); Multimicrogrid (MMG); Plug-in hybrid electric vehicle (PHEV); Shapley value method (SVM); Costs; Power markets; Energy management; Batteries; Tariffs; State of charge; Couplings

Availability: Singh, A., Sethi, B.K., Singh, D., and Misra, R.K. (2021). "Shapley Value Method and Stochastic Dantzig–Wolfe Decomposition for Decentralized Scheduling of Multimicrogrid." *IEEE Systems Journal* (Early Access), pp. 1–13. https://doi.org/10.1109/JSYST.2021.3119426

2.93. Title: Efficient Model for Accurate Assessment of Frequency Support by Large Populations of Plug-In Electric Vehicles

Author(s): Dakanalis, M. and Kanellos, F.D.

Abstract: In recent years, plug-in electric vehicles (PEVs) have gained immense popularity and are on a trajectory of constant growth. As a result, power systems are confronted with new issues and challenges, threatening their safety and reliability. PEVs are currently treated as simple loads due to their low penetration. However, as their numbers are growing, PEVs could potentially be exploited as distributed energy storage devices providing ancillary services to the network. Batteries used in PEVs are developed to deliver instantaneously active power, making them an excellent solution for system frequency support. This paper proposes a detailed dynamic model that is able to simulate frequency support capability from a large number of PEVs, using an innovative aggregate battery model that takes into account the most significant constraints at PEV and aggregate battery levels. The cost optimization algorithm, which is the most time-consuming process of the problem, is executed only at the aggregate battery level, thereby reducing the computational requirements of the model without compromising the obtained accuracy. The proposed method is applied to the power system of Crete exploiting detailed statistical data of EV mobility. It is proven that PEVs can effectively support power system frequency fluctuations without any significant deviation from their optimal operation.

Subject Areas: Plug-in electric vehicles; Frequency support; Vehicle-to-grid (V2G) technology; Energy management system optimization

Availability: Dakanalis, M. and Kanellos, F.D. (2021). "Efficient Model for Accurate Assessment of Frequency Support by Large Populations of Plug-In Electric Vehicles." *Inventions*, *6*(4). https://doi.org/10.3390/inventions6040089

2.94. Title: The Role of People vs. Places in Individual Carbon Emissions

Author(s): Lyubich, E.

Abstract: There is substantial spatial heterogeneity in household carbon emissions across the United States and a strong association between emissions and local amenities, such as density, transportation infrastructure, and housing characteristics. I estimate what share of this heterogeneity in carbon emissions is attributable to places themselves and what share reflects individual preferences and taste-based sorting. To do this, I construct a longitudinal panel of residential energy use and commute characteristics for more than a million individuals from two decades of administrative Decennial Census and American Community Survey data. I use movers in my data to estimate place effects—the amount by which carbon emissions change for the same individual living in different places—for almost 1,000 cities and roughly 65,000 neighborhoods across the United States. I find that place effects explain about 15 to 25 percent of overall variation in carbon emissions but more than half of the variation between places. My estimates suggest that decreasing neighborhood-level place effects from 1 standard deviation above the mean to 1 standard deviation below the mean would decrease household carbon emissions from residential energy use and commuting by about 40 percent.

Subject Areas: Household carbon emissions; Energy use; Local amenities; Housing characteristics

Availability: Lyubich, E. (2021). *The Role of People vs. Places in Individual Carbon Emissions*. Job Market Paper, Department of Economics and Energy Institute at Haas, University of California, Berkeley, CA. https://evalyubich.com/files/Lyubich_UCBerkeley_JMP.pdf

2.95. Title: Generating Synthetic Occupants for Use in Building Performance Simulation

Author(s): Putra, H.C., Andrews, C., and Hong, T.

Abstract: Occupant behavior simulation frameworks can employ synthetic populations to characterize occupancy and behavioral patterns in buildings based on observed demographic data at a certain geographical location. For buildings, very few synthetic occupant populations have been generated. This paper uses a Bayesian Networks (BN) structural learning approach to synthesize populations of occupants in a multi-family housing case study. Two additional cases of office occupants and senior housing residents are considered as a cross-case comparison. We draw upon the extended version of drivers-needs-actions-systems (DNAS) framework to guide the selection of variables and data imputation. Our results show that the BN approach is powerful in learning the structure of datasets. The synthetic datasets successfully match the joint distributions of the underlying combined datasets. Experiments on the multi-family housing particularly show better performance than the office and senior housing cases.

Subject Areas: Synthetic occupants; Occupant behavior; Building performance simulation; Occupant behavior model; Data model

Availability: Putra, H.C., Andrews, C., and Hong, T. (2021). "Generating Synthetic Occupants for Use in Building Performance Simulation." *Journal of Building Performance Simulation*, *14*(6), pp. 712–729. https://doi.org/10.1080/19401493.2021.2000029

2.96. Title: Optimal Dispatch Based on Aggregated Operation Region of EVs Considering Spatio-Temporal Distribution

Author(s): Shi, X., Xu, Y., Guo, Q., and Sun, H.

Abstract: The optimal dispatch of electric vehicles (EVs) aims to minimize the system operation cost while satisfying the requirements for peak shaving, congestion management, and voltage regulation. However, the stochastic mobility of EVs makes dispatch difficult and requires modeling the spatial and temporal distribution of EV availability. In this paper, a trip-chain-based EV resource aggregation model considering EV flexibility similarity is developed. Then, a bi-level optimization model is formulated to enable participation of the EV aggregators (EAGGs) in the day-ahead dispatch while ensuring various system operation constraints. Finally, the proposed bi-level model is transformed into a single-level convex optimization problem that can be conveniently solved by off-the-shelf software. Simulation tests substantiate that the proposed approach is superior to the existing method in terms of higher computational efficiency and lower system operation cost.

Subject Areas: Trip chain; Spatial and temporal distribution; Flexibility similarity; Aggregation; Day-ahead market; Auxiliary services; Costs; Batteries; Mathematical models; State of charge; Probabilistic logic; Systems operation; Spatiotemporal phenomena

Availability: Shi, X., Xu, Y., Guo, Q., and Sun, H. (2021). "Optimal Dispatch Based on Aggregated Operation Region of EVs Considering Spatio-Temporal Distribution." *IEEE Transactions on Sustainable Energy* (Early Access). https://doi.org/10.1109/TSTE.2021.3130547

2.97. Title: Estimation of Greenhouse Gas Emission Reduction from Shared Micromobility System

Author(s): Peng, H., Nishiyama, Y., and Sezaki, K.

Abstract: Shared micromobility is widely recognized as an environmentally friendly travel mode and a critical component of transportation decarbonization. However, quantitatively assessing its environmental impact using real-world trip data is an unresolved and challenging subject. In this research, we proposed a system combining machine learning algorithms and the Monte Carlo simulation to address this issue. First, several machine learning algorithms (Random Forest, XGBoost, and LightGBM) were utilized to identify citizens' travel mode choice preferences and then estimate the substituted travel mode of each micromobility trip. Second, to ensure the reliability of the final environmental impact assessment, the Monte Carlo simulations were used to simulate the substituted mode of each trip. Then, the environmental impacts were calculated based on the life cycle greenhouse gas emissions. Instead of estimating a specific number, we obtained a probabilistic outcome for environmental impacts by using the Monte Carlo simulation, which considers the uncertainty. According to the studies, the shared bike service and the shared e-scooter service have positive environmental impacts. However, these effects are limited compared to the transportation sector's total emissions. The most compelling reason is that shared micromobility comprises a minuscule part of total urban travel.

Subject Areas: Shared micromobility; Monte Carlo methods; Machine learning algorithms; Uncertainty; Greenhouse effect; Green products; Transportation; Low-carbon economy

Availability: Peng, H., Nishiyama, Y., and Sezaki, K. (2021). "Estimation of Greenhouse Gas Emission Reduction from Shared Micromobility System." *2021 IEEE Green Energy and Smart Systems Conference (IGESSC)*, pp. 1–6. https://doi.org/10.1109/IGESSC53124.2021.9618701

2.98. Title: Electric Vehicle's Impacts on China's Electricity Load Profiles Based on Driving Patterns and Demographics

Author(s): Li, B., Chen, M., Kammen, D.M., Kang, W., Qian, X., and Zhang, L.

Abstract: This paper presents a stochastic model to quantify the impact of the electric vehicle (EV) on China's electricity load profiles. Most of the existing literature utilized travel data to model EV charging behavior and ignored the influence of people's social attributes that are significant for the accuracy of EV charging behavior. Based on the dataset of the National Household Travel Survey, the most significant influencing factors, e.g., age, location, and weekday/weekend, are identified. Markov chain is used to construct a sequence of destinations of each vehicle trip, depending on EV's driver, day of the week, and time of day. Vehicle-driven distance, driving time, and parking duration are used to model electricity demand and potential EV charging flexibility. The charging infrastructure accessibility in a certain parking location has an influence on EV charging decisions. The model's outputs are used to assess the impacts of various EV charging strategies on electricity load profiles on a national scale. It is found that at 60 percent gasoline vehicle replacement with EVs by 2050, the electricity demand of EVs will be 510 TWh, accounting for 4.5 percent of the national demand in 2050. The national peak loads will further increase by 8.2 percent under the unmanaged charging strategy of EV. In contrast, implying last-minute charging strategy only increases peak demand by 2.6 percent relative to the unmanaged charging strategy.

Subject Areas: Electric vehicles; EV charging load; Typical load profiles; Monte Carlo; China

Availability: Li, B., Chen, M., Kammen, D.M., Kang, W., Qian, X., and Zhang, L. (2021). "Electric Vehicle's Impacts on China's Electricity Load Profiles Based on Driving Patterns and Demographics." *Energy Reports*, *8*(1), pp. 26–35. https://doi.org/10.1016/j.egyr.2021.11.003

2.99. Title: A Game-Theoretic Approach for Charging Demand Management of Electric Vehicles During System Overload

Author(s): Hussain, A. and Musilek, P.

Abstract: To manage the charging demand of electric vehicles (EVs) under maximum power limit constraints, a single-leader-multi-follower Stackelberg game theory-based solution approach is proposed in this study. A utility function is formulated for EVs considering the sensitivity of the EV owners to the battery degradation and the current energy level. A pricing mechanism for charging station operators is also devised to incentivize EVs for managing their charging demands locally, without violating the maximum power limit set by the distribution system operator. To this end, a decentralized welfare maximization model is formulated, where EVs do not need to share their private information with the charging station operator. The developed model is solved in a distributed way using the primal-dual subgradient method. The performance of the proposed method is analyzed for different power limits along with different sensitivity and energy levels. Results have shown that the proposed method can manage the charging demand of EVs considering individual sensitivities and maximum power limits of the charging station.

Subject Areas: Degradation; Sensitivity; Simulation; Conferences; Pricing; Games; Charging stations; System overload; Electric vehicles

Availability: Hussain, A. and Musilek, P. (2021). "A Game-Theoretic Approach for Charging Demand Management of Electric Vehicles During System Overload." *2021 IEEE Electrical Power and Energy Conference (EPEC)*, pp. 353–358.
https://doi.org/10.1109/EPEC52095.2021.9621384

2.100. Title: A Reward Mechanism for Reliability-as-a-Service Usage of Electric Vehicles

Author(s): Hussain, A. and Musilek, P.

Abstract: Instead of using a dedicated backup power source to fulfill the energy needs of buildings during contingencies, a reward mechanism for providing reliability-as-a-service (RaaS) via electric vehicles (EVs) is proposed in this study. The proposed positive reward mechanism comprises an upfront reward portion (paid upon registering) and a per-event reward portion (paid based on the amount of energy used). Similarly, a negative reward is applied to the registered EV owners not complying with their contracts. In addition, a score updating mechanism is proposed to incentivize EVs following their contracts and penalize the violating EVs. The score will be decisive during events when more EVs are available than the required energy. The use of EVs for providing RaaS is compared with two commonly used technologies for backup power, i.e., diesel generator and battery storage. Simulations have shown that the proposed scheme can significantly save the cost for building operators/owners while providing revenues for EV owners. The fairness in incentive allocation versus the amount of used energy is also demonstrated.

Subject Areas: Backup power; Electric vehicles; Power contingency; Reliability-as-a-service (RaaS); Reward mechanism

Availability: Hussain, A. and Musilek, P. (2021). *A Reward Mechanism for Reliability-as-a-Service Usage of Electric Vehicles*. Workshop Presentation, Education and Research Archive, University of Alberta, Alberta, Canada. https://doi.org/10.7939/r3-me8m-j862

2.101. Title: Generation Dispatch and Power Grid Emission Impacts of Transportation Electrification

Author(s): Shetye, K.S., Li, H., Wert, J.L., Xu, X., Meitiv, A., Xu, Y., and Overbye, T.J.

Abstract: Generators in the bulk power grid are having to meet the growing demand for electric vehicles (EV) charging. This can affect emissions arising from these generators, which should be accounted for in analyzing the benefits of EVs over internal combustion engine vehicles. This paper describes the impacts of EVs on generator emissions, considering different scenarios of EV penetration, charging strategies, and wind curtailment. It discusses the sensitivity of generation dispatch and emissions to the system generation mix and the EV charging strategy. Using a synthetic grid model based on the footprint of the State of Texas shows that even a 5-percent EV penetration in one part of the system can change the dispatch far across the network, highlighting the importance of using large, regional models in EV grid integration assessments. The paper also shows how different methods of modeling wind generation, such as wind curtailment, affect the emissions, especially in the presence of EVs.

Subject Areas: Sensitivity; Transportation; Internal combustion engines; Generators; Power grids; Electric vehicle charging; Coupled infrastructure simulation; Emissions

Availability: Shetye, K.S., Li, H., Wert, J.L., Xu, X., Meitiv, A., Xu, Y., and Overbye, T.J. (2021). "Generation Dispatch and Power Grid Emission Impacts of Transportation Electrification." *2021 North American Power Symposium (NAPS)*, pp. 1–6. https://doi.org/10.1109/NAPS52732.2021.9654527

2.102. Title: Multidimensional Models to Understand Travel Behavior Implications for Transport and Household Energy Use

Author(s): Sharda, S.

Abstract: To reduce the environmental burden of transport, previous studies have resorted on solutions that accentuate toward techno-economical pathways. However, there is growing evidence that transport behaviors, lifestyle choices, and the role of individuals' attitudes/perceptions are considered influential factors in shaping households' engagement with sustainable technologies in the face of environmental crises. The objective of this dissertation is to develop multidimensional econometric model systems to explore complex relationships that can help us understand travel behaviors' implications for transport and household energy use. To this end, the second chapter of this dissertation utilizes the latent segmentation approach to quantify and unravel the relationship between attitudes and behaviors while recognizing the presence of unobserved heterogeneity in the population. It was found that two-thirds of the population fall in the causal structure where behavioral experiences are shaping attitudes, while for one-third attitudes are shaping behaviors. The findings have implications on the energy-behavior modeling paradigm and forecasting household energy use. Building on chapter 2, chapter 3 develops an integrated modeling framework to explore the factors that influence the adoption of on-demand mobility services and electric vehicle ownership while placing special emphasis on attitudes/perceptions. Results indicated that attitudes and values significantly affect the use of on-demand transportation services and electric vehicle ownership, suggesting that information campaigns and free trials/demonstrations would help advance toward the sustainable transportation future and decarbonizing the transport sector. The integrated modeling framework is enhanced, in chapter 4, to explore the interrelationship between transport and residential energy consumption. The findings indicated the existence of small but significant net complementary relationships between transport and residential energy consumption. Additionally, the modeling framework enabled the comparison of energy consumption patterns across market segments. The resulting integrated transport and residential energy consumption model system is utilized, in chapter 5, to shed light on the overall household energy footprint implications of shifting vehicle/fuel type choices. Results indicated that electric vehicles are driven as much as gasoline vehicles are. Interestingly, while an increase in residential energy consumption was observed with the wide-scale adoption of electric vehicles, the total household energy use decreased, indicating benefits associated with transportation electrification.

Subject Areas: Environmental burden; Electric vehicles; Transport behaviors; Lifestyle choices; Sustainable technologies; Multidimensional econometric model systems; Integrated modeling framework; Residential energy consumption

Availability: Sharda, S. (2021). *Multidimensional Models to Understand Travel Behavior Implications for Transport and Household Energy Use*. Doctoral Dissertation, Arizona State University, Tempe, AZ.
https://www.proquest.com/openview/18b78a5931dfe4a023c14523454f7c29/1?pq-origsite=gscholar&cbl=18750&diss=y

2.103. Title: Lucid Dethrones Tesla as Electric Vehicle Range King

Author(s): Barry, K.

Abstract: Blog.

Subject Areas: Electric vehicle range; EPA ratings; Range anxiety; Electric vehicle brand comparison

Availability: Barry, K. (2021). "Lucid Dethrones Tesla as Electric Vehicle Range King." *Consumer Reports, Inc.* https://www.consumerreports.org/hybrids-evs/lucid-dethrones-tesla-as-electric-vehicle-range-king-a6640734780/

2.104. Title: Spatial and Unobserved Heterogeneity in Consumer Preferences for Adoption of Electric and Hybrid Vehicles: A Bayesian Hierarchical Modeling Approach

Author(s): Khattak, Z.H. and Khattak, A.J.

Abstract: The transition to low carbon vehicles known as alternative fuel vehicles (AFVs) is well underway. This transition has been motivated partly by consumer demand and partly by legislation such as the Zero Emission Vehicle mandate, which requires manufacturers to sell a certain percentage of their vehicles as AFVs. While the long-term adoption of AFVs (specifically, electric and hybrids) may take several years, there is a need to understand consumer preferences for AFV adoption and the pathways of AFV adoption from a national perspective. Therefore, this study sought to provide information about consumer preferences regarding AFV ownership while considering spatial and unobserved heterogeneity in consumer preferences, which can potentially impact societal transition to low carbon fueled vehicles. The 2017 National Household Travel Survey was used to calibrate Bayesian logit and hierarchical models. The findings of these models reveal that higher gasoline prices contribute toward the adoption of battery electric vehicles. The results also reveal that the perceived disadvantages of AFVs for long commutes are the key barrier in wider adoption of AFVs. Interestingly, frequent use of the internet by consumers revealed a higher likelihood for purchase of hybrid vehicles. Furthermore, West Coast residents are observed to be a large portion of the early adopters and are more likely to purchase hybrids as compared to battery electric vehicles. The knowledge generated by this study has implications for making better informed decisions about AFV adoption and developing incentives to promote wider adoption of AFVs by overcoming their perceived disadvantages.

Subject Areas: Alternative fuel vehicles; Bayesian hierarchical models; Bayesian logit models; Consumer adoption; Electric; Hybrids; Preference heterogeneity

Availability: Khattak, Z.H. and Khattak, A.J. (2021). "Spatial and Unobserved Heterogeneity in Consumer Preferences for Adoption of Electric and Hybrid Vehicles: A Bayesian Hierarchical Modeling Approach." *International Journal of Sustainable Transportation*. https://doi.org/10.1080/15568318.2021.1975327

2.105. Title: The Biggest Mistakes Buyers Make When Shopping for an Electric Car

Author(s): Tucker, S.

Abstract: Blog.

Subject Areas: Shopping for an electric car; Driving range; Local electric vehicle infrastructure

Availability: Tucker, S. (2021). "The Biggest Mistakes Buyers Make When Shopping for an Electric Car." *MarketWatch, Inc.* https://www.marketwatch.com/story/the-biggest-mistakes-buyers-make-when-shopping-for-an-electric-car-11634860487

2.106. Title: Estimating Energy Bounds for Adoption of Shared Micromobility

Author(s): Sun, B., Garikapati, V., Wilson, A., and Duvall, A.

Abstract: Shared micromobility has garnered widespread popularity in recent years, but limited attention has been given to the energy impacts of trips replaced by micromobility. This paper investigates the energy bounds of shared micromobility adoption. Travel demand data at the national and city level were analyzed to identify trips that can be served through micromobility, and scenarios with varying levels of micromobility adoption were evaluated. Results show that peak adoption of shared micromobility can reduce energy consumption from reported passenger travel by 1 percent at the national level and 2.6 percent at the city level, with micromobility-induced transit trips identified as the largest contributor for energy reduction. Sensitivity analysis was carried out to show how the energy impacts would change with various levels of key micromobility-related parameters, and results show distance threshold having a stronger influence on the energy impacts, compared to redistribution energy intensity.

Subject Areas: Micromobility; Mobility-as-a-service; Shared mobility; E-bike; E-scooter; Energy impacts assessment

Availability: Sun, B., Garikapati, V., Wilson, A., and Duvall, A. (2021). "Estimating Energy Bounds for Adoption of Shared Micromobility." *Transportation Research Part D: Transport and Environment*, *100*. https://doi.org/10.1016/j.trd.2021.103012

2.107. Title: Data-Informed Analysis Reveals Energy Impacts of Shared Micromobility

Author(s): U.S. Department of Energy.

Abstract: Blog.

Subject Areas: Shared micromobility; Electric bicycles and scooters; Energy impact; Traffic congestion; Sustainable mobility

Availability: U.S. Department of Energy. (2021). "Data-Informed Analysis Reveals Energy Impacts of Shared Micromobility." *Clean Technica.* https://cleantechnica.com/2021/12/02/data-informed-analysis-reveals-energy-impacts-of-shared-micromobility/

Chapter 3. Environment

3.1. Title: The Climate Change Mitigation Impacts of Active Travel: Evidence from a Longitudinal Panel Study in Seven European Cities

Author(s): Brand, C., Goetschi, T., Dons, E., Gerike, R., Anaya-Boig, E., Avila-Palencia, I., de Nazelle, A., Gascon, M., Gaupp-Berghausen, M., Iacorossi, F., Kahlmeier, S., Panis, L.I., Racioppi, F., Rojas-Rueda, D., Standaert, A., Stigell, E., Sulikova, S., Wegener, S., and Nieuwenhuijsen, M.J.

Abstract: Active travel (walking or cycling for transport) is generally good for health, the environment and the economy. Yet the net effects of changes in active travel on changes in mobility-related CO_2 emissions are complex and under-researched. Here we collected longitudinal data on daily travel behavior, mode choice, as well as personal and geospatial characteristics in seven European cities and derived mobility-related lifecycle CO_2 emissions from daily travel activity over time and space. Fixed- and mixed-effects modelling of longitudinal panel data (n=1849) was performed to assess the associations between changes in lifecycle CO_2 emissions and changes in transport mode use (primary exposure), main mode of travel, and cycling frequency (secondary exposures).

Daily mobility-related lifecycle CO_2 emissions were 2.8 $kgCO_2$ per person at baseline, with car travel contributing 69% and cycling 1%. At follow-up, mobility-related lifecycle CO_2 emissions were –0.52 (95% CI –0.82 to –0.21) $kgCO_2$/day lower per additional cycling trip, –0.41 (95% CI –0.69 to –0.12) $kgCO_2$/day lower per additional walking trip, and –2.11 (95% CI –1.78 to –2.43) $kgCO_2$/day lower per "avoided" car trip. An average person cycling 1 trip/day more and driving 1 trip/day less for 200 days a year would decrease mobility-related lifecycle CO_2 emissions by about 0.5 tonnes over a year. Those who changed from "not cycling" to "cycling" decreased daily CO_2 emissions by –2.54 (95% CI –3.90 to –1.17) $kgCO_2$/day. Mobility-related CO_2 emissions decreased by –9.28 (95% CI –11.46 to –7.11) kg/day for those who changed their "main mode" from car, van, or motorbike to active travel. Extensive sensitivity analyses by city, journey purpose, and key personal characteristics largely confirmed our results.

Active travel is shown to substitute for motorized travel, with significant climate change mitigation effects. Even if not all car trips could be substituted by active travel the potential for decreasing emissions is considerable and significant. Investing in and promoting active travel should therefore be a cornerstone of strategies to meet net zero carbon targets, particularly in urban areas, while also improving public health and quality of urban life.

Subject Areas: Climate change mitigation; Active travel; Walking; Cycling; Sustainable urban transport; Mode shift

Availability: Brand, C., Goetschi, T., Dons, E., Gerike, R., Anaya-Boig, E., Avila-Palencia, I., de Nazelle, A., Gascon, M., Gaupp-Berghausen, M., Iacorossi, F., Kahlmeier, S., Panis, L.I., Racioppi, F., Rojas-Rueda, D., Standaert, A., Stigell, E., Sulikova, S., Wegener, S., and Nieuwenhuijsen, M.J. (2021). "The Climate Change Mitigation Impacts of Active Travel:

Evidence from a Longitudinal Panel Study in Seven European Cities." *Research Square*. https://doi.org/10.21203/rs.3.rs-149916/v1

3.2. Title: Towards A More Sustainable Future? Simulating the Environmental Impact of Online and Offline Grocery Supply Chains

Author(s): Trott, M., von Viebahn, C., and Auf der Landwehr, M.

Abstract: The negative effects of traffic, such as air quality problems and road congestion, put a strain on the infrastructure of cities and high-populated areas. A potential measure to reduce these negative effects are grocery home deliveries (e-grocery), which can bundle driving activities and, hence, result in decreased traffic and related emission outputs. Several studies have investigated the potential impact of e-grocery on traffic in various last-mile contexts. However, no holistic view on the sustainability of e-grocery across the entire supply chain has yet been proposed. Therefore, this paper presents an agent-based simulation to assess the impact of the e-grocery supply chain compared to the stationary one in terms of mileage and different emission outputs. The simulation shows that a high e-grocery utilization rate can aid in decreasing total driving distances by up to 255% relative to the optimal value as well as CO_2 emissions by up to 50%.

Subject Areas: Roads; Supply chains; Urban areas; Air quality; Sustainable development; Strain

Availability: Trott, M., von Viebahn, C., and Auf der Landwehr, M. (2020). "Towards A More Sustainable Future? Simulating the Environmental Impact of Online and Offline Grocery Supply Chains." *2020 Winter Simulation Conference (WSC)*, pp. 1218–1229. https://doi.org/10.1109/WSC48552.2020.9383987

3.3. Title: Machine Learning on the COVID-19 Pandemic, Human Mobility, and Air Quality: A Review

Author(s): Rahman, M.M., Paul, K.C., Hossain, M.A., Ali, G.G.M.N., Rahman, M.S., and Thill, J.

Abstract: The ongoing COVID-19 global pandemic is affecting every facet of human lives (e.g., public health, education, economy, transportation, and the environment). This novel pandemic and citywide implemented lockdown measures are affecting virus transmission, people's travel patterns, and air quality. Many studies have been conducted to predict the COVID-19 diffusion, assess the impacts of the pandemic on human mobility and air quality, and assess the impacts of lockdown measures on viral spread with a range of Machine Learning (ML) techniques. This review study aims to analyze results from past research to understand the interactions among the COVID-19 pandemic, lockdown measures, human mobility, and air quality. The critical review of prior studies indicates that urban form, people's socioeconomic and physical conditions, social cohesion, and social distancing measures significantly affect human mobility and COVID-19 transmission. During the COVID-19 pandemic, many people are inclined to use private transportation for necessary travel purposes to mitigate coronavirus-related health problems. This review study also noticed that COVID-19 related lockdown measures significantly improve air quality by reducing the concentration of air pollutants, which in turn improves the COVID-19 situation by reducing respiratory-related sickness and deaths of the people. It is argued that ML is a powerful, effective, and robust analytic paradigm to handle complex and wicked problems such as a global pandemic. This study also discusses policy implications, which will be helpful for policymakers to take prompt actions to moderate the severity of the pandemic and improve urban environments by adopting data-driven analytic methods.

Subject Areas: COVID-19; Coronavirus; Pandemic; Machine learning; Public health; Human mobility; Air quality; Review

Availability: Rahman, M.M., Paul, K.C., Hossain, M.A., Ali, G.G.M.N., Rahman, M.S., and Thill, J. (2021). "Machine Learning on the COVID-19 Pandemic, Human Mobility, and Air Quality: A Review." *Preprints*. https://www.preprints.org/manuscript/202103.0396/v1

3.4. Title: Driving California's Transportation Emissions to Zero

Author(s): Bakibillah, A.S.M., Paw, Y.F., Kamal, M.A.S., Susilawati, S., Tan, C.P., Abrams, C., Chakraborty, D., Coffee, D., Dabag, S., Davis, A., Delucchi, M.A., Fleming, K.L., Forest, K., Sanchez, J.C.G., Handy, S., Hyland, M., Jenn, A., Karten, S., Lane, B., Mackinnon, M., Martin, E., Miller, M., Ramirez-Ibarra, M., Ritchie, S., Schremmer, S., Segui, J., Shaheen, S., Tok, A., Voleti, A., Witcover, J., and Yang, A.

Abstract: The purpose of this report is to provide a research-driven analysis of options that can put California on a pathway to achieve carbon-neutral transportation by 2045. The report comprises 13 sections. Section 1 provides an overview of the major components of transportation systems and how those components interact. Section 2 discusses the impacts the COVID-19 pandemic has had on transportation. Section 3 discusses California's current transportation-policy landscape. These three sections were previously published as a synthesis report. Section 4 analyzes the different carbon scenarios, focusing on "business as usual" (BAU) and Low Carbon (LC1). Section 5 provides an overview of key policy mechanisms to utilize in decarbonizing transportation. Section 6 is an analysis of the light-duty vehicle sector, section 7 is the medium- and heavy-duty vehicle sectors, section 8 is reducing and electrifying vehicle miles traveled, and section 9 is an analysis of transportation fuels and their lifecycle. The following sections are an analysis of external costs and benefits: section 10 analyzes the health impacts of decarbonizing transportation, section 11 analyzes equity and environmental justice, and section 12 analyzes workforce and labor impacts. Finally, future research needs are provided in section 13. The study overall finds that cost-effective pathways to carbon-neutral transportation in California exist, but that they will require significant acceleration in a wide variety of policies.

Subject Areas: Greenhouse gases; Carbon emissions; Decarbonization; Transportation policy; Environmental policy; Policy analysis; Trucks; Vehicle miles of travel; Social equity; Environmental justice; Alternate fuels; Labor force

Availability: Bakibillah, A.S.M., Paw, Y.F., Kamal, M.A.S., Susilawati, S., Tan, C.P., Abrams, C., Chakraborty, D., Coffee, D., Dabag, S., Davis, A., Delucchi, M.A., Fleming, K.L., Forest, K., Sanchez, J.C.G., Handy, S., Hyland, M., Jenn, A., Karten, S., Lane, B., Mackinnon, M., Martin, E., Miller, M., Ramirez-Ibarra, M., Ritchie, S., Schremmer, S., Segui, J., Shaheen, S., Tok, A., Voleti, A., Witcover, J., and Yang, A. (2021). *Driving California's Transportation Emissions to Zero*. UC Office of the President: University of California Institute of Transportation Studies. https://escholarship.org/uc/item/3np3p2t0

3.5. Title: Intra-city Variability of Fine Particulate Matter During COVID-19 Lockdown: A Case Study from Park City, Utah

Author(s): Mendoza, D.L., Benney, T.M., Bares, R., and Crosman, E.T.

Abstract: Urban air quality is a growing concern due a range of social, economic, and health impacts. Since the SARS-CoV-19 pandemic began in 2020, governments have produced a range of non-medical interventions (NMIs) (e.g., lockdowns, stay-at-home orders, mask mandates) to prevent the spread of COVID-19. A co-benefit of NMI implementation has been the measurable improvement in air quality in cities around the world. Using the lockdown policy of the COVID-19 pandemic as a natural experiment, we traced the changing emissions patterns produced under the pandemic in a mid-sized, high-altitude city to isolate the effects of human behavior on air pollution. We tracked air pollution over time periods reflecting the Pre-Lockdown, Lockdown, and Reopening stages, using high quality, research grade sensors in both commercial and residential areas to better understand how each setting may be uniquely impacted by pollution downturn events. Based on this approach, we found the commercial area of the city showed a greater decrease in air pollution than residential areas during the lockdown period, while both areas experienced a similar rebound post lockdown. The easing period following the lockdown did not lead to an immediate rebound in human activity and the air pollution increase associated with reopening, took place nearly two months after the lockdown period ended. We hypothesize that differences in heating needs, travel demands, and commercial activity, are responsible for the corresponding observed changes in the spatial distribution of pollutants over the study period. This research has implications for climate policy, low-carbon energy transitions, and may even impact local policy due to changing patterns in human exposure that could lead to important public health outcomes, if left unaddressed.

Subject Areas: PM2.5; COVID-19 lockdown; Public health; Pollution downturn events; Spatiotemporal pollution variability

Availability: Mendoza, D.L., Benney, T.M., Bares, R., and Crosman, E.T. (2021). "Intra-city Variability of Fine Particulate Matter During COVID-19 Lockdown: A Case Study from Park City, Utah." *Environmental Research*, *201*. https://doi.org/10.1016/j.envres.2021.111471

3.6. Title: Towards Indirect Top–Down Road Transport Emissions Estimation

Author(s): Mukherjee, R., Rollend, D., Christie, G., Hadzic, A., Matson, S., Saksena, A., and Hughes, M.

Abstract: Road transportation is one of the largest sectors of greenhouse gas (GHG) emissions affecting climate change. Tackling climate change as a global community will require new capabilities to measure and inventory road transport emissions. However, the large scale and distributed nature of vehicle emissions make this sector especially challenging for existing inventory methods. In this work, we develop machine learning models that use satellite imagery to perform indirect top-down estimation of road transport emissions. Our initial experiments focus on the United States, where a bottom-up inventory was available for training our models. We achieved a mean absolute error (MAE) of 39.5 kg CO_2 of annual road transport emissions, calculated on a pixel-by-pixel (100 m^2) basis in Sentinel-2 imagery. We also discuss key model assumptions and challenges that need to be addressed to develop models capable of generalizing to global geography. We believe this work is the first published approach for automated indirect top-down estimation of road transport sector emissions using visual imagery and represents a critical step towards scalable, global, near-real-time road transportation emissions inventories that are measured both independently and objectively.

Subject Areas: Greenhouse gas emissions; Satellite imagery; Machine learning models; Automated indirect top-down estimation

Availability: Mukherjee, R., Rollend, D., Christie, G., Hadzic, A., Matson, S., Saksena, A., and Hughes, M. (2021). *Towards Indirect Top–Down Road Transport Emissions Estimation.* arXiv preprint, arXiv:2103.08829 [cs.CV]. https://arxiv.org/abs/2103.08829

3.7. Title: Real-world Particle and NO_x Emissions From Hybrid Electric Vehicles Under Cold Weather Conditions

Author(s): Li, C., Swanson, J., Pham, L., Hu, S., Hu, S., Mikailian, G., and Jung, H.S.

Abstract: Hybrid electric vehicle (HEV) technology is critical to reduce the impact of the internal combustion engines on air pollution and greenhouse gases. HEVs have an advantage in market penetration due to their lower cost and higher driving range compared to battery electric vehicles (BEVs). On the other hand, HEVs use an internal combustion engine and still emit air pollutants. It is hypothesized that HEV performance is impacted by the weather conditions as a result of many factors. It was beyond the scope of this work to systematically evaluate all factors so instead we measured emissions from two vehicles driving city and highway routes in Minneapolis, Minnesota in the winter (−5 °C) and looked for major differences in emissions relative to each vehicle and relative to results that would be obtained from a chassis dynamometer in a controlled laboratory setting at a higher temperature approximately 20 °C). The study then looked to associate differences in emissions with the prevailing conditions to gain new insights. Emissions of interest included the total particle number (TPN), solid particle number (SPN), particulate matter mass (PM), and NO_x. One key difference in vehicle engine technology was PFI (port fuel injection) versus GDI (gasoline direct injection). We found the frequency at which the Prius hybrid engine reignited was much higher than the Sonata for city and highway driving, although for both vehicles the catalyst temperature remained high and appeared to be unaffected by the reignitions, despite the cold weather. For most conditions, the Prius emitted more NO_x but fewer particles than the Sonata. In some cases, NO_x and particle emissions exceeded the most comparable laboratory-based emissions standards.

Subject Areas: Re-ignition; Charge sustaining mode; Charge depletion mode; Solid particle number; Total particle number

Availability: Li, C., Swanson, J., Pham, L., Hu, S., Hu, S., Mikailian, G., and Jung, H.S. (2021). "Real-world Particle and NO_x Emissions From Hybrid Electric Vehicles Under Cold Weather Conditions." *Environmental Pollution*, *286*. https://doi.org/10.1016/j.envpol.2021.117320

3.8. Title: Beyond Carbon Mitigation: Understanding the Co-benefits and Co-Costs of Greenhouse Gas Mitigation Policies in Broader Contexts

Author(s): Li, Y.

Abstract: The use of cost-benefit analysis (CBA) is firmly entrenched in U.S. policy-making and other regulatory processes. The validity of CBA relies on the systematic and comprehensive understanding of the co-benefits and co-costs associated with the public policy evaluated. However, we still don't have a complete picture or a thorough understanding of the broader impacts of public policies on energy and the environment, especially carbon mitigation policies. Notably, the recent developments from the federal governments have attracted more attention to revisiting the concepts.

To address the gaps in understanding the broader impacts of energy policies, this dissertation expands existing research on energy and environment policies by providing more empirical evidence and advanced systematic quantification frameworks. In general, this study highlights critical relationships in intricate modeling systems, thereby enabling insights that might otherwise be obfuscated or overlooked. By applying complex integrated models of energy policies, climate systems, and health evaluations, this dissertation enhances a better understanding of the complexity of features that influence policy markets in the energy-related economy. The three case studies cover the systematic and comprehensive quantifications of co-benefits and co-costs in various sectors and scopes (air quality and health, sectoral and macroeconomic activities).

The first study applies integrated macroeconomics and air quality model to evaluate the unintended environmental consequences of relaxing the energy policies on the ozone standard attainments. The results demonstrate that a relaxation of the energy policies would significantly increase the ozone levels in many counties, inducing considerable health costs. The impacts are more prominent when considering the synergistic effect of dramatic climate change. Overall, the xi study demonstrates the critical need to conduct assessments of energy policies in the context of local air quality and associated health benefits and costs.

The second study focuses on a case of the sectoral economic activities – quantifying the impacts of electric vehicle mandates on grid operations under the current infrastructures and grid management practices of the electric power sector. This chapter explores the benefits and costs of EV-related policies on the electric power grid when the infrastructures are locked-in, and the technological innovations are limited in practice. The third study expands the scope to demonstrate the long-term societal macroeconomic impacts, quantifying the effects of the EV sales mandates beyond the direct impact on the transportation sector and the electric power sector, including the indirect and induced impacts on all sectors through macro-economic activities. Overall, the two studies indicate significant potentials for the grid and other sectors to adapt and reduce both the costs and carbon emissions. The results call for policymakers to move beyond sectoral narratives, adopt a holistic and systematic view, and design policies with great care to address the regional heterogeneity and equity concerns.

Subject Areas: Cost-benefit analysis; Environment policies; Macroeconomics; Air quality model

Availability: Li, Y. (2021). *Beyond Carbon Mitigation: Understanding the Co-benefits and Co-Costs of Greenhouse Gas Mitigation Policies in Broader Contexts*. Doctoral Dissertation, Georgia Institute of Technology, Atlanta, GA. https://smartech.gatech.edu/handle/1853/64802

3.9. Title: Reducing Greenhouse Gas Emissions from U.S. Light-Duty Transport in Line with the 2 °C Target

Author(s): Zhu, Y., Skerlos, S., Xu, M., and Cooper, D.R.

Abstract: Making, driving, and disposing of U.S. light-duty vehicles (LDVs) account for 3% of global greenhouse gas emissions related to energy and processing. This study calculates future emissions and global temperature rises attributable to U.S. LDVs. We examine how 2021–2050 U.S. LDV cumulative emissions can be limited to 23.1 Gt CO2equiv, helping to limit global warming to less than 2 °C. We vary four vehicle life cycle parameters (transport demand, sales share of alternative fuel vehicles, vehicle material recycling rates, and vehicle lifespans) in a dynamic fleet analysis to determine annual LDV sales, scrappage, and fleet compositions. We combine these data with vehicle technology and electricity emission scenarios to calculate annual production, use, and disposal emissions attributable to U.S. LDVs. Only 3% of the 1512 modeled pathways stay within the emission limit. Cumulative emissions are most sensitive to transport demand, and the speed of fleet electrification and electricity decarbonization. Increasing production of battery electric vehicles (BEVs) to 100% of sales by 2040 (at the latest) is necessary, and early retirement of internal combustion engine vehicles is beneficial. Rapid electricity decarbonization minimizes emissions from BEV use and increasingly energy-intensive vehicle production. Deploying high fuel economy vehicles can increase emissions from the production of BEV batteries and lightweight materials. Increased recycling has a small effect on these emissions because over the time period there are few postconsumer batteries and lightweight materials available for recycling. Without aggressive actions, U.S. LDVs will likely exceed the cumulative emissions budget by 2039 and contribute a further 0.02 °C to global warming by 2050, 2.7% of the remaining global 2 °C budget.

Subject Areas: Climate change; Transportation; Electric vehicles; Fossil fuels; Electricity decarbonization; Batteries

Availability: Zhu, Y., Skerlos, S., Xu, M., and Cooper, D.R. (2021). "Reducing Greenhouse Gas Emissions from U.S. Light-Duty Transport in Line with the 2 °C Target." *Environmental Science & Technology*, *55*(13), pp. 9326–9338. https://pubs.acs.org/doi/10.1021/acs.est.1c00816

3.10. Title: Potential Climate Impact Variations Due to Fueling Behavior of Plug-in Hybrid Vehicle Owners in the US

Author(s): Wolfram, P. and Hertwich, E.G.

Abstract: With the expected rapid growth of renewable electricity generation, charging plug-in hybrid electric vehicles (PHEVs) from the grid promise ever higher reductions in CO_2 emissions. Previous analyses have found that the share that PHEVs are driven in electric mode can differ substantially depending on region, battery size, and trip purpose. Here, we provide a first fleet-wide emissions mitigation potential of US-based PHEV drivers adopting high or low shares of electric driving. Specifically, we illustrate scenarios of different combinations of PHEV uptake, renewable electricity generation shares, and PHEV fueling behavior. Across 21 analyzed scenarios, annual greenhouse gas (GHG) emissions of the light-duty vehicle (LDV) fleet could differ by an average of 21% (5–43% range) in 2050 depending alone on the fueling behavior of PHEV drivers. This behavior could further determine the discharge of about 1.3 (0.7–1.9) Gt CO_2 (or roughly one year of current emissions) over the next three decades, significantly influencing the feasibility of reaching an 80% emission reduction target for the LDV sector. Governments can nudge PHEV drivers toward environmentally favorable fueling behavior. We discuss several options for nudging, including charging infrastructure availability, battery design, and consumer education.

Subject Areas: Redox reactions; Fossil fuels; Environmental modeling; Energy; Batteries

Availability: Wolfram, P. and Hertwich, E.G. (2021). "Potential Climate Impact Variations Due to Fueling Behavior of Plug-in Hybrid Vehicle Owners in the US." *Environmental Science & Technology*, *55*(1), pp. 65–72. https://pubs.acs.org/doi/full/10.1021/acs.est.0c03796

3.11. Title: Ridesharing Services and Urban Transport CO_2 Emissions: Simulation-Based Evidence from 247 Cities

Author(s): Tikoudis, I., Martinez, L., Farrow, K., Bouyssou, C.G., Petrik, O., and Oueslati, W.

Abstract: Could a widespread proliferation of ride-sharing services mitigate or exacerbate the carbon footprint of urban passenger transport? Despite having profound policy implications, this question has not yet been answered in the literature. This paper examines that impact ex ante, by simulating the aggregate travel demand, the choice of transport mode, and the resulting CO_2 emissions in 247 cities between 2015 and 2050. We find that if ride-sharing services receive substantial policy support, CO_2 emissions from passenger transport in 2050 will be on average 6.3 percent lower than their reference level. However, we show that this finding differs widely across cities. The paper identifies the reasons for this variation and the policies that are socially desirable in a given city, conditional on its characteristics.

Subject Areas: CO_2 emissions; Ride-sharing; Urban transport; Shared mobility; Algorithm-based services; Transport mode competition

Availability: Tikoudis, I., Martinez, L., Farrow, K., Bouyssou, C.G., Petrik, O., and Oueslati, W. (2021). "Ridesharing Services and Urban Transport CO_2 Emissions: Simulation-Based Evidence from 247 Cities." *Transportation Research Part D: Transport and Environment*, *97*. https://doi.org/10.1016/j.trd.2021.102923

3.12. Title: To Tackle Climate Change, We Must Reform Land Use

Author(s): DeGood, K.

Abstract: Blog.

Subject Areas: Global climate change; Greenhouse gas; Decarbonization; Vehicle electrification; Automobile dependence; Electric vehicle charging; Land use; Transportation system

Availability: DeGood, K. (2021). *To Tackle Climate Change, We Must Reform Land Use*. Center for American Progress, Washington, DC. https://www.americanprogress.org/issues/economy/reports/2021/07/22/501894/tackle-climate-change-must-reform-land-use/

3.13. Title: A Framework for Localizing Global Climate Solutions and Their Carbon Reduction Potential

Author(s): Brown, M.A. et al.

Abstract: Localized carbon reduction strategies are especially critical in States and regions that lack top-down climate leadership. This paper illustrates the use of coupled systems in assessments of subnational climate solutions with a case study of Georgia, a State located in the southeastern United States that does not have statewide climate goals or plans. The paper illustrates how robust place-specific plans for climate action could be derived from foundational global and national work and by embedding that research into the context of socioecological-technological systems. Our replicable methodology advances the traditional additive sectoral wedge analysis of carbon abatement potential by incorporating solution interdependencies and by spanning both carbon sources and sinks. We estimate that a system of 20 solutions could cut Georgia's carbon footprint by 35 percent in 2030 relative to a business-as-usual forecast and by 50 percent relative to Georgia's emissions in 2005. We also produce a carbon abatement cost curve that aligns private and social costs as well as benefits with units of avoided CO_2-e. The solutions are affiliated with various social co-costs and co-benefits that highlight societal concerns extending beyond climate impacts, including public health, environmental quality, employment, and equity.

Subject Areas: Carbon footprint; Carbon neutrality; Equity; Climate roadmap

Availability: Brown, M.A. et al. (2021). "A Framework for Localizing Global Climate Solutions and Their Carbon Reduction Potential." *Proceedings of the National Academy of Sciences of the United States of America*, *118*(31). https://doi.org/10.1073/pnas.2100008118

3.14. Title: Measures to Reduce Greenhouse Gas Emissions from Transportation and Land Use Across the Met Council Region

Author(s): Hawkins, J., Dean, M., and Kockelman, K.

Abstract: Climate change is among the most pressing issues of the 21st xentury. Its impacts include more severe weather events and temperature variations, increasing home insurance premiums, increasing repair costs of public facilities, and stresses to the economy and well-being of residents (Met Council, 2014b). One of the largest sources of anthropogenic greenhouse gas (GHG) emissions is the transportation sector, accounting for roughly a third of all emissions in the United States. This report's objectives are to outline a range of policy and technology strategies and their relative potentials to reduce GHG emissions from the transportation and land use sectors. This review is then used in the development of a tool for comparing decarbonization strategies in the MSP region.

The GHG scenario planning tool allows users to compare possible futures for land use, buildings, transportation, and urban tree canopies. The tool operates at the level of municipalities and townships. The main inputs are population, land use, transportation, and energy projections for the year 2040. The transportation component of the tool also relies on projections of the adoption of electric vehicles (EVs), autonomous vehicles (AVs), and dynamic ride-sharing (DRS). The tool also examines the use of road, parking, and decongestion pricing to reduce VMT, and therefore, GHG emissions. Cost and emissions factors are then coupled with demand elasticities to inform comparisons of alternative scenarios to a business-as-usual (BAU) forecast.

Subject Areas: Climate change; Greenhouse gas emissions reduction strategies; Greenhouse gas emission assessment; Transportation decarbonization strategies

Availability: Hawkins, J., Dean, M., and Kockelman, K. (2021). *Measures to Reduce Greenhouse Gas Emissions from Transportation and Land Use Across the Met Council Region*. Recommendations Report, University of Texas, Austin, TX. https://www.caee.utexas.edu/prof/Kockelman/public_html/TRB22MetCouncilDecarbOfTranspSector.pdf

3.15. Title: Steering Towards Cleaner Air: Measures to Mitigate Transport Air Pollution in Addis Ababa

Author(s): Grutter, J., Jia, W., and Xie, J.

Abstract: Air pollution, exacerbated by urbanization and motorization, is a growing concern in Addis Ababa and many other SSA cities. In Addis Ababa, air pollution from the urban transport sector is attributable to rapid motorization, an aging vehicle fleet, high sulfur fuels, lack of emission standards, and inadequate vehicle inspection and enforcement, calling for a shift toward integrated transport and air quality management. The report is one of the deliverables of the World Bank's Advisory Services & Analytics program entitled "Ethiopia: Air Quality Management and Urban Mobility." It aims to assess mitigation options for transport emissions for Addis Ababa (AA) in the Ethiopian context and recommend priority measures for short- and mid-term actions. The formulation of potential mitigation options builds upon a review of relevant development strategies and ongoing initiatives of the Federal and AA governments and development partners, the Ethiopian and international experiences, the results of Addis Ababa's source apportionment study including vehicle emission inventory conducted for this ASA, and consultations with relevant stakeholders. A set of transport air pollution mitigation measures are assessed, prioritized, and recommended for Addis Ababa.

Subject Areas: Air pollution; Transport emissions; Mitigation options

Availability: Grutter, J., Jia, W., and Xie, J. (2021). *Steering Towards Cleaner Air: Measures to Mitigate Transport Air Pollution in Addis Ababa*. Report, The World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/36286

3.16. Title: Does Telecommuting Reduce Commuting Emissions?

Author(s): Marz, W. and Sen, S.

Abstract: The long-term trend toward more work from home due to digitization has found a strong new driver, the COVID-19 pandemic. The profound change in urban mobility patterns supports the often-held view that reducing the number of commuting trips can lower carbon emissions to a certain degree. We investigate this optimistic view from a long-run perspective in a monocentric urban model with household-level vehicle choice based on fuel efficiency. In the medium run, fewer trips lead to the choice of less fuel-efficient vehicles. In addition, with lower annual driving costs to the city center, households change their location in the long run toward longer commuting trips but cheaper housing, implying an adjustment in the real-estate market. These changes in vehicle choice and the urban form largely eliminate the initial environmental benefits. Binding fuel economy standards completely prevent the medium-run drop in fuel efficiency but slightly exacerbate the long-term increase in commuting trip length.

Subject Areas: Telecommuting; Monocentric city; Fuel economy; Carbon emissions

Availability: Marz, W. and Sen, S. (2021). *Does Telecommuting Reduce Commuting Emissions?* CESifo Working Papers, Munich Society for the Promotion of Economic Research, CESifo GmbH, Munich, Germany. https://www.cesifo.org/DocDL/cesifo1_wp9357.pdf

3.17. Title: Aviation Fuel and Emissions in Air Markets with Interregional Passenger Leakage

Author(s): Yirgu, K.W. and Kim, A.M.

Abstract: Attractive air services at large airports in the United States, over the last two decades, have encouraged interregional air passenger leakage, a phenomenon in which air travelers abandon their nearby small airports in favor of starting their air journeys from large hub airports farther away. The disparities between small and large airports, in terms of air services, are expected to widen because of COVID-19 and further exacerbate passenger leakage. This study estimates the differences in mean aviation fuel consumed and pollutants emitted between air routes from small and large airports in the U.S. Midwest region—routes that are known to be contested according to analysis of an air ticket dataset. Findings indicate that air journeys originating from large airports result in 24 percent less aviation fuel consumption and considerably lower emissions at the passenger-kilometer level, offering additional insight toward better understanding the environmental impact of a geographically shifting air travel demand.

Subject Areas: Interregional passenger leakage; Small airports; Large (hub) airports; Aviation fuel; Emissions

Availability: Yirgu, K.W. and Kim, A.M. (2021). "Aviation Fuel and Emissions in Air Markets with Interregional Passenger Leakage." *Transportation Research Part D: Transport and Environment*, *101*. https://doi.org/10.1016/j.trd.2021.103092

3.18. Title: It Will Take More Than EVs to Save the Planet, Study Finds

Author(s): Descant, S.

Abstract: Blog.

Subject Areas: Urban planning; Transportation; Micromobility; Electric vehicles; Smart cities

Availability: Descant, S. (2021). "It Will Take More Than EVs to Save the Planet, Study Finds." *GovTech*. https://www.govtech.com/fs/it-will-take-more-than-evs-to-save-the-planet-study-finds

Chapter 4. Health

4.1. Title: Comparative Cost-effectiveness of SARS-CoV-2 Testing Strategies in the USA: A Modelling Study

Author(s): Du, Z., Pandey, A., Dai, Y., Fitzpatrick, M.C., Chinazzi, M., Piontti, A.P., Lachmann, M., Vespignani, A., Cowling, B.J., Galvani, A.P., and Meyers, L.A.

Abstract: Background: To mitigate the COVID-19 pandemic, countries worldwide have enacted unprecedented movement restrictions, physical distancing measures, and face mask requirements. Until safe and efficacious vaccines or antiviral drugs become widely available, viral testing remains the primary mitigation measure for rapid identification and isolation of infected individuals. We aimed to assess the economic trade-offs of expanding and accelerating testing for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) across the USA in different transmission scenarios.

Methods: We used a multiscale model that incorporates SARS-CoV-2 transmission at the population level and daily viral load dynamics at the individual level to assess eight surveillance testing strategies that varied by testing frequency (from daily to monthly testing) and isolation period (1 or 2 weeks), compared with the status-quo strategy of symptom-based testing and isolation. For each testing strategy, we first estimated the costs (incorporating costs of diagnostic testing and admissions to hospital, and salary lost while in isolation) and years of life lost (YLLs) prevented under rapid and low transmission scenarios. We then assessed the testing strategies across a range of scenarios, each defined by effective reproduction number (R_e), willingness to pay per YLL averted, and cost of a test, to estimate the probability that a particular strategy had the greatest net benefit. Additionally, for a range of transmission scenarios (R_e from 1·1 to 3), we estimated a threshold test price at which the status-quo strategy outperforms all testing strategies considered.

Findings: Our modelling showed that daily testing combined with a 2-week isolation period was the most costly strategy considered, reflecting increased costs with greater test frequency and length of isolation period. Assuming a societal willingness to pay of US$100 000 per YLL averted and a price of $5 per test, the strategy most likely to be cost-effective under a rapid transmission scenario (R_e of 2·2) is weekly testing followed by a 2-week isolation period subsequent to a positive test result. Under low transmission scenarios (R_e of 1·2), monthly testing of the population followed by 1-week isolation rather than 2-week isolation is likely to be most cost-effective. Expanded surveillance testing is more likely to be cost-effective than the status-quo testing strategy if the price per test is less than $75 across all transmission rates considered.

Interpretation: Extensive expansion of SARS-CoV-2 testing programmes with more frequent and rapid tests across communities coupled with isolation of individuals with confirmed infection is essential for mitigating the COVID-19 pandemic. Furthermore, resources recouped from shortened isolation duration could be cost-effectively allocated to more frequent testing.

Funding: U.S. National Institutes of Health, U.S. Centers for Disease Control and Prevention, and Love, Tito's.

Subject Areas: COVID-19; Testing strategy; Assessment

Availability: Du, Z., Pandey, A., Dai, Y., Fitzpatrick, M.C., Chinazzi, M., Piontti, A.P., Lachmann, M., Vespignani, A., Cowling, B.J., Galvani, A.P., and Meyers, L.A. (2021). "Comparative Cost-effectiveness of SARS-CoV-2 Testing Strategies in the USA: A Modelling Study." *The Lancet Public Health*, *6*(3), pp. 184–191. https://doi.org/10.1016/S2468-2667(21)00002-5

4.2. Title: Prioritizing Allocation of COVID-19 Vaccines Based on Social Contacts Increases Vaccination Effectiveness

Author(s): Chen, J., Hoops, S., Marathe, A., Mortveit, H., Lewis, B., Venkatramanan, S., Haddadan, A., Bhattacharya, P., Adiga, A., Vullikanti, A., Srinivasan, A., Wilson, M.L., Ehrlich, G., Fenster, M., Eubank, S., Barrett, C., and Marathe, M.

Abstract: We study allocation of COVID-19 vaccines to individuals based on the structural properties of their underlying social contact network. Even optimistic estimates suggest that most countries will likely take 6 to 24 months to vaccinate their citizens. These time estimates and the emergence of new viral strains urge us to find quick and effective ways to allocate the vaccines and contain the pandemic. While current approaches use combinations of age-based and occupation-based prioritizations, our strategy marks a departure from such largely aggregate vaccine allocation strategies. We propose a novel agent-based modeling approach motivated by recent advances in (i) science of real-world networks that point to efficacy of certain vaccination strategies and (ii) digital technologies that improve our ability to estimate some of these structural properties. Using a realistic representation of a social contact network for the Commonwealth of Virginia, combined with accurate surveillance data on spatio-temporal cases and currently accepted models of within- and between-host disease dynamics, we study how a limited number of vaccine doses can be strategically distributed to individuals to reduce the overall burden of the pandemic. We show that allocation of vaccines based on individuals' degree (number of social contacts) and total social proximity time is significantly more effective than the currently used age-based allocation strategy in terms of number of infections, hospitalizations and deaths. Our results suggest that in just two months, by March 31, 2021, compared to age-based allocation, the proposed degree-based strategy can result in reducing an additional 56–110k infections, 3.2–5.4k hospitalizations, and 700–900 deaths just in the Commonwealth of Virginia. Extrapolating these results for the entire US, this strategy can lead to 3–6 million fewer infections, 181–306k fewer hospitalizations, and 51–62k fewer deaths compared to age-based allocation. The overall strategy is robust even: (i) if the social contacts are not estimated correctly; (ii) if the vaccine efficacy is lower than expected or only a single dose is given; (iii) if there is a delay in vaccine production and deployment; and (iv) whether or not non-pharmaceutical interventions continue as vaccines are deployed. For reasons of implementability, we have used degree, which is a simple structural measure and can be easily estimated using several methods, including the digital technology available today. These results are significant, especially for resource-poor countries, where vaccines are less available, have lower efficacy, and are more slowly distributed.

Subject Areas: COVID-19; Vaccine allocation; Social proximity time; Degree-based strategy; Agent-based modeling

Availability: Chen, J., Hoops, S., Marathe, A., Mortveit, H., Lewis, B., Venkatramanan, S., Haddadan, A., Bhattacharya, P., Adiga, A., Vullikanti, A., Srinivasan, A., Wilson, M.L., Ehrlich, G., Fenster, M., Eubank, S., Barrett, C., and Marathe, M. (2021). *Prioritizing Allocation of COVID-19 Vaccines Based on Social Contacts Increases Vaccination Effectiveness*. medRxiv preprint, medRxiv 2021.02.04.21251012. https://doi.org/10.1101/2021.02.04.21251012

4.3. Title: The Public Health Implications of the Paris Agreement: A Modelling Study

Author(s): Hamilton, I., Kennard, H., McGushin, A., Höglund-Isaksson, L., Kiesewetter, G., Lott, M., Milner, J., Purohit, P., Rafaj, P., Sharma, R., Springmann, M., Woodcock, J., and Watts, N.

Abstract: Background: Nationally determined contributions (NDCs) serve to meet the goals of the Paris Agreement of staying "well below 2°C," which could also yield substantial health co-benefits in the process. However, existing NDC commitments are inadequate to achieve this goal. Placing health as a key focus of the NDCs could present an opportunity to increase ambition and realise health co-benefits. We modelled scenarios to analyse the health co-benefits of NDCs for the year 2040 for nine representative countries (i.e., Brazil, China, Germany, India, Indonesia, Nigeria, South Africa, the UK, and the USA) that were selected for their contribution to global greenhouse gas emissions and their global or regional influence.

Methods: Modelling the energy, food and agriculture, and transport sectors, and mortality related to risk factors of air pollution, diet, and physical activity, we analysed the health co-benefits of existing NDCs and related policies (i.e., the current pathways scenario) for 2040 in nine countries around the world. We compared these health co-benefits with two alternative scenarios, one consistent with the goal of the Paris Agreement and the Sustainable Development Goals (i.e., the sustainable pathways scenario), and one in line with the sustainable pathways scenario, but also placing health as a central focus of the policies (i.e., the health in all climate policies scenario).

Findings: Compared with the current pathways scenario, the sustainable pathways scenario resulted in an annual reduction of 1·18 million air pollution-related deaths, 5·86 million diet-related deaths, and 1·15 million deaths due to physical inactivity, across the nine countries, by 2040. Adopting the more ambitious health in all climate policies scenario would result in a further reduction of 462 000 annual deaths attributable to air pollution, 572 000 annual deaths attributable to diet, and 943 000 annual deaths attributable to physical inactivity. These benefits were attributable to the mitigation of direct greenhouse gas emissions and the commensurate actions that reduce exposure to harmful pollutants, as well as improved diets and safe physical activity.

Interpretation: A greater consideration of health in the NDCs and climate change mitigation policies has the potential to yield considerable health benefits as well as achieve the "well below 2°C" commitment across a range of regional and economic contexts.

Funding: This work was in part funded through an unrestricted grant from the Wellcome Trust (award number 209734/Z/17/Z) and supported by an Engineering and Physical Sciences Research Council grant (grant number EP/R035288/1).

Subject Areas: Nationally determined contributions; Sustainable development; Health

Availability: Hamilton, I., Kennard, H., McGushin, A., Höglund-Isaksson, L., Kiesewetter, G., Lott, M., Milner, J., Purohit, P., Rafaj, P., Sharma, R., Springmann, M., Woodcock, J., and Watts,

N. (2021). “The Public Health Implications of the Paris Agreement: A Modelling Study.” *The Lancet Planetary Health*, *5*(2), pp. 74–83. https://doi.org/10.1016/S2542-5196(20)30249-7

4.4. Title: Scalable Epidemiological Workflows to Support COVID-19 Planning and Response

Author(s): Machi, D., Bhattacharya, P., Hoops, S., Chen, J., Mortveit, H., Venkatramanan, S., Lewis, B., Wilson, M., Fadikar, A., Maiden, T., Barrett, C.L., and Marathe, M.V.

Abstract: The COVID-19 global outbreak represents the most significant epidemic event since the 1918 influenza pandemic. Simulations have played a crucial role in supporting COVID-19 planning and response efforts. Developing scalable workflows to provide policymakers quick responses to important questions pertaining to logistics, resource allocation, epidemic forecasts and intervention analysis remains a challenging computational problem. In this work, we present scalable, high-performance computing-enabled workflows for COVID-19 pandemic planning and response. The scalability of our methodology allows us to run fine-grained simulations daily and to generate county-level forecasts and other counterfactual analysis for each of the 50 States (and DC), 3,140 counties across the USA. Our workflows use a hybrid cloud/cluster system utilizing a combination of local and remote cluster computing facilities, and using over 20,000 CPU cores running for 6–9 hours every day to meet this objective. Our state (Virginia), state hospital network, our university, the DOD and the CDC use our models to guide their COVID-19 planning and response efforts. We began executing these pipelines March 25, 2020, and have delivered and briefed weekly updates to these stakeholders for over 30 weeks without interruption.

Subject Areas: COVID-19; Epidemic modeling; High-performance computing workflow development

Availability: Machi, D., Bhattacharya, P., Hoops, S., Chen, J., Mortveit, H., Venkatramanan, S., Lewis, B., Wilson, M., Fadikar, A., Maiden, T., Barrett, C.L., and Marathe, M.V. (2021). *Scalable Epidemiological Workflows to Support COVID-19 Planning and Response*. medRxiv preprint, medRxiv 2021.02.23.21252325. https://doi.org/10.1101/2021.02.23.21252325

4.5. Title: How is the COVID-19 Pandemic Shaping Transportation Access to Health Care?

Author(s): Chen, K.L., Brozen, M., Rollman, J.E., Ward, T., Norris, K.C., Gregory, K.D., and Zimmerman, F.J.

Abstract: The Coronavirus disease 19 (COVID-19) pandemic has disrupted both transportation and health systems. While about 40% of Americans have delayed seeking medical care during the pandemic, it remains unclear to what extent transportation is contributing to missed care. To understand the relationship between transportation and unmet health care needs during the pandemic, this paper synthesizes existing knowledge on transportation patterns and barriers across five types of health care needs. While the literature is limited by the absence of detailed data for trips to health care, key themes emerged across populations and settings. We find that some patients, many of whom already experience transportation disadvantage, likely need extra support during the pandemic to overcome new travel barriers related to changes in public transit or the inability to rely on others for rides. Telemedicine is working as a partial substitute for some visits but cannot fulfill all health care needs, especially for vulnerable groups. Structural inequality during the pandemic has likely compounded health care access barriers for low-income individuals and people of color, who face not only disproportionate health risks, but also greater difficulty in transportation access and heightened economic hardship due to COVID-19. Partnerships between health and transportation systems hold promise for jointly addressing disparities in health- and transportation-related challenges but are largely limited to Medicaid-enrolled patients. Our findings suggest that transportation and health care providers should look for additional strategies to ensure that transportation access is not a reason for delayed medical care during and after the COVID-19 pandemic.

Subject Areas: Health care; Access to care; Transportation equity; COVID-19; Non-emergency medical transportation; Non-emergency medical transportation

Availability: Chen, K.L., Brozen, M., Rollman, J.E., Ward, T., Norris, K.C., Gregory, K.D., and Zimmerman, F.J. (2021). "How is the COVID-19 Pandemic Shaping Transportation Access to Health Care?" *Transportation Research Interdisciplinary Perspectives*, *10*. https://doi.org/10.1016/j.trip.2021.100338

4.6. Title: The Influence of Hearing Impairment on Driving Avoidance Among a Large Cohort of Older Drivers

Author(s): Vivoda, J.M., Molnar, L.J., Eby, D.W., Bogard, S., Zakrajsek, J.S., Kostyniuk, L.P., Louis, R.M.S., Zanier, N., LeBlanc, D., Smith, J., Yung, R., Nyquist, L., DiGuiseppi, C., Li, G., and Strogatz, D.

Abstract: As people age, some of the commonly experienced psychomotor, visual, and cognitive declines can interfere with the ability to safely drive, often leading to situational avoidance of challenging driving situations. The effect of hearing impairment on these avoidance behaviors has not been comprehensively studied. Data from the American Automobile Association (AAA) Longitudinal Research on Aging Drivers (LongROAD) study were used to assess the effect of hearing impairment on driving avoidance, using three measures of hearing. Results indicated that hearing loss plays a complex role in driving avoidance, and that an objective hearing measure was a stronger predictor than hearing aid use and self-rated hearing. Greater hearing impairment was related to less nighttime and freeway driving, more trips farther than 15 mi from home, and lower odds of avoiding peak driving times. The moderating influence of hearing on both vision and cognition is also discussed, along with study implications and future research.

Subject Areas: Driving; Hearing; Vision; Perceptual decline; Sensory problems; Driving exposure

Availability: Vivoda, J.M., Molnar, L.J., Eby, D.W., Bogard, S., Zakrajsek, J.S., Kostyniuk, L.P., Louis, R.M.S., Zanier, N., LeBlanc, D., Smith, J., Yung, R., Nyquist, L., DiGuiseppi, C., Li, G., and Strogatz, D. (2021). "The Influence of Hearing Impairment on Driving Avoidance Among a Large Cohort of Older Drivers." *Journal of Applied Gerontology*. https://doi.org/10.1177/0733464821999223

4.7. Title: Transform Transportation: Strategies for a Healthier Future

Author(s): Horrox, J., Weissman, G., Casale, M., and Stout, J.

Abstract: America's transportation system is wrecking our health. Traffic-related air pollution kills an estimated 58,000 Americans every year, and increases the risk of serious health conditions, including lung cancer, stroke, heart disease, asthma, and even dementia. More than 38,000 people die in vehicle crashes in the U.S. every year, and millions more are seriously injured.[2] Even our mental health and the health of our relationships are at risk – the time we spend driving, much less the time we spend stuck in stressful traffic, is time away from family, friends, exercise and leisure pursuits.

These health problems are a direct result of the way we've built our communities and our transportation system to be dependent on travel in fossil fuel-powered cars. Every year, Americans drive more than 3.2 trillion miles – nearly 10,000 miles per person and more miles per capita than people almost anywhere else in the world.[3] Since 1990, the number of vehicle miles traveled by light-duty vehicles like cars and light-duty trucks has risen by more than 46 percent.[4]

There is a better way. By rebuilding our transportation system to give more people the option to spend less time in a car, by expanding access to active means of travel such as walking and biking, and by adopting zero-emission electric cars and buses, we can make our transportation safer, healthier, cleaner and more efficient.

Subject Areas: Health; Air pollution; Transportation system

Availability: Horrox, J., Weissman, G., Casale, M., and Stout, J. (2021). *Transform Transportation: Strategies for a Healthier Future*. Frontier Group, Santa Barbara, CA. https://frontiergroup.org/reports/fg/transform-transportation

4.8. Title: Device-Measured and Self-Reported Active Travel Associations with Cardiovascular Disease Risk Factors in an Ethnically Diverse Sample of Adults

Author(s): Crist, K., Benmarhnia, T., Zamora, S., Yang, J., Sears, D.D., Natarajan, L., Dillon, L., Sallis, J.F., and Jankowska, M.M.

Abstract: Active travel (AT) provides an opportunity to alleviate the physical inactivity and climate crises contributing to the global chronic disease burden, including cardiovascular diseases (CVD). Though AT shows promising links to reduced CVD risk, prior studies relied on self-reported AT assessment. In the present study, device-measured and self-reported AT were compared across population subgroups and relationships with CVD risk biomarkers were evaluated for both measures. The study recruited an ethnically diverse sample (N = 602, mean age 59 years, 42% Hispanic/Latino ethnicity) from neighborhoods that varied by walkability and food access. AT was assessed using concurrently collected accelerometer and GPS data and self-report data from a validated survey. Relationships with body mass index (BMI), triglycerides, high-density lipoprotein (HDL) cholesterol, blood pressure (BP), and moderate-to-vigorous physical activity (MVPA) were modeled using multivariable linear regression. Devices captured more AT than did self-report. We found differences in AT measures by population subgroups, including race, ethnicity, education, income, vehicle access, and walkability. Men had more accelerometer-measured MVPA, though women self-reported more daily minutes. Both device and survey AT measures were positively associated with total accelerometer-measured MVPA, though the relationship was stronger with device-measured AT. Device-measured AT was associated with lower BMI. No other CVD risk biomarker was associated with either AT measure. No effect modification by Hispanic/Latino ethnicity was detected. Further studies with device-based measures are warranted to better understand the relationship between AT and cardiovascular health.

Subject Areas: Transportation; Walking; Biking; Accelerometer; Obesity; Blood pressure; Lipids; Glucose; Physical activity

Availability: Crist, K., Benmarhnia, T., Zamora, S., Yang, J., Sears, D.D., Natarajan, L., Dillon, L., Sallis, J.F., and Jankowska, M.M. (2021). "Device-Measured and Self-Reported Active Travel Associations with Cardiovascular Disease Risk Factors in an Ethnically Diverse Sample of Adults." *International Journal of Environmental Research and Public Health*, *18*(8). https://doi.org/10.3390/ijerph18083909

4.9. Title: Quantifying the Effects of Norms on COVID-19 Cases Using an Agent-based Simulation

Author(s): de Mooij, J., Dell'Anna, D., Bhattacharya, P., Dastani, M., Logan, B., and Swarup, S.

Abstract: Modelling social phenomena in large-scale agent-based simulations has long been a challenge due to the computational cost of incorporating agents whose behaviors are determined by reasoning about their internal attitudes and external factors. However, COVID-19 has brought the urgency of doing this to the fore, as, in the absence of viable pharmaceutical interventions, the progression of the pandemic has primarily been driven by behaviors and behavioral interventions. In this paper, we address this problem by developing a large-scale data-driven agent-based simulation model where individual agents reason about their beliefs, objectives, trust in government, and the norms imposed by the government. These internal and external attitudes are based on actual data concerning daily activities of individuals, their political orientation, and norms being enforced in the US state of Virginia. Our model is calibrated using mobility and COVID-19 case data. We show the utility of our model by quantifying the benefits of the various behavioral interventions through counterfactual runs of our calibrated simulation.

Subject Areas: Large-scale social simulation; Norm reasoning agents; Computational epidemiology

Availability: de Mooij, J., Dell'Anna, D., Bhattacharya, P., Dastani, M., Logan, B., and Swarup, S. (2021). *Quantifying the Effects of Norms on COVID-19 Cases Using an Agent-based Simulation*. Biocomplexity Institute and Initiative, University of Virginia, Charlottesville, VA. https://nssac.bii.virginia.edu/~swarup/papers/mooij_etal_mabs_2021.pdf

4.10. Title: Physical Activity from Transportation: New Insights and Lingering Questions

Author(s): Abshire, D.A., Pinto, B.M., and Wilson, D.K.

Abstract: Editorial.

Subject Areas: Physical activity; Race; Income; Safety; Infrastructure; Health; Active transportation; Young people

Availability: Abshire, D.A., Pinto, B.M., and Wilson, D.K. (2021). "Physical Activity from Transportation: New Insights and Lingering Questions." *Journal of Adolescent Health*, *69*(2), pp. 187–188. https://doi.org/10.1016/j.jadohealth.2021.04.034

4.11. Title: Towards a Health-Conscious Transportation Planning: A Framework for Estimating Health Impacts of Active Transportation at Local Level

Author(s): Peng, B., Erdoğan, S., Nasri, A.A., and Zou, Z.

Abstract: Introduction: The interrelationship between physical activity and health is well documented in transportation and public health literature. Nevertheless, health impacts are rarely considered in transportation planning processes due to the lack of a robust mechanism to quantify such impacts. The Integrated Transport and Health Impact Modeling (ITHIM) framework provides an opportunity to systematically estimate health impacts of active travel as a result of variations in transportation infrastructure and policies that involve non-motorized modes.

Methods: This study applies ITHIM framework to Prince George's County, Maryland, to explore potential health impacts of improved active travel through hypothetical scenarios. ITHIM integrates data on travel behavior, health, demographics, road injuries, and air quality. We constructed three what-if scenarios that reflect significant increases in walking and biking—a potential result of the ambitious infrastructure plans in place in PG County—and decrease in personal vehicle miles.

Results: Significant health and economic benefits are observed under three scenarios. We observed considerable health benefits in the scenarios where we made assumptions about increased active travel and reduced automobile usage—e.g., if everyone bikes 1.5 miles and drives 1.5 miles less per day, the county will save about 35 lives and 1,443 DALYs. We also observed significant monetary values of lifesaving in the economic analysis, indicating $117 million savings in the cost of illness (COI) for scenario1 (increased walking) and $34 million savings in COI as a result of scenario 2 (increased biking) and scenario 3 (increased biking and reduced driving).

Conclusion: This study provides insight into a better understanding of the potential health impacts of various transportation planning scenarios and provides an example for including health impact estimates in evaluating transportation policies and plans at local level. It highlights the importance of policies that encourage people to walk and bike also need to adopt measures that increase safety.

Subject Areas: Integrated transport and health impact modeling; Active travel; Physical activity; Health impact; Transportation planning; Transportation and health

Availability: Peng, B., Erdoğan, S., Nasri, A.A., and Zou, Z. (2021). "Towards a Health-Conscious Transportation Planning: A Framework for Estimating Health Impacts of Active Transportation at Local Level." *Journal of Transport & Health*, *22*. https://doi.org/10.1016/j.jth.2021.101231

4.12. Title: Ambient Air Pollution and Atherosclerosis: Recent Updates

Author(s): Bevan, G.H., Al-Kindi, S.G., Brook, R., and Rajagopalan, S.

Abstract: Purpose of Review: During the past century, exposure to particulate matter (PM) air pollution < 2.5 μm in diameter (PM2.5) has emerged as an all-pervading element of modern-day society. This increased exposure has come at the cost of heightened risk for cardiovascular (CV) morbidity and mortality. Not only can short-term PM2.5 exposure trigger acute CV events in susceptible individuals, but longer-term exposure over years augments CV risk to a greater extent in comparison with short-term exposure. The purpose of this review is to examine the available evidence for how ambient air pollution exposure may precipitate events at various time frames.

Recent Findings: Recent epidemiological studies have demonstrated an association between ambient PM2.5 exposure and the presence and progression of atherosclerosis in humans. Multiple animal exposure experiments over two decades have provided strong corroborative evidence that chronic exposure in fact does enhance the progression and perhaps vulnerability characteristics of atherosclerotic lesions.

Summary: Evidence from epidemiological studies, including surrogates of atherosclerosis, human translational studies, and mechanistic investigations utilizing animal studies, have improved our understanding of how ambient air pollution may potentiate atherosclerosis and precipitate cardiovascular events. Even so, future research is needed to fully understand the contribution of different constituents in ambient air pollution–mediated atherosclerosis as well as how other systems may modulate the impact of exposure, including adaptive immunity and the gut microbiome. Nevertheless, due to the billions of people continually exposed to PM2.5, the long-term pro-atherosclerotic effects of this ubiquitous air pollutant are likely to be of enormous and growing global public health importance.

Subject Areas: Atherosclerosis; Ambient air pollution

Availability: Bevan, G.H., Al-Kindi, S.G., Brook, R., and Rajagopalan, S. (2021). "Ambient Air Pollution and Atherosclerosis: Recent Updates." *Current Atherosclerosis Reports*, *23*. https://doi.org/10.1007/s11883-021-00958-9

4.13. Title: Webinar: The Impact of Transportation-Related Barriers on Self-Perceived Physical Health Among Adults in the US

Author(s): Baiden, P. and Boateng, G.

Abstract: Drawing from the framework of social determinants of health, the objective of this study is to investigate the cross-sectional association between transportation-related factors and self-perceived physical health among adults in the United States.

Data for this study were derived from the 2017 National Household Travel Survey. An analytic sample of 71,235 respondents aged 18–64 years was analyzed using binary logistic regression. Of the 71,235 respondents examined, 8.9 percent perceived their physical health to be poor. About 36 percent of the respondents had fewer vehicles per individuals in the household.

Controlling for the effects of other factors, respondents who had fewer vehicles per individuals in the household were 1.27 times more likely to report poor self-perceived physical health when compared to their counterparts with more vehicles per individuals in the household (AOR = 1.27, 95 percent CI = 1.17–1.39). Having higher education, higher income, and homeownership were inversely associated with poor self-perceived physical health.

The findings of this study suggest that as the gap between the number of household members and the number of vehicles present increases, respondents' self-perceived physical health deteriorates due to the uncertainty in having access to transportation when the need arises. Social workers, engineers, and policymakers should begin working on viable solutions to reduce or eliminate transportation barriers and address disparities created by lack of access to reliable transportation.

Subject Areas: Physical health; Demographics; Vehicle ownership; Transportation barriers; Accessibility

Availability: Baiden, P. and Boateng, G. (2021). *Webinar: The Impact of Transportation-Related Barriers on Self-Perceived Physical Health Among Adults in the US*. National Institute for Transportation and Communities, Portland State University, Portland, OR. https://nitc.trec.pdx.edu/events/professional-development/webinar-10-12-2021

4.14. Title: Advancing Measurement to Address Childhood Obesity: Results of 3 Workshops

Author(s): Ballard, R. et al.

Abstract: This paper arises from a series of workshops held by the National Collaborative on Childhood Obesity Research (NCCOR) and summarizes priorities and next steps for enhancing measurement tools and advancing the incorporation of high-quality measurement for surveillance, epidemiology, and intervention research aimed at accelerating progress in addressing the childhood obesity epidemic. It is intended to stimulate and inform new research on diverse aspects of childhood obesity among researchers and those who plan research initiatives.

As a public–private partnership of four leading research funders—the Centers for Disease Control and Prevention, National Institutes of Health, Robert Wood Johnson Foundation, and U.S. Department of Agriculture—NCCOR has a mission to accelerate progress in reducing childhood obesity among all children with particular attention to high-risk populations and communities. A key priority for NCCOR is to promote the use of high-quality, standardized measures and methods across childhood obesity surveillance, epidemiology, and intervention research. Use of such measures improves comparison of results across different studies and further advances progress against childhood obesity. New measures will be needed as understanding of key influences on childhood obesity, including individual, family, policy, and environmental factors, continues to evolve.

Subject Areas: Childhood obesity; Surveillance; Epidemiology; Intervention; Measurement

Availability: Ballard, R. et al. (2021). "Advancing Measurement to Address Childhood Obesity: Results of 3 Workshops." *American Journal of Preventive Medicine*, *61*(6), pp.e296–e304. https://doi.org/10.1016/j.amepre.2021.05.025

4.15. Title: Improving Transport-Related Health Impacts by Promoting Active Transport and Public Transport

Author(s): Huong, L.T.

Abstract: Health is always an important aspect of every individual and every community to ensure a happy life, happy community, and well-being; to increase productivity; and to save healthcare costs. For every individual and community, good health is considered one of their main goals and one of the vital inputs for sustainable development. In the first International Conference on Health Promotion, there was a statement that "Good Health is a major resource for social, economic, and personal development and an important dimension of quality of life" (WHO, 1986).

However, human health is a complex issue and is influenced by many sectors beyond the health sectors. Among these sectors, transport plays an essential role in both promoting and threatening health. Health benefits of transport include providing people with accessibility to employment, education, shops, recreation, social and family networks, healthcare services, and a wide range of other services and giving the opportunities for integrating physical activity into daily life through walking and cycling. However, transport also creates tremendous detrimental health effects directly through traffic accidents, air pollution, noise pollution, and stress. These adverse health effects of transport are becoming global issues. Additionally, transport generates other indirect health effects on the population through land consumption, community severance, and climate change, which are generally ignored when thinking about the health impacts of transport.

The negative health impacts of the transport system are highly related to private motorized transport, which are consequences of transport infrastructure and transport policies that focus on the movement of private motor vehicles. Despite the adverse health effects associated with private motorized vehicles, the number of individual motorized vehicles is still increasing as a result of the increase in travel demand. The travel demand is predicted to grow continuously due to economic development, population growth, and urbanization, particularly in urban areas where the current transport system has already experienced an imbalance between supply and demand. Consequently, the negative health impacts of transport will continue to increase, and if no effective solution is implemented, the negative health effects of the transport system will become worse.

A number of actions have been implemented to mitigate the negative impacts of the transport system, such as mixed land use, control vehicle ownership, applying stricter emission standards, congestion charge, vehicle sharing, and parking control. However, the benefits of these actions are limited and largely offset by the growth in travel demand. Among solutions, the shifting from private motorized transport to active transport (walking and cycling) and public transport seems to bring health benefits for both the individual and community. This approach is presented as an obvious solution to improve health and well-being through increased physical activity, reduced air and noise pollution, decreased greenhouse gas emissions, increased social interaction, reduced land consumption, provided equal opportunity, livability, and transport efficiency without the side effect of pollution. As health awareness is increasing rapidly, promoting active transport and public transport as healthy transport modes may contribute to improve the image and increase the

attractiveness of these transport modes. Therefore, the infrastructure supporting active transport and public transport, together with policies to promote walking, cycling, and public transport use, are crucial for transport systems and deserves ongoing attention.

This study aims to improve transport-related health impacts through promoting active transport and public transport. First, the primary transport-related health impacts have been investigated. Four primary transport-related health impacts have been selected for detailed investigation, including traffic accidents, health impacts of exposure to traffic-related air pollution, health impacts of exposure to traffic-related noise pollution, and transport-related physical activity. The cause-effect relationships have been developed for these four major transport-related health impacts showing the health impact pathway of transport from the source to the human. Factors influencing these health impacts have been comprehensively described. Second, the literature review on the association of transport mode use and its health impacts on its users and other road users as well as on the general population has been conducted. Third, as a case study, the transport-related health impacts in Ho Chi Minh City have been investigated in more detail. The awareness of commuters, the general population, and city authorities about the health impacts of transport is also evaluated. Then, the health impact assessment has been reviewed, and a causal pathway of transport and health has been proposed. Based on that, a qualitative health impact assessment of increasing active transport and public transport in HCM has been conducted. Fifth, a health-oriented transport policy has been discussed, and a goal and objective system of the health-oriented transport policy has been proposed. Then, the importance of active transport and public transport in a healthy transport system has been highlighted. Finally, five strategies to promote active transport and public transport have been proposed.

Subject Areas: Active transport; Public transport; Health effects of transport; Transport policy

Availability: Huong, L.T. (2021). *Improving Transport-Related Health Impacts by Promoting Active Transport and Public Transport*. Doctoral Dissertation, Technical University Darmstadt, Germany. https://tuprints.ulb.tu-darmstadt.de/19666/

4.16. Title: Performance Evaluation of Transportation Systems for Sustainability and Smart-Growth of Cities: An Integrated Assessment of Health Impacts

Author(s): Feizi, A.

Abstract: The performance of transportation systems is a significant component that influences the quality of life. The performance evaluation refers to a process of determining how well transportation systems perform regarding their intended goals and objectives. The advancement of information and communication technology and the integration between transportation systems and advanced technologies have directed more attention to the concept of smart cities. Smart cities constitute several interrelated components. Therefore, this offers comprehensive and integrated frameworks to evaluate the transportation performance and understanding of multifaceted interactions between the components from a transportation engineering perspective in four sections.

In the first part of the study, a framework is developed to identify poor cycling infrastructure by studying bicyclists' perception and driver's behavior in bicycle-vehicle maneuvers. Active transportation modes aid livable communities by enhancing physical activity and public health, known as important factors of the sustainability of smart cities. I found that environments with more intersections or uphill segments incorporate a risk of being uncomfortable or stationary. In terms of the legislation approach, this study demonstrated that overtaking distances in the locations with a 5-foot passing law were significantly greater than those with a 3-foot law or no specific law.

In the second part, I developed a conceptual assessment framework of multifaceted transportation performances for sustainability and smart growth in cities. A multi-criteria decision analysis method was employed to composite the criteria and evaluate the final Closeness Coefficient Score (CCS) to the negative ideal solution. I applied the proposed framework to 46 cities in the United States. The results indicated that the physical activity indicator is a significant criterion to distinguish the sustainability of study areas.

Third, the study proposed a framework utilizing open-source databases to generate a synthetic population offering household- and person-level attributes. The framework provided a procedure to develop agent-based trip chains for individuals in the synthetic population. I also developed a method to accurately impute land use polygons to each tour within the traffic analysis zones. The analysis results suggested a perfect fit between the actual and the synthetic population, and the proposed framework added up the existing approaches by providing additional steps to build spatial and temporal distributions of agents' activity plan using open-source data.

The final framework proposes how to evaluate integrated health impacts of transportation scenarios using agent-based simulation. An agent-based simulation approach was developed to analyze three factors of physical activity, traffic accidents, and air pollution exposure through four scenarios: the base scenario, increase in demand, introducing bikeable infrastructure, and a combination of the last two scenarios. The case study results demonstrated that the quantified benefits of physical activity in the environment with an average background pollution concentration is substantially larger than risks of vehicle crashes and emission exposure, even

though active travelers are more vulnerable to air pollution. Thus, the framework can be used as an effective tool to capture smart and sustainable strategies, such as bike-sharing programs, demand-responsive transport, and micro-transit in urbanized areas, and determine the long-term health outcomes of each scenario.

Subject Areas: Smart city; Sustainable transportation; Active transportation; Health impact assessment; Agent-based modeling; Traffic simulation

Availability: Feizi, A. (2021). *Performance Evaluation of Transportation Systems for Sustainability and Smart-Growth of Cities: An Integrated Assessment of Health Impacts*. Doctoral Dissertation, Western Michigan University, Kalamazoo, MI.
https://scholarworks.wmich.edu/dissertations/3758/

4.17. Title: Rural-Urban Variations in Travel Burdens for Care: Findings from the 2017 National Household Travel Survey

Author(s): Akinlotan, M., Primm, K., Khodakarami, N., Bolin, J., and Ferdinand, A.O.

Abstract: Burdensome travel arrangements for medical or dental care have been identified as barriers to healthcare access, particularly in rural areas. Higher travel burden has been associated with delayed or foregone medical care and missed appointments, which leads to reduced preventive care, greater disease burden, poorer treatment outcomes, and reduced quality of life. A previous study using the 2001 National Household Travel Survey (NHTS) found that rural residents traveled farther and spent more time in travel for medical and dental care. Given that the previous study is 20 years old, this study uses the more recent 2017 NHTS to achieve the following objectives:

a) provide recent national estimates of the distance traveled and time spent on one-way trips for medical and dental care among rural and urban dwellers,

b) examine how the travel behaviors of rural residents vary by sociodemographic and geographic characteristics, and

c) evaluate factors associated with a high travel burden for medical and dental care among rural residents.

Subject Areas: Rural and urban residents; Medical and dental care; Healthcare access; Travel burden; Trip distance and time; Travel behaviors

Availability: Akinlotan, M., Primm, K., Khodakarami, N., Bolin, J., and Ferdinand, A.O. (2021). *Rural-Urban Variations in Travel Burdens for Care: Findings from the 2017 National Household Travel Survey*. Policy Brief, Southwest Rural Health Research Center, Texas A&M School of Public Health, College Station, TX. https://srhrc.tamhsc.edu/docs/travel-burdens-07.2021.pdf

4.18. Title: AI-Driven Agent-Based Models to Study the Role of Vaccine Acceptance in Controlling COVID-19 Spread in the US

Author(s): Bhattacharya, P. et al.

Abstract: We study the role of vaccine acceptance in controlling the spread of COVID-19 in the United States using AI-driven agent-based models. Our study uses a 288 million node social contact network spanning all 50 States plus Washington, DC, comprising 3,300 counties, with 12.59 billion daily interactions. The highly resolved agent-based models use realistic information about disease progression, vaccine uptake, production schedules, acceptance trends, prevalence, and social distancing guidelines. Developing a national model at this resolution that is driven by realistic data requires a complex scalable workflow, model calibration, simulation, and analytics components. Our workflow optimizes the total execution time and helps in improving overall human productivity.

This work develops a pipeline that can execute U.S.-scale models and associated workflows that typically present significant big data challenges. Our results show that, when compared to faster and accelerating vaccinations, slower vaccination rates due to vaccine hesitancy cause averted infections to drop from 6.7 to 4.5 million, and averted total deaths to drop from 39,400 to 28,200 nationwide. This occurs despite the fact that the final vaccine coverage is the same in both scenarios. Improving vaccine acceptance by 10 percent in all States increases averted infections from 4.5 to 4.7 million (a 4.4-percent improvement) and total deaths from 28,200 to 29,900 (a 6-percent increase) nationwide. The analysis also reveals interesting spatio-temporal differences in COVID-19 dynamics as a result of vaccine acceptance. To our knowledge, this is the first national-scale analysis of the effect of vaccine acceptance on the spread of COVID-19, using detailed and realistic agent-based models.

Subject Areas: High performance computing workflow; Agent-based modeling and simulation; COVID-19 vaccine acceptance

Availability: Bhattacharya, P. et al. (2021). "AI-Driven Agent-Based Models to Study the Role of Vaccine Acceptance in Controlling COVID-19 Spread in the US." *Proceedings of the 2021 IEEE International Conference on Big Data (IEEE BigData)*.
https://parantapa.net/mypapers/bhattacharya-bigdata21.pdf

4.19. Title: Causal Evaluation of the Health Effects of Light Rail Line: A Natural Experiment

Author(s): Wali, B., Frank, L.D., Young, D.R., Meenan, R.T., Saelens, B.E., Dickerson, J.F., and Fortmann, S.P.

Abstract: Background and objective: No research to date has causally linked built environment data with healthcare costs derived from clinically assessed health outcomes within the framework of longitudinal intervention design. This study examined the impact of light rail transit (LRT) line intervention on healthcare costs after controlling for mode-specific objectively assessed moderate-to-vigorous physical activity (MVPA), participant-level neighborhood environmental measures, demographics, attitudinal predispositions, and residential choices.

Data and methods: Based on a natural experiment related to a new LRT line in Portland – 282 individuals divided into treatment and control groups were prospectively followed during the pre- and post-intervention periods. For each individual, we harness high-resolution data on electronic medical record (EMR)-based healthcare costs, mode-specific MVPA, survey-based travel behavior, attitudinal/perception information, and objectively assessed built environment measures. Simulation-assisted longitudinal grouped random parameter models are developed to gain more accurate insights into the effects of LRT line intervention.

Results: Regarding the "average effect" of the LRT line intervention, no statistically significant reductions in healthcare costs were observed for the treated individuals over time. However, substantial heterogeneity was observed not only in the magnitude of effects but its direction as well after controlling for the within- and between-individual variations. For a subgroup of treated individuals, the LRT line opening decreased healthcare costs over time relative to the control group. Further comparative analysis based on the findings of heterogeneity-based models revealed that the effect of LRT intervention for the treated individuals differed by individual characteristics, attitudes/perceptions, and neighborhood-level environmental features.

Conclusions: The study revealed the presence of significant effect modifiers and distinct subgroup structures in the data related to the effects of LRT line intervention on healthcare costs. Severe implications of ignoring unobserved heterogeneity are highlighted. Limitations and potential avenues for future research are discussed.

Subject Areas: Transportation; Light rail transit; Longitudinal analysis; Healthcare costs; Built environment and active travel; Simulation-assisted random parameter models

Availability: Wali, B., Frank, L.D., Young, D.R., Meenan, R.T., Saelens, B.E., Dickerson, J.F., and Fortmann, S.P. (2021). "Causal Evaluation of the Health Effects of Light Rail Line: A Natural Experiment." *Journal of Transport & Health*, *24.*
https://doi.org/10.1016/j.jth.2021.101292

4.20. Title: Going to the Doctor: Rideshare as Nonemergency Medical Transportation

Author(s): Fraade-Blanar, L., Koo, T., and Whaley, C.M.

Abstract: Ride-sharing apps have changed how people get around. Its use in nonemergency medical transportation (NEMT) is nascent but possibly growing. The authors of this report build on existing research on healthcare access to describe NEMT challenges that ride-share-based NEMT (RB-NEMT) may address for those who need NEMT by identifying rider and ride types most appropriate for RB-NEMT. Population estimates for these profiles are drawn from three nationally representative sources.

The authors found that RB-NEMT could help reduce system strain and satisfy an unmet or poorly met need for on-demand cost-effective solutions within the NEMT ecosystem. Current RB-NEMT capabilities are most appropriate for individuals with medical conditions that result in the need to request rides and those who use Door2Door, Curb2Curb, or Area2Area (e.g., bus stop–to–bus stop) services. RB-NEMT is also most appropriate for in-patient and outpatient discharges, on-demand rides, requests for rides in which the scheduled mode failed to arrive, and rides requiring minimal assistance or monitoring.

The authors recommend more research on (1) RB-NEMT outcomes and the efficiency of programs targeting potential users and (2) the size, distribution, and projections for required transportation services, especially for vulnerable populations. The authors argue that policymakers should recognize that (1) transportation is a fundamental component of healthcare access and NEMT is a central pathway of ensuring access to vulnerable populations and (2) ride-share is a generally unique, economical, efficient, and otherwise unoccupied niche of the NEMT ecosystem, although the specific pathways to incorporating ride-share into NEMT will vary by State.

Subject Areas: Healthcare access; Healthcare technology; Medicaid; Medicare; Surface transportation; Transportation technology

Availability: Fraade-Blanar, L., Koo, T., and Whaley, C.M. (2021). *Going to the Doctor: Rideshare as Nonemergency Medical Transportation*. Research Report, RAND Corporation, Santa Monica, CA. https://www.rand.org/pubs/research_reports/RRA1019-1.html

Chapter 5. Policy and Mobility

5.1. Title: Developing Policy Thresholds for Objectively Measured Environmental Features to Support Active Travel

Author(s): Wali, B., Frank, L.D., Chapman, J.E., and Fox, E.H.

Abstract: A novel evidence-based methodology is presented for determining place-based thresholds of objectively measured built environment features' relationships with active travel. Using an innovative machine-learning based Generalized Additive Modeling framework, systematic heterogeneity fundamental to the development of well-justified and objective environmental thresholds is accounted for. The methodology is employed to model an individual's likelihood of transport walking as a function of environmental factors using California Household Travel Survey linked with comprehensive built environment data. The results reveal strong and complex non-linear dependencies of likelihood of transport walking on environmental features that cannot be quantified using standard threshold detection methods. Thresholds for key environmental features to enhance active travel vary significantly across different socioeconomic groups. Accounting for strong income-based differences in development of environmental benchmarks is emphasized. The thresholds can serve as a useful guiding tool for policymakers, planners, engineers, and public health officials to track existing environmental conditions and healthy behaviors.

Subject Areas: Walking for transport; Objectively measured built environment; Built-environment thresholds; Generalized additive models; Thin plate regression splines; Systematic heterogeneity

Availability: Wali, B., Frank, L.D., Chapman, J.E., and Fox, E.H. (2021). "Developing Policy Thresholds for Objectively Measured Environmental Features to Support Active Travel." *Transportation Research Part D: Transport and Environment*, *90*. https://doi.org/10.1016/j.trd.2020.102678

5.2. Title: Mortality Implications of Increased Active Mobility for A Proposed Regional Transportation Emission Cap-and-Invest Program

Author(s): Raifman, M., Lambert, K.F., Levy, J.I., and Kinney, P.L.

Abstract: The transportation sector is now the primary contributor to greenhouse gas emissions in the USA. The Transportation Climate Initiative (TCI), a partnership of 12 States and the District of Columbia currently under development, would implement a cap-and-invest program to reduce transportation sector emissions across the Northeast and Mid-Atlantic region, including substantial investment in cycling and pedestrian infrastructure. Using outputs from an investment scenario model and the World Health Organization Health Economic Assessment Tool methodology, we estimate the mortality implications of increased active mobility and their monetized value for three different investment allocation scenarios considered by TCI policymakers. We conduct these analyses for all 378 counties in the TCI region. We find that even for the scenario with the smallest investment in active mobility, when it is fully implemented, TCI would result in hundreds of fewer deaths per year across the region, with monetized benefits in the billions of dollars annually. Under all scenarios considered, the monetized benefits from deaths avoided substantially exceed the direct infrastructure costs of investment. We conclude that investing proceeds in active mobility infrastructure is a cost-effective way of reducing mortality, especially in urban areas, providing a strong motivation for investment in modernization of the transportation system and further evidence of the health co-benefits of climate action.

Subject Areas: Physical activity; Transportation; Active transport; Bicycling; Walking; Mortality

Availability: Raifman, M., Lambert, K.F., Levy, J.I., and Kinney, P.L. (2021). "Mortality Implications of Increased Active Mobility for A Proposed Regional Transportation Emission Cap-and-Invest Program." *Journal of Urban Health*. https://doi.org/10.1007/s11524-020-00510-1

5.3. Title: When Might Lower-Income Drivers Benefit from Electric Vehicles? Quantifying the Economic Equity Implications of Electric Vehicle Adoption

Author(s): Bauer, G., Hsu, C., and Lutsey, N.

Abstract: This analysis finds that cost reductions in new electric vehicles (EVs) will lead to decreased used EV prices and cost parity with used gasoline vehicles for low-income households in the 2025–2030 time period.

Higher rates of depreciation for first owners of EVs will lead to larger benefits for lower-income second owners. By 2029, EVs will reach upfront price parity with the average vehicle purchased by a low-income household, less than two years after the average vehicle purchased by a high-income household. Currently, once accounting for fuel and other operating savings, some households in all income groups could save money by replacing at least one vehicle with an EV; this increases to 45% of households by 2025 and 95% of households by 2030.

Savings from EVs relative to income are significantly higher for low-income households, non-White households, and households in areas with higher levels of pollution. For car owners in the lowest-income quintile, savings from switching to EVs amount to $1,000 per household annually, or 7% of income, by 2030.

Even with widespread EV affordability, additional policy action would ensure equal access to EVs. Previous studies have shown that low-income EV buyers are more responsive to incentives, and that purchase incentives have become more important over time. Combustion vehicle phase-out regulations can force manufacturers to serve diverse markets, and broader access to financing for EVs will be critical for low-income households. In addition, policymakers will need to ensure targeted deployment of home and public charging deployment to support vulnerable communities and renters with less charging access.

Subject Areas: Electric vehicles; Used vehicle market; Equity impact; Cost projection; Transportation planning

Availability: Bauer, G., Hsu, C., and Lutsey, N. (2021). *When Might Lower-Income Drivers Benefit from Electric Vehicles? Quantifying the Economic Equity Implications of Electric Vehicle Adoption*. Working Paper 2021-06, International Council on Clean Transportation, Washington, DC. http://www.indiaenvironmentportal.org.in/files/file/EV%20equity.pdf

5.4. Title: Home-deliveries Before-during COVID-19 Lockdown: Accessibility, Environmental Justice, Equity, and Policy Implications

Author(s): Figliozzi, M. and Unnikrishnan, A.

Abstract: During the COVID-19 lockdowns, home deliveries have changed from being a desirable luxury or comfortable solution to a health-supporting and essential service for many COVID-19 at-risk populations. However, not all households are equal in terms of access to home deliveries. The onset of COVID-19 has brought to light access inequalities that preceded the pandemic and that the COVID-19 lockdown has exacerbated and made visible. The concept of home-based accessibility (HBA) is introduced, and novel research questions are addressed: (i) What type of households had zero home deliveries before COVID-19 lockdown? (ii) How the COVID-19 lockdown affected the type of households that receive home deliveries? and (iii) What are the implications of no access to home delivery services in terms of equity and environmental justice? To answer the first two questions, exploratory and confirmatory models with latent variables are estimated utilizing data collected from an online survey representative of the population in the Portland metropolitan region. Policy and environmental equity implications are discussed using the concept of home-based accessibility (HBA). The results indicate that traditionally underserved populations are less likely to benefit from home-based delivery services and that COVID-19 has worsened home delivery inequalities for underserved populations.

Subject Areas: Home deliveries; E-commerce; COVID-19; Equity; Accessibility; Environmental justice

Availability: Figliozzi, M. and Unnikrishnan, A. (2021). "Home-deliveries Before-during COVID-19 Lockdown: Accessibility, Environmental Justice, Equity, and Policy Implications." *Transportation Research Part D: Transport and Environment*, *93*. https://doi.org/10.1016/j.trd.2021.102760

5.5. Title: Zero-Based Transportation Policy: Recommendations for 2021 Transportation Reauthorization

Author(s): O'Toole, R.

Abstract: The devastating effects of the COVID-19 pandemic and associated lockdowns on various forms of transportation create an opportunity to review the successes and failures of federal transport policies before Congress reauthorizes federal highway and transit programs. After a one-year extension approved by Congress in September 2020, authorization for these programs will expire on September 30, 2021.

The COVID-19 pandemic highlights the need for a resilient transportation system, and motor vehicles and roads have proven far more resilient than any form of mass transportation. Unlike mass transportation, which requires continuing inputs of labor and funds, roads are available when they are needed even if a recession or other economic shock reduces revenues to highway agencies. Roads have also proven to be the best way to evacuate people and deliver rescue and recovery services in the event of natural disasters. "Road diets" and other programs that reduce roadway capacities are reducing the resiliency of our transportation system.

After elaborating on the data and arguments above, this paper concludes with specific recommendations for the 2021 surface transportation reauthorization.

Subject Areas: COVID-19; Transport policies; Transportation system; Energy

Availability: O'Toole, R. (2021). *Zero-Based Transportation Policy: Recommendations for 2021 Transportation Reauthorization*. Policy Analysis, Cato Institute, Washington, DC. https://www.cato.org/policy-analysis/zero-based-transportation-policy-recommendations-2021-transportation

5.6. Title: The Impact of the COVID-19 Pandemic on People's Mobility: A Longitudinal Study of the U.S. from March to September of 2020

Author(s): Kim, J. and Kwan, M.

Abstract: This paper examines changes in people's mobility over a 7-month period (from March 1 to September 30, 2020) during the COVID-19 pandemic in the United States using longitudinal models and county-level mobility data obtained from people's anonymized mobile phone signals. It differentiates two distinct waves of the study period: Wave 1 (March–June) and Wave 2 (June–September). It also analyzes the relationships of these mobility changes with various social, spatial, policy, and political factors. The results indicate that mobility changes in Wave 1 have a V-shaped trend: people's mobility first declined at the early stage of the COVID-19 pandemic (March–April) but quickly recovered to the pre-pandemic mobility levels from April to June. The rates of mobility changes during this period are significantly associated with most of our key variables, including political partisanship, poverty level, and the strictness of mobility restriction policies. For Wave 2, there was very little mobility decline despite the existence of mobility restriction policies and the COVID-19 pandemic becoming more severe. Our findings suggest that restricting people's mobility to control the pandemic may be effective only for a short period, especially in liberal democratic societies. Further, since poor people (who are mostly essential workers) kept traveling during the pandemic, health authorities should pay special attention to these people by implementing policies to mitigate their high COVID-19 exposure risk.

Subject Areas: COVID-19; Human mobility; Longitudinal data analysis; Mobile phone data; Pandemic; Travel behavior

Availability: Kim, J. and Kwan, M. (2021). "The Impact of the COVID-19 Pandemic on People's Mobility: A Longitudinal Study of the U.S. from March to September of 2020." *Journal of Transport Geography*, *93*. https://doi.org/10.1016/j.jtrangeo.2021.103039

5.7. Title: The Effects of Driver Licensing Laws on Immigrant Travel

Author(s): Barajas, J.M.

Abstract: Car use is critical to improving access to opportunities, especially for low-wage immigrants whose jobs are dispersed and when transit service is minimal. But many States have restricted the ability of undocumented immigrants to obtain drivers licenses, making it potentially difficult for them to improve their economic standing. The effects of these laws have been tested for their association with traffic safety but not on mode choice itself. Using the two most recent versions of the National Household Travel Survey, I fit a series of difference-in-difference models to estimate the effect of permissive immigrant driver licensing on travel outcomes. Permissive licensing increased the rate of giving rides by about 13% and increased the rate of getting a ride by about 6.5%, but changes to driving alone were insignificant. Results suggest permissive licensing has beneficial accessibility impacts for all immigrants in addition to the positive safety and economic externalities documented elsewhere.

Subject Areas: Travel behavior; Transportation equity; Immigrants; Driver licensing; Carpooling; Difference-in-difference estimation

Availability: Barajas, J.M. (2021). "The Effects of Driver Licensing Laws on Immigrant Travel." *Transport Policy*, *105*, pp. 22–34. https://doi.org/10.1016/j.tranpol.2021.02.010

5.8. Title: Transportation Economics Simplified: An Introduction to Cost and Benefit Analysis for Transport Planning and Policy Evaluation

Author(s): Litman, T.A.

Abstract: Transportation is an important but costly activity. It is important to consider all significant impacts in transportation policy and planning analysis. This report provides an introduction to basic transportation evaluation concepts and methods, with examples of their application. It estimates 10 costs (subsidies, vehicle ownership and operation, road and parking facilities, traffic congestion, barrier effect, crashes, pollution, and resource externalities) for 6 modes and discusses other impacts including travel time, social equity, health, and sprawl-related costs. This analysis indicates that automobile travel is more costly than other modes when measured per travel-mile, and since motorists tend to travel more annual miles than people who rely on other modes, their annual costs are many times larger. Many of these costs are external, making them inefficient and unfair. This results in economically inefficient mobility, vehicle travel in which total costs exceed total benefits. Given better mobility and accessibility options, and more efficient incentives, many travelers would drive less, rely more on other modes, choose to live in more accessible and multimodal neighborhoods, and be better off overall as a result.

Subject Areas: Transportation policy; Planning analysis; Basic transportation evaluation; Cost; Mobility; Accessibility

Availability: Litman, T.A. (2021). *Transportation Economics Simplified: An Introduction to Cost and Benefit Analysis for Transport Planning and Policy Evaluation*. Victoria Transport Policy Institute, Victoria, British Columbia, Canada. https://www.vtpi.org/tes.pdf

5.9. Title: Access to Transportation, Residential Segregation, and Economic Opportunity

Author(s): Yilmaz, K. and Yesilirmak, M.

Abstract: The Housing Choice Voucher Program assists low-income families to afford decent housing and provide them with better economic opportunities. There is growing evidence that public transportation plays an important role in shaping the residential location choices of low-income households. However, transportation has not been a major focus of the research related to housing voucher programs. We develop a general equilibrium model of a city with multiple districts, decentralized employment, multiple commuting modes, and locally financed education. We compare housing vouchers with transportation vouchers with respect to poverty deconcentration, educational quality in each district, unskilled employment in the suburbs, and welfare.

Subject Areas: Affordable housing; Transportation access; Residential segregation; Hybrid tiebout model

Availability: Yilmaz, K. and Yesilirmak, M. (2021). *Access to Transportation, Residential Segregation, and Economic Opportunity*. Global Research Unit Working Paper Series, Department of Economics and Finance, City University of Hong Kong, Kowloon, Hong Kong. https://ideas.repec.org/p/cth/wpaper/gru_2021_012.html

5.10. Title: The Road Less Traveled: Economic Analysis of Roads and Highways

Author(s): Bock, M.C.

Abstract: Roads are an integral component of civilization, connecting people, markets, and ideas. In different settings and geographies, roads can take on many different purposes. In rural, more isolated areas, roads can serve as a cost-saving benefit and can be used as tools to increase accessibility. In urban, more congested areas, roads can be seen as an externality-producing hindrance. Naturally, given this view, the overall analysis of roads should reflect these different settings. To date, however, the study of roads in the economics literature has surprisingly large pitfalls, notably in terms of topics of study and methodologies used.

Spending on roads is a non-negligible portion of government budgets across the country, making this topic relevant to study to make informed policy suggestions. This dissertation research, titled *The Road Less Traveled: Economic Analysis of Roads and Highways*, analyzes one overarching theme using three different perspectives: urban, political economy, and regional.

Chapter 1 examines the impact of high occupancy vehicle (HOV) lanes on commuting times. The effects of HOV lanes studied from a causal perspective have been minimal in the economics literature. Knowing the impacts of these types of infrastructure projects is beneficial in terms of public policy and resource allocation. Using an instrumental variable (IV) approach to overcome the endogeneity problems associated with HOV lane location selection, this study aims to uncover the impacts of HOV lanes on commuters' time spent going to and coming home from work in California. Making use of the 2017 National Household Travel Survey, and after data pre-processing through coarsened exact matching (CEM), this paper finds that both having HOV lanes in workplace counties and living closer to HOV lanes cause increased commute times to and from work for commuters, lending credence to earlier works on road construction and traffic outcomes citing induced demand from increased road construction (Duranton & Turner, 2011).

Chapter 2 studies the impact of mayoral election cycles impact the timing and location of road maintenance. Political incentives affect infrastructure construction, but how incentives affect infrastructure upkeep, like road maintenance, is sparsely documented. Previous empirical results find different conclusions than theoretical evidence about road maintenance perceptions. Political alignment and local election cycles are leveraged using difference-in-differences to investigate if political incentives cause shifts in road maintenance. Robust results identify political distortions in invasive road maintenance timing. Local election cycles, which are widespread and frequent, shift road maintenance timing. Conservative calculations suggest local US elections cost at least $185.5 million from 1960–2020, equivalent to 4 million meters of maintenance or maintaining all local Pittsburgh roads ≈ 1.45 times.

Chapter 3 looks at the impact of rural roads on mortality outcomes in the Appalachian region. Specific attention to federally funded rural roads and highways is sparse given implicit endogeneity concerns about road placement decisions for the sake of rural development and market exposure.

This study examines the impact of the Appalachian Development Highway System (ADHS), one of the largest and most expensive Federal infrastructure projects in the United States, on mortality outcomes in the region. IV results suggest ADHS construction significantly reduced travel-time-sensitive mortality rates, such as heart disease and hypertension, in earlier decades of the sample. IV results also suggest the ADHS may be associated with increased mortality rates, notably accidents, in later decades of the sample. The additional cost caused by the ADHS in terms of mortality is estimated to be $24.2 billion dollars over the length of the sample. However, benefits such as improved travel times, employment, and income increases outweigh these costs.

Subject Areas: Roads; Transportation; Commuting; Road maintenance; Mortality

Availability: Bock, M.C. (2021). *The Road Less Traveled: Economic Analysis of Roads and Highways*. Doctoral Dissertation, West Virginia University, Morgantown, WV. https://researchrepository.wvu.edu/etd/8128

5.11. Title: Accessibility: From Ivory Tower to Practice

Author(s): Sundquist, E. and McCahill, C.

Abstract: Quantifiable measures of accessibility allow transportation professionals to account for many factors that affect destination access—traffic congestion; transit service; proximity of origins and destinations; and accommodations for people who walk, bike, or roll. They make it possible to measure how well people can get where they need to go. Unfortunately, most practitioners are not exposed to those measures or the methods behind them. Understandably, they tend to base decisions on longstanding, mode-specific measures of speed and level of service (LOS), which imperfectly capture accessibility. The authors have created new practitioner guide, which aims to bridge the gap between research and practice. This article focuses on that guide and how it can be used to meet transportation accessibility goals. "Measuring Accessibility" was released in January of 2021 by the State Smart Transportation Initiative (SSTI) at the University of Wisconsin-Madison.

Subject Areas: Accessibility; Bicycling; Driving; Measurement; Metrics; Quantitative assessment; Mobility; Public transit; Transportation planning; Walking

Availability: Sundquist, E. and McCahill, C. (2021). "Accessibility: From Ivory Tower to Practice." *ITE Journal*, *91*(5), pp. 44–49. https://www.nxtbook.com/ygsreprints/ITE/ite-journal-may-2021/index.php#/p/44

5.12. Title: Critics Call Foul Over Transportation Bill Funding; 'Violates Intent' of Both TABOR, Prop 117

Author(s): Weiser, S.

Abstract: Blog.

Subject Areas: Air pollution; Colorado Department of Transportation; Enterprises; Fees; Public transit; Transportation bill

Availability: Weiser, S. (2021). "Critics Call Foul Over Transportation Bill Funding; 'Violates Intent' of Both TABOR, Prop 117." *Complete Colorado – Page Two*. https://pagetwo.completecolorado.com/2021/05/24/critics-call-foul-over-transportation-bill-violates-intent-tabor-prop-117/

5.13. Title: More Access and Less Traffic: Transportation Demand Management Recommendations for Minnesota Municipalities and Employers

Author(s): Zeerak, R., Fonseca, C., and Zhao, J.

Abstract: Most Minnesota cities have an interest in attracting more people to visit, work, and live, all of which would contribute to their local economy. Many Minnesota cities also experience problems from vehicle traffic: congestion, pollution, and associated costs.

How can localities in Minnesota welcome people while limiting the impacts of vehicle traffic? One answer is transportation demand management (TDM). Car traffic brings cost and benefits; therefore, cities and employers may want to manage traffic in the most cost-effective way.

The goal of this research is to support Minnesota localities as they work to:

- Support travel by people as they move around to get to their places of employment, education, accessing other services, and to see their families.
- Support travel by people as they fully participate in the life of their communities.
- Balance the benefits of vehicle traffic with its costs.

People across the country have benefitted from thoughtful TDM strategies. TDM can benefit:

- Individuals by expanding transportation options, saving money, and improving health and well-being.
- Employers by reducing overhead costs, reducing costs for office space, and lower parking needs and by improving employee recruitment and retention.
- Cities by reducing congestion, improving land use, improving air quality, reducing carbon emissions, and improving the quality of life of the whole community.

This paper:

- Describes municipal-based and employer-based TDM best practices that reduce traffic and reduce emissions.
- Recommends best practices for municipalities and employers in Minnesota.

Subject Areas: Vehicle traffic; Transportation demand management; Traffic and emission reduction; Cities and employers

Availability: Zeerak, R., Fonseca, C., and Zhao, J. (2021). *More Access and Less Traffic: Transportation Demand Management Recommendations for Minnesota Municipalities and Employers*. University of Minnesota, Minneapolis, MN. https://static1.squarespace.com/static/5d8a78b7362c255660b38364/t/609d8b1ea7e14047043d238c/1620937502925/TCSMCtransportationdemandmanagement2021.pdf

5.14. Title: Comparing Twitter and LODES Data for Detecting Commuter Mobility Patterns

Author(s): Albrecht, J., Petutschnig, A., Ramasubramanian, L., Resch, B., and Wright, A.

Abstract: Local and regional planners struggle to keep up with rapid changes in mobility patterns. This exploratory research is framed with the overarching goal of asking if and how geo-social network data (GSND), in this case, Twitter data, can be used to understand and explain commuting and non-commuting travel patterns.

The research project set out to determine whether GSND may be used to augment U.S. Census LODES data beyond commuting trips and whether it may serve as a short-term substitute for commuting trips. It turns out that the reverse is true and the common practice of employing LODES data to extrapolate to overall traffic demand is indeed justified. This means that expensive and rarely comprehensive surveys are now only needed to capture trip purposes. Regardless of trip purpose (e.g., shopping, regular recreational activities, dropping kids at school), the LODES data is an excellent predictor of overall road segment loads.

Subject Areas: Planning; Activities leading to information generation; Communication; Interdisciplinary studies; Methodology

Availability: Albrecht, J., Petutschnig, A., Ramasubramanian, L., Resch, B., and Wright, A. (2021). "Comparing Twitter and LODES Data for Detecting Commuter Mobility Patterns." *Mineta Transportation Institute Publications*.
https://scholarworks.sjsu.edu/cgi/viewcontent.cgi?article=1355&context=mti_publications

5.15. Title: Maine Transportation & Equity

Author(s): Rubin, J., Ballingall, K., and Brown, E.

Abstract: Presentation.

Subject Areas: Emission; Household travel; Fuel efficiency; Equity; Accessibility; Transition to electric vehicles; Rural transit

Availability: Rubin, J., Ballingall, K., and Brown, E. (2021). "Maine Transportation & Equity." *Transportation*, *4*. https://digitalcommons.library.umaine.edu/mcspc_transport/4

5.16. Title: Transportation, Quality of Life, and Older Adults

Author(s): Wachs, M., Blumenberg, E.A., Schouten, A., and King, H.R.

Abstract: Driving rates decline with age as vision, health, and cognitive ability cause some older adults to give up driving. Many older adults first gradually limit their driving as they age and later cease driving. Using data from the Health and Retirement Study (HRS), which surveys 22,000 older Americans every 2 years, we modeled the extent to which older drivers limit and stop driving. The data are longitudinal, allowing analysis of changes in driving and residential location as well as cohort effects that could not be studied using standard, cross-sectional survey data that only allow comparisons of different people at one point in time. The analysis shows that decisions to limit and eventually stop driving vary in statistically significant ways with sex, age, and health conditions. These relationships also differ by birth cohort. More recent cohorts are less likely to stop and limit driving than older ones. To analyze the relationship between residential location and driving behavior, we linked the HRS data to census-tract level data from the U.S. Census and a categorization of community types. We found that residential density and other urban built environment features are associated with changes in driving and vehicle ownership. HRS survey participants showed a greater propensity to reduce or give up driving if they resided in denser, more diverse, transit-oriented neighborhoods. People who prefer non-automotive modes of transportation may have been more likely than others to self-select into walkable and transit-rich areas. The findings should inform California's strategic planning for aging and its community development policies. In addition to informing planning for the next generation of older Californians, this study demonstrated the utility of longitudinal information and models for the understanding of older populations and their travel.

Subject Areas: California; Travel behavior; Transportation planning

Availability: Wachs, M., Blumenberg, E.A., Schouten, A., and King, H.R. (2021). *Transportation, Quality of Life, and Older Adults*. Institute of Transportation Studies, University of California, Los Angeles, CA. https://escholarship.org/content/qt1n15k00n/qt1n15k00n.pdf

5.17. Title: New York Adirondack High Peaks Region Shuttle Feasibility Study

Author(s): Lian, F.S., Richardson, H., Englin, E., and Ireland, L.

Abstract: The New York State Adirondack High Peaks Region Shuttle Feasibility Study establishes the current road, parking, congestion, and travel pattern trends within the region. Also documented is the stakeholder outreach process to gather feedback on visitation trends, issues, and a shuttle bus service in general. The report then identifies popular recreation destinations, those that are suitable as shuttle bus pick-up/drop-off locations (stops), and delves into potential future scenarios for a shuttle bus service. Initially, the study aimed to present three concept scenarios together, representing different functional elements or levels of service. Due to circumstances that arose through the course of the project related to the ongoing COVID-19 pandemic, this report presents a potential pilot core service guided by what would be possible given present conditions, existing vehicles, and a specified amount of available funds ($800k). A subsequent deliverable will explore two potential future scenarios that provide different functional benefits that may serve the interests of recreational users exclusively, or may provide benefits to other stakeholders. The pilot service scenario detailed in this report includes cost estimates based on both hourly and mileage rates from similar services, discusses the benefits and considerations of servicing the route with a split- or continuous-service, and includes recommendations for complementary activities to support the piloting of a new shuttle service.

Subject Areas: Shuttle transportation; Shuttle system; Feasibility study; Transportation study; Recreational access; Stakeholder engagement; Traffic analysis; Congestion management; Fleet electrification; Battery-electric buses

Availability: Lian, F.S., Richardson, H., Englin, E., and Ireland, L. (2021). *New York Adirondack High Peaks Region Shuttle Feasibility Study*. Volpe National Transportation Systems Center, Cambridge, MA. https://rosap.ntl.bts.gov/view/dot/55788

5.18. Title: 2021 Urban Mobility Report: Appendix B—Change in Vehicle Occupancy Used in Mobility Monitoring Efforts

Author(s): Lasley, P.

Abstract: This appendix reflects an overhaul of the average vehicle occupancy methodology that was incorporated into the 2019 Urban Mobility Report. The occupancy values described in this methodology were also used in the 2021 Urban Mobility Report. Even though it could be hypothesized that some occupancy levels during peak periods were likely lower (due to reduced carpooling with non-related travelers) or possibly even higher during the midday, there is not a consistent, updated occupancy data source for conditions during the pandemic; therefore, the authors used the pre-pandemic occupancy approach described in this appendix. Keeping the vehicle occupancy consistent also allowed for a comparison from 2019 to 2020 with "all else equal." Virtually all measures of travel delay incorporate some form of average vehicle occupancy estimate—the number of people in a vehicle. TTI's researchers reexamined and updated this factor to incorporate changes since the 2008/2009 economic recession. Researchers estimate the average vehicle occupancy increased from 1.25 persons per vehicle to 1.50 persons per vehicle, based on data from the National Household Travel Surveys. This change will be reflected in TTI's congestion and mobility statistics.

Subject Areas: Average vehicle occupancy; Peak hours; Trip purpose; Congestion; Mobility

Availability: Lasley, P. (2021). *2021 Urban Mobility Report: Appendix B—Change in Vehicle Occupancy Used in Mobility Monitoring Efforts*. Texas A&M Transportation Institute, Bryan, TX. https://static.tti.tamu.edu/tti.tamu.edu/documents/mobility-report-2021-appx-b.pdf

5.19. Title: Dynamic Activity Chain Pattern Estimation Under Mobility Demand Changes During COVID-19

Author(s): Liu, Y., Tong, L.C., Zhu, X., and Du, W.

Abstract: During the coronavirus disease 2019 pandemic, the activity engagement and travel behavior of city residents have been impacted by government restrictions, such as temporary city-wide lockdowns, the closure of public areas, and public transport suspension. Based on multiple heterogeneous data sources, which include aggregated mobility change reports and household survey data, this paper proposes a machine learning approach for dynamic activity chain pattern estimation with improved interpretability for examining behavioral pattern adjustments. Based on historical household survey samples, we first establish a computational graph-based discrete choice model to estimate the baseline travel tour parameters before the pandemic. To further capture structural deviations of activity chain patterns from day-by-day time series, we define the activity-oriented deviation parameters within an interpretable utility-based nested logit model framework, which are further estimated through a constrained optimization problem. By incorporating the long short-term memory method as the explainable module to capture the complex periodic and trend information before and after interventions, we predict day-to-day activity chain patterns with more accuracy. The performance of our model is examined based on publicly available datasets, such as the 2017 National Household Travel Survey in the United States and the Google Global Mobility Dataset throughout the epidemic period. Our model could shed more light on transportation planning, policy adaptation, and management decisions during the pandemic and post-pandemic phases.

Subject Areas: Travel behavior; Activity chain; Discrete choice model; Machine learning; Pandemic

Availability: Liu, Y., Tong, L.C., Zhu, X., and Du, W. (2021). "Dynamic Activity Chain Pattern Estimation Under Mobility Demand Changes During COVID-19." *Transportation Research Part C: Emerging Technologies*, *131*. https://doi.org/10.1016/j.trc.2021.103361

5.20. Title: Case Studies: Best Practices for Transportation Agency Processes

Author(s): TransitCenter.

Abstract: Decisions about where to run transit, how often, and for what price directly affect the distribution of benefits from transit and determine who gains access to opportunity. These external outcomes are set in motion by internal processes—public outreach and data analysis, workforce development, budgeting, leadership practices—that set the tone for agency culture. Equity must be infused into these internal processes to generate fair outcomes for riders. But equitable internal processes are rare and not yet industry practice (perhaps because these areas are less visible to the public and therefore less subject to scrutiny).

We identified practical examples of internal processes that transit agencies and their stakeholders have adopted to achieve better outcomes for marginalized groups of people. We sought to learn how these examples were implemented (institutional frameworks that sanctioned them, resources necessary to support them) and if they successfully and equitably accomplished their operational purposes. We also questioned whether challenges remain within the transit industry that have yet to be addressed with practical, equitable solutions.

The more than two dozen case studies in this section arose from our industry scan and suggestions from our advisory committee. We conducted interviews with around 40 experts between June and September 2020. The case-study selections fall into three categories: best practices to advance internal and external equity at transit agencies and departments of transportation, reviews of emerging tools that feature equity metrics, and lessons from other public service–oriented fields to bolster equity.

Subject Areas: Marginalized population groups; Internal and external equity; Transit agencies; Case study; Best practices

Availability: TransitCenter. (2021). *Case Studies: Best Practices for Transportation Agency Processes*. Equity in Practice: A Guidebook for Transit Agencies, pp. 45–60. TransitCenter, New York, NY. https://transitcenter.org/wp-content/uploads/2021/09/Equity-in-Practice_web.pdf

5.21. Title: UK Legislation Will Require All New Homes to Have EV Chargepoints

Author(s): Fortuna, C.

Abstract: Blog.

Subject Areas: Electric vehicle legislation; Electric vehicle charging installations; Home construction; Range anxiety; Electric vehicle sales; Greenhouse gas emissions reduction

Availability: Fortuna, C. (2021). "UK Legislation Will Require All New Homes to Have EV Chargepoints." *CleanTechnica*. https://cleantechnica.com/2021/09/11/uk-legislation-will-require-all-new-homes-to-have-ev-chargepoints/

5.22. Title: Political Partisanship and Transportation Reform

Author(s): Klein, N.J., Ralph, K., Thigpen, C., and Brown, A.

Abstract: Problem, research strategy, and findings: Support for transportation policies and investments is increasingly shaped by partisan ideals. Less well documented is the role of partisanship relative to potential mediating factors such as transportation-related values, beliefs about the possibility of change, self-interest, and knowledge. We surveyed a representative sample of 600 U.S. adults about these factors, their political ideology, and their willingness to change the automobile-oriented transportation status quo. We found considerable support for change but also deep partisan divides. In exploring the pathways between partisanship and policy preferences, we found that values and beliefs about change are both deeply partisan and closely associated with policy preferences. By contrast, the results were mixed for self-interest and transportation-related knowledge. Ultimately, we found that these four pathways explain much, but not all, of the partisanship in transportation policy preferences. Very conservative respondents opposed reform efforts above and beyond what we would expect from their values, beliefs, self-interest, and knowledge, indicating continuing salience of partisanship.

Takeaway for practice: Our results suggest that transportation reforms enjoy broad public support in urban areas with moderate and left-leaning populaces but may struggle to win approval at the regional, State, or Federal level due to partisan geographic sorting. Some planners, policymakers, and advocates may choose to embrace partisanship, but doing so may exacerbate tensions and hamper progress. Others may prefer to tackle the pathways between partisanship and preferences without deepening partisan divides. For instance, practitioners may seek to increase support for reform by tackling widespread misunderstandings about induced demand or by installing pilot projects to help the public understand that it is possible to quickly and inexpensively change infrastructure and travel.

Subject Areas: Partisanship; Political ideology; Self-interest; Transportation policy; Values

Availability: Klein, N.J., Ralph, K., Thigpen, C., and Brown, A. (2021). "Political Partisanship and Transportation Reform." *Journal of the American Planning Association*. https://doi.org/10.1080/01944363.2021.1965495

5.23. Title: A Physiological Model of Human Mobility: A Global Study

Author(s): Kölbl, R. and Kozek, M.

Abstract: The movement of people has led to several challenges in terms of traffic congestion, energy consumption, emissions, and climate change. Human mobility modeling is currently described mainly through socioeconomic variables, such as travel time, travel costs, income, and car ownership. The overall objective of this paper is to relate mobility behavior based on measurable entities of travel time and distance and the entities of speed. A simple underlying mechanism of human mobility is presented based on the human energy expended. The energy is related first to the average values of travel modes. Explicit formulas for the distribution within each travel mode are developed, and the concept is also shown to apply to multi-modal mobility. The approach is described in its most basic and fundamental form but opens up perspectives for new applications and analyses approaches to transport modeling, planning and appraisals. The approach shows that travel time and distance are consistently inversely proportional and limited by the physiological power consumption. The basic hypothesis and the related verifications is shown on all modal combinations of daily mobility with a median R2 of around 0.8. The approach is validated using national travel surveys of Germany, Switzerland, the United Kingdom, and the United States, spanning over five decades to 2018.

Subject Areas: Complex networks; Operational research; Science; Technology and society

Availability: Kölbl, R. and Kozek, M. (2021). "A Physiological Model of Human Mobility: A Global Study." *Humanities and Social Sciences Communications, 8*. https://doi.org/10.1057/s41599-021-00931-6

5.24. Title: The Benefits and Costs of Automotive Regulations for Low-Income Americans

Author(s): Conrad, K. and Graham, J.D.

Abstract: Benefit-cost analyses of regulations address Kaldor-Hicks efficiency but rarely investigate the distribution of benefits and costs as experienced by low-income households. In order to fill this gap, this article assembles the available evidence to determine how regulations of the automobile industry may impact the well-being of low-income Americans. The scope of the investigation includes air pollution, safety, and fuel-economy regulations. We find that performing benefit-cost analyses for low-income households is more challenging than commonly understood. Given the difficulties in completing distributional analysis with available information, the authors offer practical suggestions on how to change the Federal data systems and the rule-making process to ensure that information is collected about how future automobile regulations impact the well-being of the poor.

Subject Areas: Automobile; Transportation; Regulation; Low-Income; Benefit-cost

Availability: Conrad, K. and Graham, J.D. (2021). "The Benefits and Costs of Automotive Regulations for Low-Income Americans." *Journal of Benefit-Cost Analysis*, *12*(3), pp. 518–549. https://doi.org/10.1017/bca.2021.12

5.25. Title: Examining the Induced Demand Arguments Used to Discourage Freeway Expansion

Author(s): Polzin, S.

Abstract: Blog.

Subject Areas: Induced demand; Roadway capacity expansion; Trip pattern; Travel behavior

Availability: Polzin, S. (2021). "Examining the Induced Demand Arguments Used to Discourage Freeway Expansion." *Reason Foundation*. https://reason.org/commentary/examining-the-induced-demand-arguments-used-to-discourage-freeway-expansion/

5.26. Title: Micromobility, Macro Goals: Aligning Scooter Parking Policy with Broader City Objectives

Author(s): Brown, A.

Abstract: Dockless electric scooters challenge cities seeking to regulate them amidst broader goals such as universal access. Cities are particularly concerned with improper scooter parking, which can impede access by other travelers. Despite an important role that scooter parking plays in both regulations and public discourse, no comprehensive view of current scooter parking regulations exists, nor is it clear how regulations align with broader city objectives. This research asks: How have U.S. cities regulated scooter parking to date and what issues do parking regulations aim to address? Data from 37 U.S. cities show that while areas of widespread agreement exist—nearly all (95 percent) cities allow scooters to park in the furniture zone—a wide range in scooter parking requirements exists. About three-fourths of cities allow scooters to park at bike racks (78 percent) and against buildings (70 percent), while fewer than two-thirds allow scooters to park either on landscaping (62 percent) or against signs (60 percent). Even among cities with similar regulations, however, considerable nuance exists. Interviews with staff from six U.S. cities and existing research highlight motivations for scooter parking regulations. The regulations employed—and the high degree of variability across cities—yield implications for scooter parking policies, as well as scooters' role in advancing broader city objectives. Scooter parking regulations play an important role in access, but cities should approach regulations as just one piece within a broader agenda of reclaiming streets for people and promoting mobility, sustainability, and access for all.

Subject Areas: E-scooter; Parking; Shared mobility; Micromobility

Availability: Brown, A. (2021). "Micromobility, Macro Goals: Aligning Scooter Parking Policy with Broader City Objectives." *Transportation Research Interdisciplinary Perspectives*, *12*. https://doi.org/10.1016/j.trip.2021.100508

5.27. Title: Mobility Analysis of Persons with Disabilities

Author(s): Počuč, M., Mirović, V., Simić, J.M., and Karamasa, C.

Abstract: This study presents the results of the research on travel behavior for persons with different types of disabilities. Persons with disabilities are a group of participants with specific traffic requirements often not included in traffic research and, consequently, adequate planning of urban transport. To obtain the data, a home interview was conducted on a representative sample. The paper presents the main results of the research and indicates the specificity of the requirements of this group of users. The results are compared with the results of the same research conducted for the development of the Smart Plan of Novi Sad and the results of similar research abroad. The main goal is to obtain a qualitative and quantitative database of the requirements of this group of users as a basis for creating sustainable urban mobility plans.

Subject Areas: Persons with disabilities; Urban mobility plans; Traffic requirements

Availability: Počuč, M., Mirović, V., Simić, J.M., and Karamasa, C. (2021). "Mobility Analysis of Persons with Disabilities." *Discrete Dynamics in Nature and Society*, *2021*. https://doi.org/10.1155/2021/7430340

5.28. Title: The Promise of Excess Mobility Analysis: Measuring Episodic-Mobility with Geotagged Social Media Data

Author(s): Huang, X., Martin, Y., Wang, S., Zhang, M., Gong, X., Ge, Y., and Li, Z.

Abstract: Human mobility studies have become increasingly important and diverse in the past decade with the support of social media big data that enable human mobility to be measured in a harmonized and rapid manner. However, what is less explored in the current scholarship is episodic mobility as a special type of human mobility defined as the abnormal mobility triggered by episodic events excess to the normal range of mobility at large. Drawing on a large-scale systematic collection of 1.9 billion geotagged Twitter data from 2017 to 2020, this study contributes the first empirical study of episodic mobility by producing a daily Twitter census of visitors at the U.S. county level and proposing multiple statistical approaches to identify and quantify episodic mobility. It is followed by four case studies of episodic mobility in U.S. nationwide to showcase the great potential of Twitter data and our proposed method to detect episodic mobility subject to episodic events that occur both regularly and sporadically. This study provides new insights on episodic mobility in terms of its conceptual and methodological framework and empirical knowledge, which enriches the current mobility research paradigm.

Subject Areas: Twitter; Mobility analytics; Episodic events

Availability: Huang, X., Martin, Y., Wang, S., Zhang, M., Gong, X., Ge, Y., and Li, Z. (2021). "The Promise of Excess Mobility Analysis: Measuring Episodic-Mobility with Geotagged Social Media Data." *Cartography and Geographic Information Science*. https://www.researchgate.net/publication/356816239_The_promise_of_excess_mobility_analysis_measuring_episodic-mobility_with_geotagged_social_media_data

5.29. Title: Using Behavioral Data to Understand Shared Mobility Choices of Electric and Hybrid Vehicles

Author(s): Khattak, Z.H. and Khattak, A.J.

Abstract: Travel increases with urban sprawl leading to increased congestion and emissions. Advances in technologies provide new paradigms of transport, such as mobility as a service (MaaS), which is a novel concept providing users with mobility services including ride-hailing, car-sharing, and bike-sharing, based on their needs. The goal of transitioning to a low-carbon economy and recent development of alternative fuel vehicles (AFVs), including electric and hybrids, offers a promising mobility option for MaaS. However, the use decisions of these vehicles, specifically the shared use for their role in MaaS, is not well understood. Thus, the study is intended to provide information about travel choice of consumers and shared use of electric and hybrid vehicles for their role in MaaS. This paper utilizes more than 125,345 observations from the National Household Travel Survey 2017 to calibrate Heckman switching regime models for AFV travel choice decisions, accounting for self-selection and heterogeneity bias and Bayesian logistic regression with random parameter specifications to model the shared mobility decision of AFVs while accounting for unobserved heterogeneity and temporal/spatial variation. On average, 20 percent AFVs and 26 percent conventional vehicles are used for shared mobility in Uber and Lyft. Additional increases in ride-hailing involving AFVs are observed to substantially reduce net greenhouse gas emissions (GHGs). The use of AFVs for travel depends on factors such as personal interest in technologies. Furthermore, travelers using ride-hailing apps increase the likelihood of using electric and hybrid vehicles for shared mobility purposes. This research has implications for making policy decisions and placing incentives to promote the purchase and shared mobility use of AFVs for MaaS.

Subject Areas: Alternative fuel vehicles; Electric vehicles; Hybrids; Use decisions; Shared mobility; Mobility as a service; Green-house gas emissions

Availability: Khattak, Z.H. and Khattak, A.J. (2021). "Using Behavioral Data to Understand Shared Mobility Choices of Electric and Hybrid Vehicles." *International Journal of Sustainable Transportation*. https://doi.org/10.1080/15568318.2021.2004627

Chapter 6. Special Population Groups

6.1. Title: Individual and Neighborhood Characteristics Associated with Neighborhood Walking Among US Older Adults

Author(s): Besser, L.M., Chang, L., and Kluttz, J.

Abstract: Background: Neighborhood walking connotes physical activity and opportunities for social and cognitive engagement and improved mental health, factors previously associated with outcomes including mortality, cardiovascular disease, and dementia. Few studies have examined correlates of neighborhood-specific walking in older adults.

Purpose: We investigated the individual and neighborhood/regional correlates of neighborhood-based walking among U.S. older adults.

Methods: We obtained cross-sectional data on ≥ 65-year-olds from the population-based 2017 National Household Travel Survey (n = 73,523). Respondents completed diaries detailing trips during an assigned travel day. Adjusted logistic regression (using survey weights) tested associations between individual, neighborhood, and regional characteristics and ≥ 1 versus no neighborhood walk trips/day (from travel diary).

Results: Twelve percent had ≥ 1 neighborhood walk trip/day, and 54% of the neighborhood walkers achieved ≥ 30 min of walking/day. African Americans/Blacks (versus non-Hispanic whites) and working individuals (versus retired) had lower odds of neighborhood walking. Individuals without cars, bus/train users, and those with higher neighborhood housing density had greater odds of neighborhood walking. Utilitarian walking was less likely among African Americans/Blacks and Hispanics but more likely among Asians (versus non-Hispanic whites). Social/recreational neighborhood walking was more likely for those without cars, bus/train users, and those with greater neighborhood housing density.

Conclusion: Few U.S. older adults walked in their neighborhoods, suggesting a potentially fruitful target for health promotion efforts and community interventions to improve health and quality of life in older adults. Future work is needed to determine other neighborhood factors associated with greater neighborhood walking.

Subject Areas: Neighborhood; Walking; Physical activity; Older adults; Travel; Built environment

Availability: Besser, L.M., Chang, L., and Kluttz, J. (2021). "Individual and Neighborhood Characteristics Associated with Neighborhood Walking Among US Older Adults." *Preventive Medicine Reports*, *21*. https://doi.org/10.1016/j.pmedr.2020.101291

6.2. Title: Examining the Travel Behavior of Transport Disadvantaged Communities Using the 2017 National Household Travel Survey

Author(s): Esekhaigbe, E. and Bills, T.

Abstract: Understanding the differences of travel behavior of transport disadvantaged communities, relative to dominant travel patterns is important for supporting transportation investments. Transport disadvantaged groups, including low income, transit dependent, elderly, and disabled travelers tend to be constrained from participating in economic and other activities at their desired levels. The conditions associated with where they live, work, and play; the quality and cost of available modes of transportation, and distinct differences in travel preferences together construct the picture of how these groups are affected by system and policy related transportation investments. This paper is concerned with understanding the nature of travel behavior differences that exists for low income and 0-auto travelers. Using the 2017 National Household Travel Survey, we investigate travel behavior differences at the trip and tour (trip-chain) levels, with emphasis on household structures. Similar to previous studies, we find that disadvantaged groups tend to experience much shorter trip lengths. Further, we find that disadvantaged groups are more likely to engage is multiple tour patterns, although there are more likely to be simple tours with fewer stops per tour and fewer primary destinations.

Subject Areas: Transport disadvantage communities; Travel behavior; Trip chaining

Availability: Esekhaigbe, E. and Bills, T. (2021). *Examining the Travel Behavior of Transport Disadvantaged Communities Using the 2017 National Household Travel Survey*. Transportation Research Board 100th Annual Meeting—A Virtual Event, Washington, DC. https://annualmeeting.mytrb.org/OnlineProgram/Details/15683

6.3. Title: Examining the Mobility Needs and Challenges of Older Adults in Urban, Suburban, and Rural Environments

Author(s): Lee, M., Jin, X., and Tousif, F.

Abstract: A comprehensive examination of the 2017 National Household Travel Survey (NHTS) data was conducted to identify the mobility needs and challenges faced by older adults (i.e., age 65 and older) in urban, suburban, and rural environments. Data pertaining to older adults in the NHTS dataset were divided into three age groups: ages 65 to 74, 75 to 85, and 85 and older. Travel behavioral variables examined include average daily trip rate, average daily person miles traveled, trip purposes, and trip modes. Personal characteristics relevant to potential mobility challenges include age, gender, residential environment, income level, and ambulation assistive devices required for daily activities. Cross tabulation of these variables was used to elicit consistent patterns of inter-relationships among the variables to see how age and environment can affect mobility of older adults. Findings from the analysis confirm common conjectures that average number of daily person trips and daily person miles generally decreased with increasing age as well as decreasing urbanization of the environment. This general pattern also applied to those requiring ambulation assistance to a certain degree. Daily person trip rates also increased consistently as income levels increased, while older females tend to travel less frequent and shorter distance than their male counterparts. Privately owned vehicles (POVs) were the dominant transportation mode in the U.S with a significant lack of alternatives in the suburban and rural areas. We identified with evidence from the data that older adults in urban areas with low income are most vulnerable for adverse consequences of immobility.

Subject Areas: Older adults; Mobility; Daily travel behaviors; Geographical effects

Availability: Lee, M., Jin, X., and Tousif, F. (2021). *Examining the Mobility Needs and Challenges of Older Adults in Urban, Suburban, and Rural Environments*. Transportation Research Board 100th Annual Meeting—A Virtual Event, Washington, DC. https://annualmeeting.mytrb.org/OnlineProgram/Details/15879

6.4. Title: Heterogeneities in Older Adults Travel Times and Activity Durations: Analysis of the 2017 NHTS Personal Trip Data

Author(s): Yao, M., Mitra, S., and Ritchie, S.

Abstract: This paper analyzed travel diary data from the 2017 National Household Travel Survey to examine the heterogeneities in travel time and activity durations of U.S. older adults (aged 65+). To identify the heterogeneities resulting from activity sequences, older adults were partitioned into eight and seven clusters based on their weekdays and weekend activities, respectively. The study then estimated a hazard-based duration model with random effects for each distinct cluster to account for individual-level unobserved heterogeneities. Results of the model estimation showed that the hazard relationships between different types of activity-travel times and activity durations varied across clusters. The individual-level unobserved heterogeneities imposed substantially greater influence to travel times than activity durations of older population. Our results also found that female older adults, on average, traveled a shorter time while spent more time in activity participation than their male counterparts. Generally, older adults inclined to spend more time in activity engagement if their travel time were longer. The expectancy of travel times for urban older adults was significantly less than their rural counterparts; however, this urban/rural location did not have any substantial influence in activity durations. Transferability test results suggested that older adults' trip and activity durations on weekdays and weekends should be modeled separately regardless of similar activity sequences. This study will help transportation planners and policymakers understand the differences in travel time and activity duration of elderly mobility, thereby facilitating the development of policies targeting the special needs of different elderly groups to improve their transportation options.

Subject Areas: Travel time; Activity duration; Older adults; Hazard-based duration model; Transferability test

Availability: Yao, M., Mitra, S., and Ritchie, S. (2021). *Heterogeneities in Older Adults Travel Times and Activity Durations: Analysis of the 2017 NHTS Personal Trip Data*. Transportation Research Board 100th Annual Meeting—A Virtual Event, Washington, DC. https://annualmeeting.mytrb.org/OnlineProgram/Details/15879

6.5. Title: A Study on Geographic Education Cost Variations and School District Transportation Costs

Author(s): Taylor, L.L., Gronberg, T.J., Jansen, D.W., and Bartlett, C.S.

Abstract: In accordance with House Bill 3 (section 48.012), 86th Texas Legislature, 2019, the Texas Education Agency entered a Memorandum of Understanding and Agreement with Texas A&M University to conduct a study on geographic variations in known resource costs and costs of education due to factors beyond the control of school districts; and school district transportation costs.

This report presents the results of that study. The report was divided into four chapters. Chapter 1 of this report describes geographic differences in the cost of education that arise from uncontrollable differences in wages and salaries. Chapter 2 describes variations in the cost of education that arise from uncontrollable differences in cost factors other than wage levels. Chapter 3 describes differences in the cost of student transportation. Chapter 4 concludes the report by describing strategies for adjusting the Foundation School Program and Transportation Allotment protocols to address the cost differences identified in the previous chapters.

Subject Areas: Transportation costs; Geographic differences; Student transportation; Foundation School Program

Availability: Taylor, L.L., Gronberg, T.J., Jansen, D.W., and Bartlett, C.S. (2021). *A Study on Geographic Education Cost Variations and School District Transportation Costs*. Texas A&M University, College Station, TX. https://tea.texas.gov/sites/default/files/hb3-transportation-report.pdf

6.6. Title: Evaluating and Enhancing Driving Skills for Individuals with Intellectual Disabilities Through Simulator Training

Author(s): Randall, K.N., Ryan, J.B., Stierle, J.N., Walters, S.M., and Bridges, W.

Abstract: Research consistently demonstrates that attainment of a driver's license and access to a vehicle directly and favorably influence employment outcomes, enhance one's ability to capitalize on quality jobs, and expand one's access to community and independent opportunities. This study used a driving simulator to provide driving lessons to 12 young adults with intellectual disabilities (IDs). The purpose was to use a safe learning environment to screen candidates for those who showed the potential to obtain a driver's license. Instruction was provided using a set of interactive exercises focusing on controlling the vehicle via lane keeping, speed maintenance, and obstacle avoidance tasks. Results revealed that simulator training provided a safe learning environment to identify individuals demonstrating the potential to safely operate a motor vehicle. Participants demonstrated moderate to large gains in maintaining lane position, speed, braking response, and target detection. Implications and suggestions for future research are provided.

Subject Areas: Community mobility; Driving simulator; Driving skills; Intellectual disability

Availability: Randall, K.N., Ryan, J.B., Stierle, J.N., Walters, S.M., and Bridges, W. (2021). "Evaluating and Enhancing Driving Skills for Individuals with Intellectual Disabilities Through Simulator Training." *Focus on Autism and Other Developmental Disabilities*. https://doi.org/10.1177%2F1088357620985458

6.7. Title: Characterizing Zero-Vehicle Households: A Double-Hurdle Problem Perspective

Author(s): Tahlyan, D. and Mahmassani, H.S.

Abstract: This study presents a double-hurdle problem perspective to the household vehicle ownership modeling problem, where the authors argue that the traditionally used econometric models of vehicle ownership assume a single latent equation to express the household vehicle data generation process. However, these models ignore the fact that no vehicle owning state can correspond to two situations: (1) inability to own a vehicle due to financial constraints and (2) either voluntarily giving up owning a vehicle due to attitudinal reasons, even when there is an ability to own one or external constraints like medical condition that makes it impossible to own a vehicle. The authors propose to use a zero-inflated version of traditionally used ordered probit model to address this issue, which allows the zero states to be generated using two separate latent equations. Using 2017 National Household Travel Survey's California add-on dataset, the authors show that the proposed zero-inflated ordered probit model fits the data better than a traditionally estimated ordered probit model and can help us to gain insights about an understudied segment of the population.

Subject Areas: Automobile ownership; Decisionmaking; Households; Mathematical models; Probits

Availability: Tahlyan, D. and Mahmassani, H.S. (2021). *Characterizing Zero-Vehicle Households: A Double-Hurdle Problem Perspective*. The National Academies of Sciences, Engineering, and Medicine, Washington, DC. https://trid.trb.org/view/1759854

6.8. Title: Do Millennials Value Travel Time Differently Because of Productive Multitasking? A Revealed-Preference Study of Northern California Commuters

Author(s): Malokin, A., Circella, G., and Mokhtarian, P.L.

Abstract: Millennials, the demographic cohort born in the last two decades of the 20th century, are reported to adopt information and communication technologies (ICTs) in their everyday lives, including travel, to a greater extent than older generations. As ICT-driven travel-based multitasking influences travelers' experience and satisfaction in various ways, millennials are expected to be affected at a greater scale. Still, to our knowledge, no previous studies have specifically focused on the impact of travel multitasking on travel behavior and the value of travel time (VOTT) of young adults. To address this gap, we use an original dataset collected among Northern California commuters (N = 2216) to analyze the magnitude and significance of individual and household-level factors affecting commute mode choice. We estimate a revealed-preference mode choice model and investigate the differences between millennials and older adults in the sample. Additionally, we conduct a sensitivity analysis to explore how incorporation of explanatory factors such as attitudes and propensity to multitask while traveling in mode choice models affects coefficient estimates, VOTT, and willingness to pay to use a laptop on the commute. Compared to non-millennials, the mode choice of millennials is found to be less affected by socio-economic characteristics and more strongly influenced by the activities performed while traveling. Young adults are found to have lower VOTT than older adults for both in-vehicle (15.0% less) and out-of-vehicle travel time (15.7% less), and higher willingness to pay (in time or money) to use a laptop, even after controlling for demographic traits, personal attitudes, and the propensity to multitask. This study contributes to better understanding the commuting behavior of millennials, and the factors affecting it, a topic of interest to transportation researchers, planners, and practitioners.

Subject Areas: Mode choice; Multitasking; Value of travel time; Millennials; Information and communication technology (ICT)

Availability: Malokin, A., Circella, G., and Mokhtarian, P.L. (2021). "Do Millennials Value Travel Time Differently Because of Productive Multitasking? A Revealed-Preference Study of Northern California Commuters." *Transportation*. https://doi.org/10.1007/s11116-020-10148-2

6.9. Title: Racial Disparities in Traffic Enforcement

Author(s): Fliss, M.D.

Abstract: Law enforcement traffic stops are one of the most common entryways to the U.S. justice system, with significant downstream impacts for both individuals and communities. Group-specific rates are typically based on jurisdiction resident populations; these rates, like many justice-system indicators, demonstrate race-ethnicity disparities. Residential-based rates implicitly assume race-ethnicity groups have equal vehicle access and equal driving volume and that all driving occurs in resident's jurisdictions. In contrast, surveys suggest Black non-Hispanic and Hispanic households have less access and drive less than white non-Hispanic households. Models incorporating U.S. Census data and race-ethnicity driving factors from the 2017 National Household Travel Survey showed increased disparities for Black non-Hispanic drivers; all models suggested both groups experience disparate traffic stop rates compared to white non-Hispanic drivers.

A police department in Fayetteville, NC, attempted to reduce these disparities by focusing on safety-related traffic stops; intervention results will be shared. The Public Health Critical Race Praxis (PHRCP) guided framing, results interpretation, and self-evaluation of study aims. Traffic stops have associated public health outcomes and create disparities of relevance for public health researchers. Interventions guided by critical public health frameworks can save lives and reduce disparities.

Subject Areas: Racial profiling in law enforcement; Discrimination in law; Discrimination in criminal justice administration; Social justice; Race relations

Availability: Fliss, M.D. (2020). *Racial Disparities in Traffic Enforcement*. TREC Friday Seminar Series, Portland State University, Portland, OR.
https://pdxscholar.library.pdx.edu/trec_seminar/199

6.10. Title: Analysis of the Temporal Transferability of Models of Trips Generated by the Elderly with National Level Data

Author(s): Kaczmarek, C.B.

Abstract: The study of the transportation needs of the elderly population consisting of persons with age 65 years and above is a current critical issue within transportation planning. Its importance in part stems from the findings of U.S. Decennial Census that the elderly segment of the population has progressively increased over the years such that their share of the population continues to warrant the development of specific plans to address the future travel needs of this segment of the population. Planning for this group requires an understanding of both their demographic and travel characteristics and their evolution over time. It also requires an understanding of how demographic characteristics of the elderly relate to the travel choices they make and whether developed mathematical relationships between these travel choices, specifically trip generation, and demographic characteristics remain stable over time.

Thus, three main objectives were defined for the research conducted, namely, to develop demographic profiles of the elderly and to document how these changed between two specific survey-years; to determine the travel characteristics of the elderly population and to document how these changed between two survey years; and finally, to develop statistical models relating the trips made daily by the elderly to their respective demographic characteristics and to investigate the temporal transferability of these statistical relationships.

The data used for the research were collected as part of National Household Travel Survey conducted by the Federal Highway Administration in years 2009 and 2017. It was found that the share of the population that is elderly grew by 22.41% in contrast to the 6.55% growth in the overall population. The majority of trips they made were found to be by automobile, with the automobile share of trips remaining numerically similar across all ages. Their trips were found to be made primarily for shopping and social/recreational purposes with the majority of them made during daytime off-peak hours. The transferability analysis of trip generations models led to the following conclusions: (1) that trip generation model parameters did not remain temporally stable. (2) That transferred models do provide useful information concerning travel in the application context for planning purposes; the transferred model had 64.5% of the explanatory power of the local application context model. (3) Working with a birth cohort enhances transfer effectiveness. It led to the transferred model having 73.4% of the explanatory power of the local application context model.

Subject Areas: Elderly population; Travel trend; Demographics; Travel characteristics

Availability: Kaczmarek, C.B. (2020). *Analysis of the Temporal Transferability of Models of Trips Generated by the Elderly with National Level Data*. Master's Thesis, Tennessee Technological University, Cookeville, TN.
https://search.proquest.com/openview/947890a233e7b9a2f361ae55b31550e5/1?pq-origsite=gscholar&cbl=18750&diss=y

6.11. Title: Research on the Choice Behavior of American Elderly Trip Chain Based on MNL

Author(s): Li, S.

Abstract: In order to study the travel behavior of the elderly, this article uses the data from the 2017 National Household Travel Survey in the United States and select groups of people aged 65 years or older. Using Python to splice the travel data into a trip chain. According to the number of activities in the trip chain, the trip chain is divided into three types: simple trip chain, complex trip chain, and super complex trip chain. The results show that more than half of the elderly have only one trip chain per day, and more than half of the trip chain is simple trip chain. Using Multinomial Logit Model to model and analyze the choice behavior of the elderly trip chain, the results show that the better health level of the elderly, the higher frequency of using smartphone on the Internet, the higher education level, and the more inclined to choose super complex trip chain. The higher frequency of using tablet on the Internet, the trip chain is more simple of the elderly; the trip chain of the elderly living alone is more complex; the trip chain of the elderly in low population density areas is more complex.

Subject Areas: Old people; Trip chain; Multinomial Logit Model (MNL); Python

Availability: Li, S. (2021). "Research on the Choice Behavior of American Elderly Trip Chain Based on MNL." *International Journal of Social Science and Education Research*, *4*(3), pp. 43–52. http://dx.doi.org/10.6918%2fIJOSSER.202103_4(3).0008

6.12. Title: Staying Home or Going Places: Mobility Factors of Older Minority Women's Daily Trip Making in The United States

Author(s): Kim, S. and Ulfarsson, G.F.

Abstract: Introduction: Older women have been widely found to be especially disadvantaged when it comes to mobility, and this has been linked to negative effects on health and well-being. This study investigates and identifies factors linked to risk of mobility deficiency among older minority women in the United States.

Methods: This study investigated older minority women age 65+ (N = 4,565) from the 2017 U.S. National Household Travel Survey, a national sample from all 50 States, with a negative binomial regression and Cragg's exponential hurdle regression.

Results: About 24% of the older minority women in the survey made no out-of-home trips on the survey day and hence had a zero travel distance, the highest such fraction among the older population. Older minority women are found especially at risk of transportation deficiency if they do not drive an automobile themselves, have low household income, are not highly educated, and live in rural areas.

Conclusion: Better access to services and facilities in higher-density areas is important to reduce mobility deficiency of older minority women. Older women who walk are linked to higher trip frequency but shorter distances. While facilitating safe driving is an instrument to maintain mobility for older minority women, this study shows that older minority women in rural areas need special attention. Particular concern is needed for foreign-born older minority women and those with lower education levels as both groups are likely to have unmet mobility needs. Similarly, the older minority women in the lowest income brackets are especially vulnerable to transportation deficiency.

Subject Areas: Aging; Older women; Minority; Transportation disadvantaged; Mobility

Availability: Kim, S. and Ulfarsson, G.F. (2021). "Staying Home or Going Places: Mobility Factors of Older Minority Women's Daily Trip Making in The United States." *Journal of Transport & Health*, *21*. https://doi.org/10.1016/j.jth.2021.101031

6.13. Title: Neighborhood Green Land Cover and Neighborhood-Based Walking in U.S. Older Adults

Author(s): Besser, L.M. and Mitsova, D.P.

Abstract: Introduction: Greenspace exposure has been associated with physical activity, but few studies have investigated its association with physical activity in the residential neighborhood. This study investigates whether greater amounts of neighborhood open space and forest are associated with neighborhood-based walking in older adults.

Methods: In 2020, cross-sectional analyses were conducted on those aged ≥65 years from the 2017 National Household Travel Survey. Minutes of neighborhood walking per day were derived from travel diaries. Green land cover measures from the 2011 National Land Cover Dataset were linked to respondent data by the U.S. Census tract. Adjusted linear regression models, using weights accounting for survey sampling, tested the associations between the percentage of green land cover in the neighborhood (open space, forest) and minutes of neighborhood walking per day. Adjusted models were stratified to examine whether the associations varied by an individual- and neighborhood-level SES, sex, and race/ethnicity.

Results: Respondents (N=72,753) were aged 74 (SD=7) years on average. Greater percentage of open space was associated with more neighborhood walking in African Americans (estimate=0.069, 95% CI=0.005, 0.133). Greater percentage of forest was associated with more neighborhood walking in the overall sample (estimate=0.028, 95% CI=0.006, 0.050), women (estimate=0.025, 95% CI=0.005, 0.045), and Whites (estimate=0.034, 95% CI=0.004, 0.064).

Conclusion: Type of neighborhood green land cover (open space versus forest) may be differentially associated with neighborhood walking depending on race/ethnicity. This study suggests a possible association between greater neighborhood open space and greater walking among African Americans that must be confirmed in future studies.

Subject Areas: Older adults; Minority; 2017 National Household Travel Survey; 2011 National Land Cover Dataset; Green land cover; Walking per day; Race/ethnicity; Adjusted linear regression models

Availability: Besser, L.M. and Mitsova, D.P. (2021). "Neighborhood Green Land Cover and Neighborhood-Based Walking in U.S. Older Adults." *American Journal of Preventive Medicine*. https://doi.org/10.1016/j.amepre.2021.01.013

6.14. Title: Use of App-based Ridehailing Services and Conventional Taxicabs by Adults with Disabilities

Author(s): Cochran, A.L. and Chatman, D.G.

Abstract: App-based ridehailing services such as Uber and Lyft are growing rapidly and serving more trips in large U.S. cities than conventional taxicabs, on which people with disabilities have historically depended. Analyzing the 2017 National Household Travel Survey, we found that adults with disabilities use app-based ridehailing at a much lower rate than adults without disabilities. This is partly because people with disabilities are older, have lower incomes, and live less in larger cities. But even when controlling for these factors, having a disability predicts lower use of app-based ridehailing, which suggests that these new services may not be sufficiently accessible to people with disabilities.

Subject Areas: Disability; Ridehailing; Taxis; TNCs; National Household Travel Survey

Availability: Cochran, A.L. and Chatman, D.G. (2021). "Use of App-based Ridehailing Services and Conventional Taxicabs by Adults with Disabilities." *Travel Behaviour and Society*, *24*, pp. 124–131. https://doi.org/10.1016/j.tbs.2021.02.004

6.15. Title: How Does Driving Status Affect Trip Patterns Among Older Adults in Suburban and Rural Communities?

Author(s): Han, D., Lee, Y., Yu, J., and Dejno, C.

Abstract: Introduction: Mobility limitation can hinder one's access to goods and services that may lead to poor health outcomes, especially among older adults who do not drive. Existing literature on older adults' mobility limitations has majorly focused on single transportation mode (e.g., walking, public transit), and little is known about the differences in trip purposes and all-mode transportation patterns between driving older adults and non-driving counterparts especially in suburban and rural areas with more aging population.

Methods: 502 individuals aged 65 and older were included in our study drawn from a transportation survey conducted in Washington County, WI. Binary and ordered logistic regression analyses were conducted to determine whether older adults' driving status was significantly associated with their trip purposes and trip frequency by various modes, while controlling for covariates including socio-demographic characteristics.

Results: A larger percentage of non-driving older adults compared to driving counterparts needed to make maintenance trips (e.g., medical or dental appointments, food pantry) but a smaller percentage for leisure trips (e.g., socializing, movies/art/theater). However, there was no difference in subsistence trips (e.g., worship, work) between drivers and non-drivers. While making more trips via dependent modes (e.g., riding with family or friends, public transit), non-driving older adults traveled less frequently than older drivers overall, because they made fewer trips via independent modes (e.g., driving, walking).

Conclusion: The findings indicate that non-driving older adults are in greater need for medical care or food assistance, as well as having greater limitations in mobility and dependency on others for trips. In addition, further analyses in this study suggest improvement of alternative transportation services (e.g., advanced vehicle scheduling methods, inter-county transit service collaboration), usage of assistive technology, and education about transportation services to help improve mobility among non-driving older adults in suburban and rural areas.

Subject Areas: Older adults; Suburban and rural areas; Trip pattern; Mobility; Driving status

Availability: Han, D., Lee, Y., Yu, J., and Dejno, C. (2021). "How Does Driving Status Affect Trip Patterns Among Older Adults in Suburban and Rural Communities?" *Journal of Transport & Health*, *21*. https://doi.org/10.1016/j.jth.2021.101052

6.16. Title: Barriers and Facilitators of Older Adults' Use of Ride Share Services

Author(s): Bayne, A., Siegfried, A., Beck, L.F., and Freund, K.

Abstract: Introduction: Safe, affordable, and convenient transportation may help older adults (age 65 and older) stay independent, access healthcare services, and maintain their quality of life. While older adults in the United States primarily rely on private automobiles, those who reduce or cease driving may require alternative forms of transportation. Ride share services show promise as an alternative mode of transportation for older adults, particularly for those who no longer drive.

Methods: We employed a qualitative research design to explore barriers and facilitators of older adults' use of ride share services and compare findings to younger adults (ages 18 to 64). We conducted 96 telephone interviews (68 older adults and 28 younger adults), and 10 in-person focus groups (56 older adults and 17 younger adults), including individuals who used a ride share service and those who never used a ride share service. We conducted qualitative data analysis to identify key themes and developed a conceptual framework to organize and describe findings.

Results: The qualitative analysis revealed the most important facilitator of older adults' use of ride share services was the desire to remain independent, particularly among those with health conditions and special needs that prevented them from using other transportation. Other facilitators included driver assistance (door-to-door service), a polite and courteous driver, a clean vehicle, and prompt and dependable service. Barriers among older adults included safety concerns, affordability, technology, and a lack of ride share services in the community. Among younger adults, technology was a facilitator of use.

Conclusion: Ride share services are a promising transportation option. Findings highlight a need to tailor these services to older adults' needs. Ride share services that are safe, reliable, and offer driver assistance and telephone scheduling have the potential to support older adults' health, mobility, and independence.

Subject Areas: Alternative transportation; Driving; Safety; Mobility; Health; Aging

Availability: Bayne, A., Siegfried, A., Beck, L.F., and Freund, K. (2021). "Barriers and Facilitators of Older Adults' Use of Ride Share Services." *Journal of Transport & Health*, *21*. https://doi.org/10.1016/j.jth.2021.101055

6.17. Title: Bicycling and Walking by Older Adults

Author(s): Mencher, S.

Abstract: Blog.

Subject Areas: Older adults; Biking; Walking; Safety

Availability: Mencher, S. (2021). "Bicycling and Walking by Older Adults." *American Association of Retired Persons*. https://www.aarp.org/livable-communities/getting-around/info-2021/bicycling-and-older-adults.html

6.18. Title: Another One Rides the Bus: The Impact of School Transportation on Student Outcomes in Michigan

Author(s): Edwards, D.S.

Abstract: School transportation may increase student outcomes by providing a reliable and safe means of getting to and from school. Little evidence of the effects of such policies exists. In this paper, I provide some of the first causal evidence of transportation impacts on student attendance and achievement using a rich panel of student-level enrollment and address data for Michigan public school students, and a unique dataset of district transportation policies for the largest 50 districts in Michigan. I exploit the walking distance cutoffs that determine transportation eligibility using a regression discontinuity design. I find that transportation eligibility increases attendance rates and lowers the probability of chronic absence. These effects are largest for economically disadvantaged students, who experience 0.5 to 1 percentage point increase in attendance rates and a 2 to 4 percentage point decrease in the probability of being chronically absent. These results are compelling evidence that school-provided transportation increases attendance for students most at-risk to miss school. However, I find no effect of school transportation on student achievement outcomes.

Subject Areas: School transportation; Student attendance; Economically disadvantaged students

Availability: Edwards, D.S. (2021). *Another One Rides the Bus: The Impact of School Transportation on Student Outcomes in Michigan*. Working Paper, Michigan State University, East Lansing, MI. https://www.daniellesandersonedwards.com/workings-papers/another-one-rides-the-bus-the-impact-of-school-transportation-on-student-outcomes-in-michigan/

6.19. Title: Magnifying Inequality? Home Learning Environments and Social Reproduction During School Closures in Ireland

Author(s): Mohan, G., Carroll, E., McCoy, S., Domhnaill, C.M., and Mihut, G.

Abstract: COVID-19 school closures have seen the homeplace become a school-place for students and their families in Ireland. This paper presents research on the resources and supports available for students to engage with learning in their home environments. Evidence from a nationally representative survey comprising one third of second-level school leaders, conducted during the first school closures in 2020, shows that attendance and engagement appears to be influenced by the educational level of parents/guardians. The association between parental education and student engagement was stronger for Junior Certificate students but was not statistically evidenced for Leaving Certificate students. Qualitative evidence sheds further light on inequalities which characterised students' experiences of online and remote learning. Viewing these developments through a social reproduction framework, this study argues that unequal home learning environments may magnify existing inequalities. To prevent a return to the classroom with more classed outcomes, it is imperative that policy, planning, and investment strive to mitigate the impact of COVID-19 on educational inequality.

Subject Areas: COVID-19; Home learning environments; Second level; Student engagement; Parental education

Availability: Mohan, G., Carroll, E., McCoy, S., Domhnaill, C.M., and Mihut, G. (2021). "Magnifying Inequality? Home Learning Environments and Social Reproduction During School Closures in Ireland." *Irish Educational Studies*. https://doi.org/10.1080/03323315.2021.1915841

6.20. Title: Travel Time Patterns of Students with Special Needs to Special Education Integrated Program-based Schools in Johor Bahru, Malaysia: An Initial Finding

Author(s): Idris, N.H., Ahmad Bakhtiar, N.A., and Ishak, M.H.I.

Abstract: Education for all has been a global priority to ensure that all students have equal access to high-quality education regardless of disability or minority status. In Malaysia, the special education integrated programme (SEIP) is designed to close the inequality gap by integrating special education into existing government and vernacular schools. Numerous studies examine the travel patterns of regular students to school, resulting in a dearth of research on the travel patterns of special needs students to formal school. Thus, this paper uses spatial analysis to demonstrate the travel patterns of students with special needs to SEIP schools. This paper demonstrated that the majority of SEIP schools in the Johor Bahru district can be reached within a 5- to 10-minute drive. Individual travel time analyses between origin (home) and destination (current versus ideal school) indicate that the majority of secondary school students attend their ideal neighbourhood schools but not primary school students. The average travel time is 12 minutes, with 89 percent of them travelling by car. The travel time clustering analysis revealed that the majority of students who commute to school live within a radius of 2 to 10 km and within a time range of 10 to 20 minutes. However, a small group of these special students commutes to school for 20 to 25 minutes each day. The preliminary findings can be improved and may aid in the design of carpool and transit schedules, as the majority of these students heavily rely on their cars for transportation. The effects of the lengthy commute to school could be further investigated, as these children are vulnerable and any negative impact on their mental, emotional, or physical development must be addressed.

Subject Areas: Travel time pattern; Special Integrated Education Program (PPKI); Learning disability student; Spatial analysis

Availability: Idris, N.H., Ahmad Bakhtiar, N.A., and Ishak, M.H.I. (2021). "Travel Time Patterns of Students with Special Needs to Special Education Integrated Program-based Schools in Johor Bahru, Malaysia: An Initial Finding." *International Journal of Geospatial and Environmental Research*, *8*(2). https://dc.uwm.edu/ijger/vol8/iss2/1?utm_source=dc.uwm.edu%2Fijger%2Fvol8%2Fiss2%2F1&utm_medium=PDF&utm_campaign=PDFCoverPages

6.21. Title: Comparing Immigrant Commute Travel Adaptation Across and Within Racial/Ethnic Groups

Author(s): Hu, L., Klein, N.J., and Smart, M.J.

Abstract: This research investigates differences in the adaptation process of immigrant commute distance and commute mode across and within three racial/ethnic groups—white, Hispanic, and Asian—in the United States to explore policies that facilitate immigrant travel in an efficient and sustainable way. A two-step analysis is conducted: the first step uses all U.S.-born as the reference group, and the second step uses U.S.-born of the same race/ethnicity as the reference. The second step overcomes a potential problem in existing research on immigrant travel adaptation: When all U.S.-born are used as the reference group, the statistics mainly reflect the travel behavior of U.S.-born white people, masking intrinsic travel differences among U.S.-born racial/ethnic groups. Based on multi-level regression analysis of the 2017 National Household Travel Survey (NHTS) data, our results support existing findings of initial difference but eventual convergence of immigrant commute behavior with U.S.-born, while highlighting white immigrants' persistence and Hispanic immigrants' low propensity in using non-automobile modes. Comparison results based on the two reference groups suggest that segmented assimilation due to racial/ethnic group membership is limited. Still, nuanced findings denote distinctive spatial mechanisms that affect immigrant and U.S.-born Asians and highlight the short time window after immigrants' arrival in the U.S. during which policies might contribute to a continuation of their sustainable travel patterns.

Subject Areas: Transit; Walking/bicycling; National household travel survey; Acculturation; Segmented assimilation

Availability: Hu, L., Klein, N.J., and Smart, M.J. (2021). "Comparing Immigrant Commute Travel Adaptation Across and Within Racial/Ethnic Groups." *Transport Policy*, *110*, pp. 112–122. https://doi.org/10.1016/j.tranpol.2021.05.024

6.22. Title: Development of Pedestrian- and Vehicle-Related Safety Performance Functions Using Bayesian Bivariate Hierarchical Models with Mode-Specific Covariates

Author(s): Singh, M., Cheng, W., Samuelson, D., Kwong, J., Li, B., Cao, M., and Li, Y.

Abstract: Introduction: Pedestrian safety is a major concern as traffic crashes are the leading cause of fatalities and injuries for commuters. Traffic safety research in the past has developed various strategies to counteract traffic crashes, including the safety performance function (SPF). However, there is still a need for research dedicated to enhancing the SPF for pedestrians from perspectives of methodological framework and data input. To fill this gap, this study aims to add to the current SPF development practice literature by focusing on pedestrian-involved collisions, while considering the typical vehicle ones as well.

Methods: First, bivariate models are used to account for the common unobserved heterogeneity shared by the pedestrian- and vehicle-related crashes at the same intersections. Second, variable importance ranking technique is used, along with correlation analysis, to determine mode-specific feature input. Third, the exposure information for both modes, annual pedestrian count, and annual daily vehicles traveled are used for model development. Fourth, a recent Bayesian inference approach (integrated nested Laplace approximation (INLA)) was adopted for bivariate setting. Finally, different evaluation criteria are used to facilitate comprehensive model assessment.

Results: The results reveal different statistically significant factors contributing to each of the modes. The offset intersection provides better safety performance for both pedestrians and drivers as compared to other intersection designs. The model findings also corroborate the sensibility of using the bivariate models, rather than the separate univariate ones.

Practical Applications: The study shows that pedestrians are more vulnerable to various intersection features such as left-turn channelization, intersection control, urban and rural population group, presence of signal mastarm on the cross-street, and mainline average daily traffic. Greater focus should be directed toward such intersection features to improve pedestrian safety.

Subject Areas: Pedestrian-vehicles crashes; Crash frequency models; Bivariate models; Pedestrian count; Safety performance function

Availability: Singh, M., Cheng, W., Samuelson, D., Kwong, J., Li, B., Cao, M., and Li, Y. (2021). “Development of Pedestrian- and Vehicle-Related Safety Performance Functions Using Bayesian Bivariate Hierarchical Models with Mode-Specific Covariates.” *Journal of Safety Research*. https://doi.org/10.1016/j.jsr.2021.05.008

6.23. Title: Understanding Senior's Daily Mobility Patterns in California Using Human Mobility Motifs

Author(s): Su, R., Xiao, J., McBride, E.C., and Goulias, K.G.

Abstract: Population ageing has been a thorny issue in many countries. One of the challenges is how to improve and change transportation design and transport policy development to adapt to the dramatic changes in the composition of our population. In this paper, we apply a network-based approach of human mobility measurement called "motif" to investigate the distinct patterns in daily travel for seniors (age 60 and above) in California using the 2017 National Household Travel Survey (California-NHTS) data. Motifs are networks of distinct locations visited in a day and the directional movements between them. Using patterns of motifs, we correlate the diverse daily mobility patterns with socio-demographic characteristics as well as built environment factors. We find that 15 distinct motifs can capture approximately 82% and 86% of the total senior respondents on workdays and non-workdays, respectively. Seniors are more likely to have simple motifs with three or fewer distinct locations on non-workdays, while they present more complex motifs during workdays. Given 65% of the included seniors are retired, a large number of seniors present diverse and complex daily mobility patterns instead of staying at home all day. In addition, given the similarity between the urban core, urban district, and urban neighborhood in function and spatial proximity, there is significant heterogeneity in the daily mobility patterns among seniors living in these areas. Furthermore, we find that seniors living in areas with higher percentages of single-family housing units are most likely to stay at home on workdays.

Subject Areas: Senior; Mobility; Motif; Travel survey; Built environment

Availability: Su, R., Xiao, J., McBride, E.C., and Goulias, K.G. (2021). "Understanding Senior's Daily Mobility Patterns in California Using Human Mobility Motifs." *Journal of Transport Geography*, *94*. https://doi.org/10.1016/j.jtrangeo.2021.103117

6.24. Title: Keys to the Car

Author(s): Schouten, A., Blumenberg, E., Wachs, M., and King, H.

Abstract: Problem, research strategy, and findings: Most Americans live in communities in which automobiles are central to participation in economic, social, and cultural activities. Outside of dense central cities, the ability to continue driving as one ages is fundamental to the quality of life among older adults. Driving rates decline significantly with age. Researchers have studied the myriad reasons former drivers stop driving, but few have examined associations between these transitions and characteristics of the neighborhoods in which older adults live or to which they move. We used longitudinal data from a national sample of 20,000 observations from the University of Michigan Health and Retirement Study (HRS) to examine relationships between residential location, driving reduction, and driving cessation. Longitudinal data allow analysis of changes in behavior, a major advantage over cross-sectional data; however, the timing and sequencing of behavioral changes remain difficult to isolate. Cities provide opportunities for older adults to travel by automobile and other modes that are less available outside cities. Older adults are more likely to reduce or give up driving if they reside in dense, urban, transit-oriented neighborhoods than other neighborhood types. Very few older adults move from suburban to urban neighborhoods; when they do, they are rarely more likely to reduce or stop driving.

Takeaway for practice: The findings underscore the importance of planning to accommodate aging in place. To do this in urban neighborhoods, policies must foster high-quality urban neighborhoods that not only attract younger adults (as is currently the trend) but also retain them as they age through the life cycle.

Subject Areas: Driving cessation; Older adults; Residential location

Availability: Schouten, A., Blumenberg, E., Wachs, M., and King, H. (2021). "Keys to the Car." *Journal of the American Planning Association*. https://www.tandfonline.com/doi/pdf/10.1080/01944363.2021.1907608

6.25. Title: Difference in Travel Behavior Between Immigrants in the U.S. and U.S. Born Residents: The Immigrant Effect for Car-Sharing, Ride-Sharing, and Bike-Sharing Services

Author(s): Lee, S., Smart, M.J., and Golub, A.

Abstract: Understanding immigrants' travel behavior is important to transportation planners and policymakers working to implement better transportation planning and public policies to serve those needs. The recent changes to the transportation system, specifically, the recent emergence of shared mobility services, such as car-sharing, ride-sharing, and bike-sharing, may have resulted in changes in how immigrants travel. Thus, we explored two research questions: (1) whether immigrants in the United States are more likely to rely on the three newly emerging transportation modes than U.S.-born persons, and (2) whether the assimilation theory can be applied to the modes. To answer these questions, we used data from the 2017 National Household Travel Survey and employed Zero-Inflated Negative Binomial regression models to understand the specific behavior of immigrant travelers.

The models found the "immigrant effect" only for car-sharing services and bike-sharing programs; that is, relative to U.S.-born residents, immigrants in the United States use car-sharing and bike-sharing services more frequently, while we found an insignificant association in ride-sharing apps use. However, the negative binomial models suggested that immigrants use car-sharing and ride-sharing less frequently than expected. Immigrants who are in their first few years of living in the United States use smartphone rideshare app more frequently, confirming the "assimilation theory." The results of the predicted frequency of the use indicated that with all other independent variables held constant, U.S.-born residents use car-sharing and ride-sharing services more frequently than immigrants, though the difference is marginal. However, immigrants would still tend to use bike-share programs more frequently rather than U.S.-born residents.

Subject Areas: Immigrants in the United States; Travel behavior; Car-sharing service; Smartphone ride-share app; Bike-share program

Availability: Lee, S., Smart, M.J., and Golub, A. (2021). "Difference in Travel Behavior Between Immigrants in the U.S. and U.S. Born Residents: The Immigrant Effect for Car-Sharing, Ride-Sharing, and Bike-Sharing Services." *Transportation Research Interdisciplinary Perspectives*, *9*. https://doi.org/10.1016/j.trip.2020.100296

6.26. Title: Differences in Daily Trips Between Immigrants and US-born Individuals: Implications for Social Integration

Author(s): Shirgaokar, M. and Nobler, E.

Abstract: A key expectation regarding immigrants is that they need to integrate into mainstream society. Some countries have social programs to meet this ideal, while the U.S. Government has largely left immigrants to integrate through their own means or receive help though non-profit organizations. One measure of integration is comparable trips for socialization and recreation. In this paper, we asked how divergent was daily trip frequency by immigrants versus U.S.-born individuals across various trip purposes. We used the 2017 National Household Travel Survey data at the person level and estimated a series of trip frequency models where our outcome variables were daily trips by purposes. We controlled for socio-economic and demographic factors at the person and household levels, as well as for characteristics of the home location. We found that immigrants made fewer social, recreational, or errand trips than U.S.-born individuals, which could slow their integration. However, immigrants made more exercise and education trips than U.S.-born individuals. There was no statistical difference between the two populations for daily frequency of work trips. The need for policies encouraging social and recreation trips for immigrants, and exercise and education trips for U.S.-born individuals, is indicated from this research.

Subject Areas: Discretionary travel; Immigrants; Integration; Negative binomial; NHTS; Trip purpose

Availability: Shirgaokar, M. and Nobler, E. (2021). "Differences in Daily Trips Between Immigrants and US-born Individuals: Implications for Social Integration." *Transport Policy*, *105*, pp. 103–114. https://doi.org/10.1016/j.tranpol.2021.03.008

6.27. Title: What Do Teenagers Think About Driving? Insights from a Bicycling-Oriented Community in the Auto-Dependent United States

Author(s): Handy, S., Wang, A., Jacobson, E., and Thigpen, C.

Abstract: The decline in driver's licensure among teenagers in the United States in recent decades has led some observers to speculate that the newest generation of adults will be less car dependent than those that preceded them. Previous studies have identified a variety factors that may explain the decline, including graduated licensing policies and economic conditions. This paper delves beneath these trends with the goal of generating a deeper understanding of what is going on with teenagers and their travel. We explore what teenagers think about driving and its alternatives through in-depth interviews with 20 high school students and their parents in Davis, California, an unusually bicycling-oriented community by U.S. standards. Although bicycling was an important mode of travel for the teenagers when they were younger, all had acquired or planned to acquire a driver's license at the time of the interview. The reasons teenagers cite for needing a driver's license are more practical than social, although the ability to socialize with friends is an important benefit of driving. Both teenagers and their parents liked the independence that having a license brings, although both expressed some fears about their driving—both the danger driving poses to themselves as well as the danger their driving poses to others. Teenagers and their parents saw driving as inevitable, as a natural step toward adulthood.

Subject Areas: Driver's licensure; Teenagers; Driving; Bicycling; Attitudes

Availability: Handy, S., Wang, A., Jacobson, E., and Thigpen, C. (2021). "What Do Teenagers Think About Driving? Insights from a Bicycling-Oriented Community in the Auto-Dependent United States." *Transportation Research Interdisciplinary Perspectives*, *11*. https://doi.org/10.1016/j.trip.2021.100422

6.28. Title: Equity of Access to Uber's Wheelchair Accessible Service

Author(s): Hassanpour, A., Bigazzi, A., and MacKenzie, D.

Abstract: Ride-sourcing service providers have expanded rapidly in recent years, but accessibility for people with disabilities is an ongoing issue. UberWAV was launched in September 2015, providing wheelchair accessible vehicles equipped with a rear-entry ramp, winch, and restraints for riders who travel with a wheeled mobility aid. The objectives of this study were (1) to assess the equity performance of UberWAV by itself and in comparison to UberX by investigating the temporal and spatial distributions of the availability and accessibility of each service and (2) to compare the availability, wait time, and price of UberWAV in Portland to the requirements in the city code. Demand-weighted probability of availability (WPA) and demand-weighted estimated time of arrival (WETA) were calculated for each service using Application Programming Interface (API) data extracted at 71 gridded locations in Portland, OR, in 2018 and U.S. National Household Travel Survey data. WPA and WETA were then regressed over sociodemographic variables, controlling for spatial correlation, to investigate systematic patterns in access by neighborhood. Results indicate large disparities in availability between the WAV and standard Uber services. WPA of UberX was consistently more than 99 percent, while WPA for UberWAV averaged 62 percent with substantial fluctuations by time of day. Average WETA for UberWAV was 18.8 minutes, 4.5 times higher than for UberX, and again had greater temporal variability. UberWAV met the service requirements in the Portland city code for availability and wait time under 30 minutes just 58 percent of the time (demand-weighted). Although UberWAV access was substantially poorer than for UberX, the access was not inequitably distributed with regard to neighborhood income or racial composition. UberWAV was more accessible in areas where a higher percentage of people with ambulatory disabilities lived. A larger fleet of UberWAV vehicles would be needed, particularly through the middle of the day, if Uber is to provide equal access for people using a wheelchair and to meet the requirements in the Portland city code.

Subject Areas: Wheelchair; Accessibility; Ride-sourcing; Uber; Equity

Availability: Hassanpour, A., Bigazzi, A., and MacKenzie, D. (2021). "Equity of Access to Uber's Wheelchair Accessible Service." *Computers, Environment and Urban Systems*, *89*. https://doi.org/10.1016/j.compenvurbsys.2021.101688

6.29. Title: Ridesharing Can Help Older People Be Functionally Independent in Their Homes, Communities

Author(s): Fraade-Blanar, L., Best, R., and Iyengar, V.

Abstract: Blog.

Subject Areas: Ride-share; Accessibility; Older people; Inequity

Availability: Fraade-Blanar, L., Best, R., and Iyengar, V. (2021). "Ridesharing Can Help Older People Be Functionally Independent in Their Homes, Communities." *STAT*. https://www.statnews.com/2021/08/10/ridesharing-help-older-people-remain-functionally-independent/

6.30. Title: Estimation and Simulation of Daily Activity Patterns for Individuals Using Wheelchairs

Author(s): Lant, N.J.

Abstract: Individuals who use wheelchairs or who have other mobility challenges often are unable to access modern mobility systems—including application-based ride-hailing and on-demand microtransit. Even designing a system targeted at these users is challenging, given the limited prior analysis of their travel behavior and activity patterns. Simulation tools are used by cities around the world to understand novel and complex transportation systems, yet few are including the needs of users with disabilities in these simulation studies. This report examines the travel patterns of wheelchair users from the 2017 National Household Travel Survey and presents a model of daily activity pattern choice of respondents who self-identify as using a wheelchair. This report discusses the application of a wheelchair status variable in the activity-based travel demand model ActivitySim and measures its effect on individual and household daily activity pattern choice. Wheelchair use is estimated to reduce the utility of a work daily activity pattern by 1.9 points relative to a home pattern for full-time workers and 3.4 for part-time workers. Including the effect of wheelchair use in a regional daily activity pattern model resulted in 21.9% of wheelchair users changing to a home activity pattern relative to a base scenario not including wheelchair use. Finally, the report evaluates the performance of an on-demand, accessible mode for users with wheelchairs in the agent-based microsimulation BEAM. This simulation showed that demand for such a service increases linearly with fleet size and wait time remains constant, although further scenario refinement and research is necessary.

Subject Areas: Ride-hailing; Wheelchair accessible; Travel behavior; Demand microsimulation

Availability: Lant, N.J. (2021). *Estimation and Simulation of Daily Activity Patterns for Individuals Using Wheelchairs*. Master's Thesis, Brigham Young University, Provo, UT. https://scholarsarchive.byu.edu/etd/9206

6.31. Title: A Recent Study by Manish Shirgaokar (MURP Faculty) and Erin Nobler (CAP PhD Student)

Author(s): Johnson, K.

Abstract: Blog.

Subject Areas: Immigrants; Integration; Transportation policy; social policy

Availability: Johnson, K. (2021). "A Recent Study by Manish Shirgaokar (MURP Faculty) and Erin Nobler (CAP PhD Student)." *CU Denver News*. https://news.ucdenver.edu/a-recent-study-by-manish-shirgaokar-murp-faculty-and-erin-nobler-cap-phd-student/

6.32. Title: Changes in the Travel Patterns of Older Americans with Medical Conditions: A Comparison of 2001 and 2017 NHTS data

Author(s): Lidbe, A., Adanu, E.K., Penmetsa, P., and Jones, S.

Abstract: The older population in the United States is increasing, and the physiological, cognitive, and psychological changes of aging can potentially pose mobility barriers for them. A medical condition further impedes travel opportunities and hinders continued engagement in civic and social life, adversely impacting their quality of life. This study uses the 2001 and 2017 National Household Travel Survey (NHTS) data and analyzes the sociodemographic, attitudinal, and travel characteristics associated with older population long-distance travel patterns to support policy changes that address their emerging travel needs. The study results find a shift in trend in the mode preference of the new generation of older people with a medical condition. They are less likely to drive a car and prefer riding a bus or some other transport modes. They are also more likely to travel more over the weekend and evening hours. The older individuals are also more likely to travel long distances for work/business, religious trips, and visits to family, friends, and relatives, but not for shopping, medical, and recreational purposes. Income and education levels of the older population with a medical condition directly impact their long-distance travel and are likely to increase in the future. The new generation of older people with a medical condition (i.e., 2017 data) are less likely to self-regulate travel by limiting or giving up driving and are more likely to be self-dependent by refusing to ask for rides or use special transportation. As a result, more older drivers with medical conditions can be expected to drive on the roads in the future, adding to their road safety risks as well as those of others. This warrants transport policy changes to support safer mobility options for older people for their continued active community life and well-being.

Subject Areas: Older drivers; Medical condition; Long-distance; Travel; National Household Travel Survey (NHTS)

Availability: Lidbe, A., Adanu, E.K., Penmetsa, P., and Jones, S. (2021). "Changes in the Travel Patterns of Older Americans with Medical Conditions: A Comparison of 2001 and 2017 NHTS data." *Transportation Research Interdisciplinary Perspectives*, *11*. https://doi.org/10.1016/j.trip.2021.100463

6.33. Title: Assessing the Impact of Health Benefits and Carbon Footprint in Student Parking Decisions at a University Campus

Author(s): Ruiz, E.

Abstract: In the student parking location problem, traditionally, the parking permit cost, the last-mile travel time, and the ease of finding an available parking stall are the only decision criteria driving permit purchases. However, a student's choice of parking location has associated walking health benefits and sustainability impacts. These impacts are related to the walking distance from the parked vehicle to the final destination on campus, in addition to the location effect on the carbon footprint of a vehicle trip taken to campus. As such, this thesis examined a multi-criteria decision approach to a university student's choice of parking location. This approach involved the consideration of both the traditional and the non-traditional decision criteria derived from the potential health benefits of walking and the desire to reduce a student's contribution to carbon footprint.

The associated health benefits were denoted by the Measure of Health Benefits (MHB) and were estimated in calories/year. Similarly, the relative contribution to carbon footprint is denoted by the Measure of Carbon Footprint (MCF) and is estimated in kilograms of CO_2/year. These parameters were estimated for each of the designated student parking lots at the University of Texas at El Paso (UTEP) by a walking study and a simulation-based estimation, respectively. The walking study collected calorie information for both male and female students. The simulation-based estimation collected vehicle emission information using an integrated approach between VISSIM, a microscopic traffic simulation software, and CMEM, an emission estimation model. The MHB results estimated potential health benefit values ranging from 5,889 to 35,938 calories/year. Similarly, the MCF results identified vehicle emission contributions ranging from 6 to 35 kilograms of CO_2 year.

The estimated MHB and MCF results were subsequently presented in a menu of choices during a permit purchase transaction simulated by a student parking survey using UTEP students as the research subjects. The results of the survey were used to assess the students' parking location decisions before and after the provision of these non-traditional decision parameters, such that the effect of this information is adequately accounted for. The results of the survey corroborated that the most important factor influencing this decision was the price of the permit. The second and third most important factors were the last-mile travel time and the ease of finding an available parking space in the selected location. Although this observation was encountered both before and after the provision of the health benefit and carbon footprint information, the presentation of MHB and MCF impacted the respondents' awareness on the importance of the consideration of environmental sustainability and a healthy lifestyle. This impact was measured by a respective increase of 7.8 and 9.4 percent in the consideration of these non-traditional decision factors at the time of making a parking location decision.

Subject Areas: Student parking location; Walking; Health benefits; Sustainability impacts; Carbon footprint

Availability: Ruiz, E. (2021). *Assessing the Impact of Health Benefits and Carbon Footprint in Student Parking Decisions at a University Campus*. Master's Thesis, The University of Texas at El Paso, El Paso, TX.
https://www.proquest.com/openview/9696203f7c8dbeef8e80c1d99679187f/1?pq-origsite=gscholar&cbl=18750&diss=y

6.34. Title: Impacts of Standardizing School Start Time on Children and Household Workers: An Examination with NHTS Data

Author(s): Deka, D.

Abstract: Due to demonstrated health, safety, and performance benefits to children from delayed school start time, academics and Government agencies in the United States are increasingly insisting on starting schools at or after 8:30 a.m.—the time recommended by the American Academy of Pediatrics. Despite this urging, schools across the country continue to start well before that time. A common argument against the change is potential negative impacts on working household members. Using data from the 2009 National Household Travel Survey (NHTS), this paper therefore examines the potential impacts of nationally standardizing school start time at 8:30 a.m. with a focus on household members who give children rides to/from school and their travel patterns before and after escorting children. In addition to estimating the number of household members and workers that may be directly affected by delayed school start time, the paper examines through multinomial logit and probit models the individual and household characteristics of children who take rides from household members and the workers who may be adversely affected by delayed school start time of household children. Analysis showed that around 4 percent of the country's population may have to adjust their trips before and after escorting children to/from school. Around 65 percent of them are workers. A comparison of adversely affected workers with other workers revealed that the delay of school start time is not likely to have disparate impacts on disadvantaged populations, but the impacts may be more significant in some regions of the country than others.

Subject Areas: Nationally standardizing school start time; Delayed school start time; Travel patterns before and after escorting children to school; Multinomial logit and probit models; Disadvantaged populations

Availability: Deka, D. (2021). "Impacts of Standardizing School Start Time on Children and Household Workers: An Examination with NHTS Data." *Journal of Transport Geography*, *59*, pp. 40–48. https://doi.org/10.1016/j.jtrangeo.2017.01.005

6.35. Title: Incoming! Spatial Enrollment Competition Between Charter Schools and Traditional Public Schools

Author(s): Hicks, B. and Lens, M.

Abstract: The meteoric rise in charter schools has several implications for traditional public schools and their students. One understudied implication is the geographic competition for students. Given traditional public school boundaries are often fixed whereas charter school boundaries are more flexible, charter schools can draw students away from existing traditional public schools, and we have very little information about how distance matters in the competition for students. Because of this, traditional public schools and school districts have little ability to plan for enrollment changes in the face of charter school growth. Our paper uses data on enrollments and demographics in all charter and traditional public schools in Los Angeles from 2000 to 2013 to better understand these dynamics. We find that traditional public school enrollments clearly decline with competition from nearby charter schools. However, we also observe that charter schools tend to locate where traditional public school enrollments are already on the decline. Competition is more relevant for elementary schools at short distances—within about 1 mile appears to be where the associations between charter school enrollments and enrollment declines in traditional public schools are the strongest. For middle and high schools, those connections are apparent within 2 to 6 miles in some models.

Subject Areas: Charter schools; School enrollments; Race; School choice

Availability: Hicks, B. and Lens, M. (2021). *Incoming! Spatial Enrollment Competition Between Charter Schools and Traditional Public Schools*. Working Paper Series, Lewis Center for Regional Policy Studies, University of California, Los Angeles, CA. https://escholarship.org/uc/item/2bk6f7mc

6.36. Title: California North Coast Vehicle and Human Use Beach Survey of False Klamath Cove

Author(s): Maloney, R.A. and Corbett, J.W.

Abstract: This study looks to provide accurate, base-line-data of north coast beach usage and will identify activities in the vicinity of False Klamath Cove (FKC) bird sanctuary, which is a giant smokestack rock bird rookery of some 40,000 seabirds called False Klamath Rock. A research review showed that the north coast does not have adequate statistical information for FKC nor on other north coast beach areas for beach use. In the absence of such local data, other beach studies are used. Most of these surveys are in beach areas of southern California. Such extrapolations often result in an overestimation of beach populations and recreational beach use patterns that do not fit the north coast well.

In an effort to provide current statistical data of human and domestic animal use of north coast beaches, the Eagle Eyes of False Klamath Cove/MPA Watch study was created. The information from this study should be useful for recreational beach and natural resource planning on the north coast in Humboldt and Del Norte counties. The study is being conducted as part of a growing statewide effort to use citizens to conduct monitoring and supplement limited research monies. This survey is run and conducted 90 percent by Native Americans from different local tribes in an area with some of the highest unemployment rates in California. Startup funding was not available because the capacity of low-income Native Americans to complete the project deliverables was doubted. The project moved forward with local volunteers and some local funding. The completed project is a positive example of citizen science and produced a high-quality, statistically valid study equal to any in the State. An underlying hypothesis is that estimates from the Marine Life Protection Act (MLPA) Initiative of northern California beach use were too high for rural northern California beaches like False Klamath Cove.

Our study found that there are 85,363 annual beach visitors and 244,670 combined parking lot visitors who primarily take photos of the beach and/or selfies. This confirms our hypothesis that public use of northern California beaches is far lower by many factors of magnitude than the Marine Life Protection Act “Levels of Protection” model projections. Since environmental factors are consistent in northern California, they can be expected to have similar impacts on human behavior, and we expect similar results across northern California beaches. This study explores an entirely new construct for estimating and analyzing northern California beach behavior and use. In conclusion, this study provides a model for other citizen monitoring projects on the north coast and provides empowerment to Native peoples to conduct their own studies.

Subject Areas: Marine Protected Area; False Klamath Rock; Tribes; Statistical baseline data

Availability: Maloney, R.A. and Corbett, J.W. (2021). “California North Coast Vehicle and Human Use Beach Survey of False Klamath Cove.” *IdeaFest: Interdisciplinary Journal of Creative Works and Research from Humboldt State University*, *5*.
https://digitalcommons.humboldt.edu/ideafest/vol5/iss1/9/

6.37. Title: Gender Differences in Elderly Mobility in the United States

Author(s): Mitra, S., Yao, M., and Ritchie, S.G.

Abstract: Mobility is a critical element of one's quality of life regardless of age. Although the challenges for women are more significant than those for men as they age, far less is known about the gender differences in mobility patterns of older adults, especially in the U.S. context. This paper reports on a study that examined potential gender gaps in mobility patterns of older adults (aged 65 years and over) in the United States by analyzing data from the 2017 National Household Travel Survey. Elderly respondents were first classified into one of six clusters based on sociodemographic variables. A structural equation model (SEM) was then estimated and showed that gender gaps existed in the mobility patterns of the elderly, and the differences were diverse across the different clusters. The most substantial gender gap was found in the Senior Elder with Medical Condition(s) cluster, followed by the High-Income Workers cluster and the Middle-Income Urban Residents cluster. In contrast, females in the Low-Income Single Elder cluster enjoyed statistically significant positive mobility differences with their male counterparts. Our results also found that female elderly in the Senior Elder with Medical Condition(s) and the Low-Income Family Elder clusters suffered most after the cessation of driving, with the largest mobility gender gap in the Middle-Income Urban Resident cluster. This study will help transportation planners and policymakers understand gender and other sociodemographic differences in elderly mobility. Thus, it will facilitate the development of measures to improve elderly mobility and reduce gender gaps by recognizing and addressing specific target groups' mobility characteristics and needs rather than treating the elderly as a single potential user group.

Subject Areas: Elderly people; Older adults; Women; Gender gap; Mobility; Clustering analysis; Structural equation modeling

Availability: Mitra, S., Yao, M., and Ritchie, S.G. (2021). "Gender Differences in Elderly Mobility in the United States." *Transportation Research Part A: Policy and Practice*, *154*, pp. 203–226. https://doi.org/10.1016/j.tra.2021.10.015

6.38. Title: Unauthorized Immigrants' Access to Driver's Licenses and Auto Insurance Coverage

Author(s): Churchill, B.F., Mackay, T., and Tan, B.Y.

Abstract: Fourteen States and the District of Columbia allow unauthorized immigrants to obtain driver's licenses. Using variation in the timing and location of these policy changes, we show these Unauthorized Immigrant License Polices (UILPs) are associated with a 1-percent increase in both the number of licensed drivers and liability insurance coverage, although we do not document a statistically significant relationship with auto insurance claims. Nor do we detect a significant relationship between UILPs and the number of miles driven, vehicle registrations, air quality, or travel behaviors. Overall, our results are consistent with UILPs licensing unauthorized immigrants who were already driving.

Subject Areas: Unauthorized immigrants; Driver's licenses; Liability insurance coverage; Unauthorized Immigrant License Polices

Availability: Churchill, B.F., Mackay, T., and Tan, B.Y. (2021). "Unauthorized Immigrants' Access to Driver's Licenses and Auto Insurance Coverage." *Contemporary Economic Policy*, *39*(1), pp. 107–125. https://doi.org/10.1111/coep.12492

6.39. Title: Assessing the Role of Shared Mobility Services in Reducing Travel-Related Greenhouse Gases (GHGs) Emissions: Focusing on America's Young Adults

Author(s): Wang, K., Liu, H., Cheng, L., Bian, Z., and Circella, G.

Abstract: This study analyzes the relation between shared mobility services and greenhouse gas (GHG) emissions by using a nationally representative sample of U.S. young adults. We conduct a comprehensive analysis based on the data collected in the 2017 National Household Travel Survey (NHTS). These trip-level emissions are calculated following MOtor Vehicle Emission Simulators (MOVES) and Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model (GREET) workflows. We find that the weekday sample has a significantly higher value in daily GHG emissions than the weekend sample. Controlling for other factors, shared micromobility services usage is found to have a significant impact on daily GHGs emissions for both weekday and weekend travel. Our analyses further indicate that car-sharing complements public transit, and its users are more likely to reside in areas with better public transit supply. We find that the use of transportation network companies (TNCs) has a positive relationship with young adults' GHG emissions on weekdays only. The study results and implications may be useful for planners and professionals interested in tracking the impacts of new mobility services on transportation and the relevant environmental outcomes.

Subject Areas: Shared mobility; National Household Travel Survey (NHTS); Greenhouse gas (GHG) emissions; Young adults

Availability: Wang, K., Liu, H., Cheng, L., Bian, Z., and Circella, G. (2021). "Assessing the Role of Shared Mobility Services in Reducing Travel-Related Greenhouse Gases (GHGs) Emissions: Focusing on America's Young Adults." *Travel Behaviour and Society*, *26*, pp. 301–311. https://doi.org/10.1016/j.tbs.2021.10.005

6.40. Title: Developing Strategies to Enhance Mobility and Accessibility for Community-Dwelling Older Adults

Author(s): Hyun, K., Lee, K., Krejci, C., Gibson, N.O., and Saha, T.

Abstract: Mobility disparities among older adults affect their ability to travel and access services. This project seeks to understand challenges, barriers, and gaps that older adults experience and develop forms of assistance or educational strategies to fill the varying mobility gaps and meet mobility needs. This study characterizes older adults' use of existing and potential transportation options, including conventional transit, paratransit, and ride-hailing systems, based on surveys collected from 146 low-income older adults in Dallas, TX. Using the survey data and interview data, we develop two mathematical modeling (a Latent Class Cluster Analysis and agent-based modeling [ABM]) and conduct content analysis to understand low-income older adults' mode choice decisions, adoption likelihoods based on their barriers to existing mobility options, and socioeconomic characteristics. Three primary personas are identified as the voice of the most vulnerable non-driver, community-dwelling older adults. The quantitative mapping of their needs to the transportation options available to them (public transit, paratransit, taxi, ride-share, and rides with family and friends) indicates that none of the existing options meets all of their mobility needs. Through the interviews during the pandemic, the research team found that both drivers and non-driver older adults reduced their trip frequency and depended on family and friends for essential needs. In particular, older adults developed their fear of using public transit and paratransit because they were concerned about other passengers not maintaining social distance. One of the noticeable differences is that older adults started to use ride-hailing services, and some even preferred it to public transit. Perceptual and knowledge barriers appear to be reduced to adopt ride-hailing, although financial and technology barriers still exist. Based on the findings, we discussed several strategies that can potentially reduce observed barriers and challenges and enhance mobility to ultimately increase social equity across transportation disadvantaged populations, particularly among low-income older adults.

Subject Areas: Low-income older adults; Mobility; Mode; Barriers; Equity; Urban transportation

Availability: Hyun, K., Lee, K., Krejci, C., Gibson, N.O., and Saha, T. (2021). *Developing Strategies to Enhance Mobility and Accessibility for Community-Dwelling Older Adults*. Final Report, Transportation Research and Education Center (TREC), Portland, OR. https://dx.doi.org/10.15760/trec.267

6.41. Title: Using Pupil Transportation Data to Explore Educational Inequities and Outcomes: A Case Study from New York City

Author(s): Cordes, S., Trajkovski, S., Rick, C., Weinstein, M., and Schwartz, A.E.

Abstract: This article explores how researchers can use pupil transportation data to explore key questions about the role of transportation in educational access and equity, such as how students get to school and the effect of transportation on student outcomes. We first describe different sources of transportation data that are available to researchers, provide a brief review of relevant literature, and discuss potential sources of measurement error in pupil transportation data. Next, we use administrative data from New York City to illustrate how pupil transportation data can be used to understand transportation eligibility and assignment as well as to describe the characteristics of students' commutes to school. For example, we find that not all students assigned for free transportation take it up. Specifically, although 47 percent of K–12 students in 2017 were eligible for pupil transportation based on distance, with another 9 percent of students receiving exceptions, only 45 percent of students were assigned to a full-fare MetroCard, general education bus, or special education bus. Further, we find the average commute to school for walkers and bus riders is quite similar—around 30 minutes—although there is wide variation, as some students experience very short or very long commutes. We end with a discussion of the importance of the institutional context when conducting research using pupil transportation data and best practices when using administrative data.

Subject Areas: Education; Pupil transportation; School bus; Commuting

Availability: Cordes, S., Trajkovski, S., Rick, C., Weinstein, M., and Schwartz, A.E. (2021). "Using Pupil Transportation Data to Explore Educational Inequities and Outcomes: A Case Study from New York City." *Center for Policy Research*, *376*. https://surface.syr.edu/cpr/376

6.42. Title: Investigating Walking and Biking Activities Among Low-Income African Americans

Author(s): Sadeghvaziri, E.

Abstract: Different transportation organizations have collected various data related to walk and bike trips. However, few studies have investigated various aspects of walk and bike trips among different races and different household income groups. The main goal of this study is to explore the number of walk trips, number of walk trips for exercise, number of bike trips, number of bike trips for exercise, and bike-share program usage among different household income groups and different races. To conduct the statistical analysis, the research team used the latest National Household Travel Survey (NHTS) dataset, which is the largest and the most valid national transportation-related dataset in the United States. The novelties of this study are to investigate the newly walk-related and bike-related attributes in the 2017 NHTS and focus on different household income groups and different races. The primary contribution of this study is to provide a deeper insight into bike travel and bike travel behavior among different household income groups and different races in the United States, which can assist the authorities and transportation planners in prioritizing investment in bike infrastructure.

Subject Areas: Bicycling; Income; Race; Travel behavior; Travel surveys; Walking

Availability: Sadeghvaziri, E. (2021). *Investigating Walking and Biking Activities Among Low-Income African Americans*. Research in Progress, The National Academies of Sciences, Engineering, and Medicine, Washington, DC. https://rip.trb.org/view/1873116

6.43. Title: Analysis of Activity-Travel Patterns and Tour Formation of Transit Users

Author(s): McNally, M.G. and Rafiq, R.

Abstract: This study analyzed the complex travel behavior of transit users by expanding conventional trip-based approaches by considering full activity-travel tours and patterns as basic units of analysis. A tour was defined as a sequence of trips that begins and ends at home, and a pattern was defined as an entire day's sequence of activities and associated travel. We considered basic descriptive analyses to first analyze work tours—the tours that contain at least one work activity—of transit commuters and then used structural equation modeling to identify the factors that determine the work tour choices. Latent Class Analysis (LCA) was then used to describe the pattern behaviors of all transit users. The results obtained using the 2017 National Household Travel Survey dataset suggested that 80 percent of work tours consisted of seven dominant tours and that work tour choice was influenced by a set of sociodemographics, built environment, and activity-travel characteristics. The LCA model suggested that transit users can be divided into five distinct classes—namely, regular 9-to-5 commuters, after-work stop commuters, multimodal multiple trip makers, morning non-work travelers, and recurrent transit users—where each class had a representative activity travel pattern. The results can help transit agencies to identify transit user groups with particular activity patterns and to consider market strategies to address user travel needs and to improve the quality of services provided.

Subject Areas: Transit; Travel behavior; Commuters; Travel patterns

Availability: McNally, M.G. and Rafiq, R. (2021). *Analysis of Activity-Travel Patterns and Tour Formation of Transit Users*. Final Report, University of Southern California, Los Angeles, CA. https://rosap.ntl.bts.gov/view/dot/58490

6.44. Title: An Electric Vehicle Rideshare Business Model: Transportation Network Company Pilot Program Providing Electric Vehicles for Low-Income Rideshare Driver Use

Author(s): Torti, M.

Abstract: Ride-share services are a significant part of the transportation mix, increasing vehicle emissions that cause environmental and social impacts. According to the California Air Resource Board (CARB), transportation network company (TNC) fleet emissions per passenger mile traveled are 50 percent higher than the statewide passenger vehicle average. Ride-share-related emissions are significant, projected to account for 19 percent of vehicle miles traveled (VMT) by 2040 (Atlas Public Policy, 2019). The ride-share industry is now regulated in California to reduce 90 percent of vehicle emissions by 2030 (CARB). Reportedly, only 0.2 percent of TNC vehicles were electric as of 2018 (International Council on Clean Transportation, 2019). Additionally, low-income ride-share drivers face barriers to accessing electric vehicles and electric vehicle charging, further complicating achieving regulatory mandates.

This project identifies the barriers to electric vehicle charging and electric vehicles. The paper provides a business model outline for the transportation network company industry that identifies criteria and location of pilot sites for ride-share electric vehicle fleets with EV charging ability in low-income communities. The project also outlines the estimated costs of this pilot project, the expected income and appreciation on investments, and a proposed public rebate program to incentivize the private sector deployment of EV fleets at identified sites.

Subject Areas: Transportation network company; Transportation mix; Low-income ride-share drivers; Electric vehicle

Availability: Torti, M. (2021). *An Electric Vehicle Rideshare Business Model: Transportation Network Company Pilot Program Providing Electric Vehicles for Low-Income Rideshare Driver Use*. Capstone Papers, University of California, San Diego, CA.
https://escholarship.org/uc/item/9tq8g3dm

Chapter 7. Survey, Data Synthesis, and Other Applications

7.1. Title: Response Willingness in Consecutive Travel Surveys: An Investigation Based on the National Household Travel Survey Using a Sample Selection Model

Author(s): Wang, X., Shawm F., and Watkins, K.

Abstract: Declining survey response rates have increased the costs of travel survey recruitment. Recruiting respondents based on their expressed willingness to participate in future surveys, obtained from a preceding survey, is a potential solution but may exacerbate sample biases. In this study, we analyze self-selection biases of survey respondents recruited from the 2017 U.S. National Household Travel Survey (NHTS) who had agreed to be contacted again for follow-up surveys. We apply a probit with sample selection (PSS) model to analyze Georgia respondents' willingness to participate in a follow-up survey and their actual response behavior once contacted. Results verify the existence of self-selection biases, which are related to survey burden, sociodemographic characteristics, travel behavior, and item non-response to sensitive variables. We find that age, homeownership, and medical conditions have opposing effects between respondents' willingness to participate and actual survey participation. Six model performance measures are summarized based on the PSS model structure: log-likelihood, McFadden's pseudo R-squared, information criteria, point-biserial correlation coefficient, root mean squared error, and success table. The PSS model is then applied and validated using holdout samples to examine the representativeness of predicted respondents compared to the corresponding population. We also summarize predictive applications of the PSS model in different survey recruitment contexts. Overall, this study provides insight into self-selection biases that exist in respondents who are recruited from preceding travel surveys. Model results can help researchers better understand and address such biases, while the nuanced application of various model performance measures lays a foundation for appropriate comparison across PSS models.

Subject Areas: Respondent recruitment; Probit with sample selection model; Response behavior; Survey participation

Availability: Wang, X., Shawm F., and Watkins, K. (2021). *Response Willingness in Consecutive Travel Surveys: An Investigation Based on the National Household Travel Survey Using a Sample Selection Model.* Transportation Research Board 100th Annual Meeting—A Virtual Event, Washington, DC. https://annualmeeting.mytrb.org/OnlineProgram/Details/15843

7.2. Title: A Statistical Approach to Small Area Synthetic Population Generation as a Basis for Carless Evacuation Planning

Author(s): Nejad, M.M., Erdogan, S., and Cirillo, C.

Abstract: Natural or man-made hazards that require evacuation put already vulnerable populations in a more precarious situation. However, when plans and decisions about evacuation are made, the assumption of access to a private car is typically made, and differences in income levels across a community are rarely accounted for. The result is that carless members of a community can find themselves stranded. Low-income carless residents need alternative transportation means to reach shelters in case of an emergency. Thus, evacuation plans, decisions, and models need necessary information that identifies and locates these populations. In this paper, data from the American Community Survey, U.S. Census, Internal Revenue Services, and the National Household Travel Survey are used to generate synthetic population for Anne Arundel County, MD, using the copula concept. Geographic locations of low-income residents are identified within each subarea of the county (census tract), and their car ownership is estimated with a binomial logit model. The developed population synthesis method will allow officials to have a more accurate account of disadvantaged populations for emergency planning and identify locations of shelters, triage points as well as planning carless transportation services.

Subject Areas: Synthetic population; Archimedean copulas; Accessibility; Car-ownership models; Evacuation planning; Low-income; Carless

Availability: Nejad, M.M., Erdogan, S., and Cirillo, C. (2021). "A Statistical Approach to Small Area Synthetic Population Generation as a Basis for Carless Evacuation Planning." *Journal of Transport Geography*, *90*. https://doi.org/10.1016/j.jtrangeo.2020.102902

7.3. Title: Improved Travel Demand Modeling with Synthetic Populations

Author(s): Wang, K., Zhang, W., Mortveit, H., and Swarup, S.

Abstract: We compare synthetic population-based travel demand modeling with the state-of-the-art travel demand models used by metropolitan planning offices in the United States. Our comparison of the models for three U.S. cities shows that synthetic population-based models match the state-of-the-art models closely for the temporal trip distributions and the spatial distribution of destinations. The advantages of the synthetic population-based method are that it provides greater spatial resolution, can be generalized to any region, and can be used for studying correlations with demographics and activity types, which are useful for modeling the effects of policy changes.

Subject Areas: Travel demand; Transportation; Synthetic population

Availability: Wang, K., Zhang, W., Mortveit, H., and Swarup, S. (2021). "Improved Travel Demand Modeling with Synthetic Populations." *Multi-Agent-Based Simulation XXI*, *12316*, pp. 94–105. https://doi.org/10.1007/978-3-030-66888-4_8

7.4. Title: A Cost-Effective Methodology to Compare Travel Time and Speed: A Tale of 11 Cities

Author(s): Sabet, S., Namdarpour, F., and Mesbah, M.

Abstract: Urban commuters and road authorities are interested in knowing how well their city stands when traffic conditions are considered. It is challenging to make a fair comparison among global cities due to the absence of a consistent, publicly accessible, and inexpensive framework. This study proposes a methodology to compare travel time and average speed in different cities. Large cities have a central core, in which many of the major activities take place. This core is called downtown or the Central Business District (CBD). In this study, a comparison is made by simulating the morning commute trips from origins outside to destinations inside the CBD. The proposed framework outlines how the city and the CBD borders are defined. The data is collected by an accessible location service (Google Maps Distance Matrix API). The framework is conducted on 11 major cities from the 5 continents, namely Cairo, London, Los Angeles, Melbourne, Moscow, New York, Paris, Singapore, Sydney, Tehran, and Toronto. As such, Singapore and Cairo had the shortest, while London and Paris had the longest travel times. According to the distribution graphs of average speed and travel time, Asian and African cities experienced a relatively higher average speed and a lower travel time.

Subject Areas: Traffic engineering; Information technology; Transportation planning; Transportation management

Availability: Sabet, S., Namdarpour, F., and Mesbah, M. (2021). "A Cost-Effective Methodology to Compare Travel Time and Speed: A Tale of 11 Cities." *Proceedings of the Institution of Civil Engineers –Municipal Engineer*, Ahead of Print, pp. 1–24.
https://doi.org/10.1680/jmuen.20.00038

7.5. Title: Robust Bayesian Inference for Big Data: Combining Sensor-based Records with Traditional Survey Data

Author(s): Rafei, A., Flannagan, C.A.C., West, B.R., and Elliott, M.R.

Abstract: Big Data often presents as massive non-probability samples. Not only is the selection mechanism often unknown, but larger data volume amplifies the relative contribution of selection bias to total error. Existing bias adjustment approaches assume that the conditional mean structures have been correctly specified for the selection indicator or key substantive measures. In the presence of a reference probability sample, these methods rely on a pseudo-likelihood method to account for the sampling weights of the reference sample, which is parametric in nature. Under a Bayesian framework, handling the sampling weights is an even bigger hurdle. To further protect against model misspecification, we expand the idea of double robustness such that more flexible non-parametric methods as well as Bayesian models can be used for prediction. In particular, we employ Bayesian additive regression trees, which not only capture non-linear associations automatically but permit direct quantification of the uncertainty of point estimates through its posterior predictive draws. We apply our method to sensor-based naturalistic driving data from the second Strategic Highway Research Program using the 2017 National Household Travel Survey as a benchmark.

Subject Areas: Big data; Non-probability sample; Quasi-randomization; Prediction model; Doubly robust; Augmented inverse propensity weighting; Bayesian additive regression trees

Availability: Rafei, A., Flannagan, C.A.C., West, B.R., and Elliott, M.R. (2021). *Robust Bayesian Inference for Big Data: Combining Sensor-based Records with Traditional Survey Data*. arXiv preprint, arXiv:2101.07456 [stat.ME]. https://arxiv.org/abs/2101.07456

7.6. Title: Checking in on America's "Data Infrastructure"

Author(s): Ryssdal, K. and Hollenhorst, M.

Abstract: Blog.

Subject Areas: Interview; Government data infrastructure; U.S. statistical system

Availability: Ryssdal, K. and Hollenhorst, M. (2021). "Checking in on America's 'Data Infrastructure.'" *Marketplace*. https://www.marketplace.org/2021/02/11/checking-in-on-americas-data-infrastructure/

7.7. Title: Measuring Global Multi-Scale Place Connectivity using Geotagged Social Media Data

Author(s): Li, Z., Huang, X., Ye, X., Jiang, Y., Yago, M., Ning, H., Hodgson, M.E., and Li, X.

Abstract: Shaped by human movement, place connectivity is quantified by the strength of spatial interactions among locations. For decades, spatial scientists have researched place connectivity, applications, and metrics. The growing popularity of social media provides a new data stream where spatial social interaction measures are largely devoid of privacy issues, easily assessable, and harmonized. In this study, we introduced a global multi-scale place connectivity index (PCI) based on spatial interactions among places revealed by geotagged tweets as a spatiotemporal-continuous and easy-to-implement measurement. The multi-scale PCI, demonstrated at the U.S. county level, exhibits a strong positive association with SafeGraph population movement records (10 percent penetration in the U.S. population) and Facebook's social connectedness index (SCI), a popular connectivity index based on social networks. We found that PCI has a strong boundary effect and that it generally follows the distance decay, although this force is weaker in more urbanized counties with a denser population. Our investigation further suggests that PCI has great potential in addressing real-world problems that require place connectivity knowledge, exemplified with two applications: (1) modeling the spatial spread of COVID-19 during the early stage of the pandemic and (2) modeling hurricane evacuation destination choice. The methodological and contextual knowledge of PCI, together with the launched visualization platform and open-sourced PCI datasets at various geographic levels, are expected to support research fields requiring knowledge in human spatial interactions.

Subject Areas: Place connectivity; Spatial interaction; Big data; Twitter; SafeGraph; Facebook social connectedness index

Availability: Li, Z., Huang, X., Ye, X., Jiang, Y., Yago, M., Ning, H., Hodgson, M.E., and Li, X. (2021). *Measuring Global Multi-Scale Place Connectivity using Geotagged Social Media Data*. arXiv preprint, arXiv:2102.03991 [cs.SI]. https://arxiv.org/abs/2102.03991

7.8. Title: A Risk Management Database Framework Implementation for Transportation Asset Management

Author(s): Nlenanya, I. and Smadi, O.

Abstract: A 2017 survey of the state of practice on how agencies are developing their risk-based asset management plan shows that State highway agencies are increasingly adapting the way they do business to include explicit considerations of risks. At the moment, this consideration of risk is not linked to data. Hence, there is a lack of integration of risk management in driving strategic cross-asset programming and decision-making. This paper proposes and implements a risk management database framework as the missing piece in the full implementation of a risk-based transportation asset management program. This risk management database framework utilizes Geographic Information Systems (GIS) and Application Programming Interface (API) to implement a risk management database of all the relevant variables an agency needs for risk modeling to improve risk monitoring, risk register updates, and decision-making. This approach allows the use of existing enterprise as well as legacy data collection systems, which eliminates the need for any capital-intensive implementation cost. Furthermore, it provides transportation agencies with the ability to track risk in quantitative terms, a framework for prioritizing risk, and the development of an actionable plan for risk mitigation. In this paper, the implementation of the fully integrated GIS-enabled risk management database employs the Iowa Department of Transportation (DOT) data and risk register.

Subject Areas: Risk management database; Transportation asset management; Framework; Data integration; Database design; Risk registers; Geographic Information Systems

Availability: Nlenanya, I. and Smadi, O. (2021). "A Risk Management Database Framework Implementation for Transportation Asset Management." *CivilEng*, *2*(1), pp. 193–213. https://doi.org/10.3390/civileng2010011

7.9. Title: The Fourth Amendment in the Digital Age

Author(s): Hecht-Felella, L.

Abstract: The Fourth Amendment stands for the principle that the Government generally may not search its people or seize their belongings without appropriate process and oversight. Today, we are at a jurisprudential inflection point as courts grapple with when and how the Fourth Amendment should apply to the data generated by technologies like cell phones, smart cars, and wearable devices. These technologies — which we rely on for enhanced communication, transportation, and entertainment — create detailed records about our private lives, potentially revealing not only where we have been but also our political viewpoints, consumer preferences, people with whom we have interacted, and more. The resulting trove of information is immensely valuable to law enforcement for use in investigations and prosecutions, and much of it is currently available without a warrant.

This paper describes how the U.S. Supreme Court's 2018 decision in *Carpenter v. United States* has the potential to usher in a new era of Fourth Amendment law. In Carpenter, the Court considered how the Fourth Amendment applies to location data generated when cell phones connect to nearby cell towers. The Court ultimately held that when the government demanded seven days of location information from defendant Timothy Carpenter's cell phone provider without a warrant, it violated the Fourth Amendment. The decision sits at the intersection of two lines of cases: those that examine location tracking technologies, like beepers or the Global Positioning System (GPS), and those that discuss what expectation of privacy is reasonable for information disclosed to third parties, like banks or phone companies. In reaching its conclusion that a warrant was required, the Court upended existing precedent, ruling for the first time that location information maintained by a third party was protected by the Fourth Amendment.

In exploring the Court's decision in *Carpenter* and its application to data from a variety of technologies — such as GPS, automated license plate readers (ALPRs), and wearables — this paper argues that it is incumbent on courts to preserve the balance of power between the people and the government as enshrined in the Fourth Amendment, which was intended to "place obstacles in the way of a too permeating police surveillance."[2] Moreover, in determining the scope of the Constitution's protections for data generated by digital technologies, courts should weigh the five factors considered in *Carpenter*: the intimacy and comprehensiveness of the data, the expense of obtaining it, the retrospective window that it offers to law enforcement, and whether it was truly shared voluntarily with a third party. Section I is an overview of Fourth Amendment jurisprudence. Section II discusses the *Carpenter* decision and its takeaways. Section III applies *Carpenter* to various surveillance technologies and looks ahead at how Fourth Amendment jurisprudence might continue to develop in the digital age.

Subject Areas: Location information; Tracking technologies; Privacy; Fourth Amendment

Availability: Hecht-Felella, L. (2021). *The Fourth Amendment in the Digital Age.* Brennan Center for Justice, New York University, New York, NY. https://www.brennancenter.org/sites/default/files/2021-03/Fourth-Amendment-Digital-Age-Carpenter.pdf

7.10. Title: Capturing Multitasking and The Role of Travel Time in the Digital Era

Author(s): Varghese, V. and Jana, A.

Abstract: Time has always been considered as a limited resource. People distribute the limited 24 hours in a day to various activities to fulfill their needs. Leisure activities, also known as discretionary activities, include social activities such as meeting friends and family and recreational activities such as going to the cinema. People distribute the 24 hours in each day to each of these activity types based on their wants and needs. Every person uses different resources to produce goods, which provide them their earnings. In the simplest terms, multitasking could be defined as doing multiple things simultaneously. The term was first used to describe the simultaneous execution of computer activities, after which it was co-opted and is now being commonly used concerning people's activity participation and time allocation behavior. Travel is one of the few activities which provide the scope of unrestricted participation in multitasking activities.

Subject Areas: Discretionary activities; Multitasking; Activity participation; Time allocation behavior

Availability: Varghese, V. and Jana, A. (2021). "Capturing Multitasking and The Role of Travel Time in the Digital Era." *Advances in Urban Planning in Developing Nations*, Routledge India, London. https://www.taylorfrancis.com/books/edit/10.4324/9781003091370/advances-urban-planning-developing-nations-arnab-jana

7.11. Title: Urban Metabolism

Author(s): Derrible, S., Cheah, L., Arora, M., and Yeow, L.W.

Abstract: Urban metabolism (UM) is fundamentally an accounting framework whose goal is to quantify the inflows, outflows, and accumulation of resources (such as materials and energy) in a city. The main goal of this chapter is to offer an introduction to UM. First, a brief history of UM is provided. Three different methods to perform an UM are then introduced: the first method takes a bottom-up approach by collecting/estimating individual flows; the second method takes a top-down approach by using nation-wide input–output data; and the third method takes a hybrid approach. Subsequently, to illustrate the process of applying UM, a practical case study is offered using the city-state of Singapore as an exemplar. Finally, current and future opportunities and challenges of UM are discussed. Overall, by the early 21st century, the development and application of UM have been relatively slow, but this might change as more and better data sources become available and as the world strives to become more sustainable and resilient.

Subject Areas: Urban metabolism; Accumulation of resources; Bottom-up approach; Top-down approach; Hybrid approach

Availability: Derrible, S., Cheah, L., Arora, M., and Yeow, L.W. (2021). "Urban Metabolism." *Urban Informatics*, pp. 85–114. The Urban Book Series. Springer, Singapore. https://doi.org/10.1007/978-981-15-8983-6_7

7.12. Title: Spatio-Temporal Analysis of Freight Flows in Southern California

Author(s): Rivera-Royero, D., Jaller, M., and Kim, C.

Abstract: This paper analyses the spatio-temporal patterns of freight flows in Southern California using weigh-in-motion (WIM) data between 2003 and 2015. The study explores the spatial relationships between truck volumes, load ratios, and gross vehicle weights for different vehicle classes, through econometric and centrographic analyses during the study period. Overall, the results confirmed the existence of the logistics sprawl phenomenon, highlighted the effect of the 2008 to 2009 major recession in the concentration of freight facilities and flows, indicated that the changes in flow patterns vary for different vehicle classes, and found low vehicle capacity utilization for light- (WIM classes 5–7) and medium- (WIM classes 8–10) heavy-duty trucks, though recently improving. These results are consistent with the growth in residential deliveries owing to e-commerce, showing increased light-heavy-duty trucks flows concentrated closer to the consumption areas, and experiencing larger flow reductions compared to heavy vehicle flows as the distance from the area increases; and showing that medium-heavy-duty vehicles used in both full-truck-load, and less-than-truck-load vocations are prevalent throughout the study area, whereas there is a trade-off between light- and heavy-heavy duty trucks (WIM classes 11–13) at the proximity, and the outskirts of the consumption markets, respectively. Moreover, the study shows the usefulness of the WIM data in identifying spatial and temporal dynamics in freight demand, providing additional information for planning, maintenance, and rehabilitation of the infrastructure. More importantly, the results, coupled with other evidence from the literature, show how major disruptions such as the recession significantly affect truck traffic.

Subject Areas: Spatio-temporal patterns; Freight flows; Weigh-in-motion; Truck traffic

Availability: Rivera-Royero, D., Jaller, M., and Kim, C. (2021). "Spatio-Temporal Analysis of Freight Flows in Southern California." *Transportation Research Record: Journal of the Transportation Research Board*. https://doi.org/10.1177%2F03611981211004130

7.13. Title: Working from Home: Small Business Performance and the COVID-19 Pandemic

Author(s): Zhang, T., Gerlowski, D., and Acs, Z.

Abstract: During the COVID-19 pandemic, many firms began operating in a working-from-home environment (WFH). This study focuses on the relationship between WFH and small business performance during the pandemic. We built a theoretical framework based on firm profit maximization, compiled an up-to-date (March through November) real-time daily and weekly multifaceted data set, and empirically estimated fixed-effect panel data, fractional logit, and multilevel mixed effects models to test our hypotheses. We find that in states with higher WFH rates, small businesses performed better overall with industry variations, controlling for the local pandemic, economic, demographic, and policy factors. We also find that WFH rates increased even after stay-at-home orders (SHOs) were rescinded. With the ready technology and practice of WFH in the pandemic, our robust empirics confirm our theory and hypotheses and demonstrate WFH as a potential force that may expedite "creative destruction" instance and permanently impact industrial structure and peoples' work lives.

Subject Areas: Work from home; COVID-19; Small business; Stay-at-home order

Availability: Zhang, T., Gerlowski, D., and Acs, Z. (2021). "Working from Home: Small Business Performance and the COVID-19 Pandemic." *Small Business Economics*. https://doi.org/10.1007/s11187-021-00493-6

7.14. Title: An Inductive Experimental Approach to Developing a Web-Based Travel Survey Builder: Developing Guidelines to Design an Efficient Web-Survey Platform

Author(s): Chung, B., Srikukenthiran, S., Miller, E.J., and Habib, K.N.

Abstract: The Household Travel Survey (HTS) is the most widely used passenger travel data collection method, and web-based HTS is currently the most dominant survey mode. However, there is a lack of proper understanding on how much the web-based approach can be used without over-burdening respondents. This study investigates methods to improve web-based HTS data quality and to reduce response burdens. It presents the lessons learned from the development and field experiment of a web survey builder. A particular focus is on designing and testing a trip diary interface through usability tests. These tests include a mouse-movement tracking study, mock web-based HTS experiments with responsive designs, and the use of a route planner application programming interface (API). Results show that creating responsive designs for web-surveys based on screen size can significantly increase completion rates and improve the usability. Collecting detailed routes with a route planner API suggesting most likely routes does not significantly increase respondent fatigue. However, it significantly improves data quality. Household size and the age of the survey respondent are significant contributing factors to survey drop-off rates and respondent fatigue. The paper contributes to the literature on household travel surveys by providing evidence-based design guidelines for web-survey interfaces.

Subject Areas: Survey methods; Web survey; Trip diary; Usability; Testing; Respondent burden; Design guidelines

Availability: Chung, B., Srikukenthiran, S., Miller, E.J., and Habib, K.N. (2021). "An Inductive Experimental Approach to Developing a Web-Based Travel Survey Builder: Developing Guidelines to Design an Efficient Web-Survey Platform." *Transportation Planning and Technology*, *44*(5), pp. 487–502. https://doi.org/10.1080/03081060.2021.1927303

7.15. Title: Supplementing Transportation Data Sources with Targeted Marketing Data: Applications, Integration, and Internal Validation

Author(s): Shaw, F.A., Wang, X., Mokhtarian, P.L., and Watkins, K.E.

Abstract: Unlike many third-party data sources, targeted marketing (TM) data constitute holistic datasets, with disaggregate variables – ranging from socioeconomic and demographic characteristics to attitudes, propensities, and behaviors – available for most individuals in the population. These qualities, along with ease of accessibility and relatively low acquisition costs, make TM data an attractive source for the supplementation of traditional transportation survey data, which are facing growing threats to quality. This paper develops a typology demonstrating ways in which TM data can aid in the design of transport studies, as well as in the augmentation of modeling efforts and policy scenarios, allowing for improved understanding and forecasting of travel-related attributes. However, challenges associated with integrating, validating, and understanding TM variables have resulted in only a few transportation studies that have used these data thus far. In this paper, we provide a transportation discipline-specific resource for TM data, informed by our integration of an extensive TM database with both the National Household Travel Survey (Georgia subset) and a statewide travel behavior survey conducted in Georgia on behalf of the Georgia Department of Transportation. Using the resultant datasets, we validate TM data by means of several approaches, and find that the TM dataset reports gender, age, tenure, race, marital status, and household size with match rates ranging from 70% to 90% relative to both transportation surveys. However, we also identify biases in favor of population segments that may have more longstanding financial/transactional records (e.g., males, homeowners, non-minorities, and older individuals), biases comparable but not identical to those of survey data. While this work suggests wide-ranging implications for the use of TM data in transportation, we caution that flexible and responsible approaches to using these data are critical for staying abreast of evolving privacy regulations that govern third-party data sources such as these.

Subject Areas: Consumer data; Targeted marketing data; Travel behavior; National Household Travel Survey; Big data; Third-party data; Travel demand modeling

Availability: Shaw, F.A., Wang, X., Mokhtarian, P.L., and Watkins, K.E. (2021). "Supplementing Transportation Data Sources with Targeted Marketing Data: Applications, Integration, and Internal Validation." *Transportation Research Part A: Policy and Practice*, *149*, pp. 150–169. https://doi.org/10.1016/j.tra.2021.04.021

7.16. Title: A Dynamic Tree Algorithm for Peer-to-Peer Ride-sharing Matching

Author(s): Yao, R. and Bekhor, S.

Abstract: On-demand peer-to-peer ride-sharing services provide flexible mobility options and are expected to alleviate congestion by sharing empty car seats. An efficient matching algorithm is essential to the success of a ride-sharing system. The matching problem is related to the well-known dial-a-ride problem, which also tries to find the optimal pickup and delivery sequence for a given set of passengers.

In this paper, we propose an efficient dynamic tree algorithm to solve the on-demand peer-to-peer ride-sharing matching problem. The dynamic tree algorithm benefits from given ride-sharing driver schedules, and provides satisfactory runtime performances. In addition, an efficient pre-processing procedure to select candidate passenger requests is proposed, which further improves the algorithm performance.

Numerical experiments conducted in a small network show that the dynamic tree algorithm reaches the same objective function values of the exact algorithm but with shorter runtimes. Furthermore, the proposed method is applied to a larger size problem. Results show that the spatial distribution of ride-sharing participants influences the algorithm performance. Sensitivity analysis confirms that the most critical ride-sharing matching constraints are the excess travel times. The network analysis suggests that small vehicle capacities do not guarantee overall vehicle-kilometer travel savings.

Subject Areas: Dynamic tree; Peer-to-peer ride-sharing; Ride-sharing matching; Vehicle routing problem

Availability: Yao, R. and Bekhor, S. (2021). *A Dynamic Tree Algorithm for Peer-to-Peer Ride-sharing Matching*. arXiv preprint, arXiv:2105.13078 [cs.DS]. https://arxiv.org/abs/2105.13078

7.17. Title: Computational Graph-based Framework for Integrating Econometric Models and Machine Learning Algorithms in Emerging Data-driven Analytical Environments

Author(s): Kim, T., Zhou, X., and Pendyala, R.M.

Abstract: In an era of big data and emergence of disrupting mobility technologies, statistical models have been utilized to uncover the influence of significant factors, and machine learning algorithms have been used to explore complex patterns in large datasets. Focusing on discrete choice modeling applications, this research aims to introduce computational graph (CG)-based frameworks for integrating the strengths of econometric models and machine learning algorithms. Specifically, multinomial logit (MNL), nested logit (NL), and integrated choice and latent variable (ICLV) models are selected to demonstrate the performance of the graph-oriented functional representation. Furthermore, the calculation of gradients in the log-likelihood function is accomplished using automatic differentiation (AD). Using the 2017 National Household Travel Survey data and synthetic datasets, we compare estimation results from the proposed methods with those obtained from Biogeme and Apollo. The results indicate that the CG-based choice modeling approach can produce consistent estimates of parameters with substantial computational efficiency.

Subject Areas: Computational graphs; Automatic differentiation; Multinomial logit; Nested logit; Integrated choice and latent variable; Gradient calculation

Availability: Kim, T., Zhou, X., and Pendyala, R.M. (2021). "Computational Graph-based Framework for Integrating Econometric Models and Machine Learning Algorithms in Emerging Data-driven Analytical Environments." *Transportmetrica A: Transport Science*. https://doi.org/10.1080/23249935.2021.1938744

7.18. Title: Respondent Recruitment to Consecutive Travel Surveys: Exploring Sample Representativeness and Travel Behavior Model Quality Using Sample Selection Models

Author(s): Wang, X.

Abstract: Declining survey response rates have increased the costs of travel survey recruitment. Recruiting respondents based on their expressed willingness to participate in future surveys, obtained from a preceding survey, is a potential solution but may exacerbate sample biases. In this thesis, we analyze self-selection biases of survey respondents recruited from the 2017 U.S. National Household Travel Survey (NHTS), who had agreed to be contacted again for follow-up surveys. We apply a probit with sample selection (PSS) model to analyze respondents' willingness to participate in a follow-up survey and their actual response behavior once contacted. Results verify the existence of self-selection biases, which are related to survey burden, sociodemographic characteristics, travel behavior, and item non-response to sensitive variables. The PSS model is then validated using a hold-out sample and applied to the NHTS samples from various geographic regions to predict follow-up survey participation. Effect size indicators suggest that resulting samples may be most biased along age and education dimensions. We further summarized six model performance measures based on the PSS model structure. Lastly, we analyze the consequence of self-selection biases by assessing their influence on travel behavior models developed on the sample recruited through the proposed method. We recommend applying the sample selection model to correct for such biases when the data are available. Otherwise, sample weights should be applied when the unweighted sample would produce inconsistent coefficient estimates. However, if the Hausman test supports the consistency of the estimated parameters, unweighted regression models should be preferred to avoid inefficient estimates.

Overall, this study provides insight into the self-selection biases associated with respondents recruited from preceding travel surveys. The PSS model results can help researchers better understand and address such biases, while the nuanced application of various model measures lays a foundation for appropriate comparison across sample selection models. This is the first study, to our knowledge, that uses the PSS model to analyze sample biases residing in consecutive survey recruitment.

Subject Areas: Probit with sample selection model; Self-selection biases; Sample biases

Availability: Wang, X. (2021). *Respondent Recruitment to Consecutive Travel Surveys: Exploring Sample Representativeness and Travel Behavior Model Quality Using Sample Selection Models*. Master's Thesis, Georgia Institute of Technology, Atlanta, GA. https://smartech.gatech.edu/bitstream/handle/1853/64659/WANG-THESIS-2021.pdf?sequence=1

7.19. Title: Residential Location and Household Spending: Exploring the Relationship Between Neighborhood Characteristics and Transportation and Housing Costs

Author(s): Schouten, A.

Abstract: Using data from the Panel Study of Income Dynamics and a seven-category neighborhood typology, this analysis examines the relationship between urban form and household spending. Results suggest that poor households living in urban areas have lower transportation expenditures than their counterparts in sprawling suburbs. Lower transportation costs, however, do not offset high housing prices, with poor households paying particularly high premiums for housing in the densest, most transit-rich neighborhoods. Households above the poverty threshold also benefit from reductions in transportation costs, especially in intensely urban areas. Nevertheless, these low transportation costs are not associated with lower overall expenditures; instead, they countervail high housing premiums, meaning that the most transit-rich neighborhoods do not offer cost savings relative to other neighborhood types. Findings highlight the need to expand the supply of both transit and housing in communities where poor households can leverage affordable transportation options to reduce their combined expenditure burden.

Subject Areas: Residential location; Location efficiency; Transportation expenditures; Housing expenditures; Built environment

Availability: Schouten, A. (2021). "Residential Location and Household Spending: Exploring the Relationship Between Neighborhood Characteristics and Transportation and Housing Costs." *Urban Affairs Review*. https://doi.org/10.1177/10780874211028814

7.20. Title: ODT FLOW: A Scalable Platform for Extracting, Analyzing, and Sharing Multi-source Multi-scale Human Mobility

Author(s): Li, Z., Huang, X., Hu, T., Ning, H., Ye, X., and Li, X.

Abstract: In response to the soaring needs of human mobility data, especially during disaster events such as the COVID-19 pandemic, and the associated big data challenges, we develop a scalable online platform for extracting, analyzing, and sharing multi-source multi-scale human mobility flows. Within the platform, an origin-destination-time (ODT) data model is proposed to work with scalable query engines to handle heterogenous mobility data in large volumes with extensive spatial coverage, which allows for efficient extraction, query, and aggregation of billion-level origin-destination (OD) flows in parallel at the server-side. An interactive spatial web portal, ODT Flow Explorer, is developed to allow users to explore multi-source mobility datasets with user-defined spatiotemporal scales. To promote reproducibility and replicability, we further develop ODT Flow REST APIs that provide researchers with the flexibility to access the data programmatically via workflows, codes, and programs. Demonstrations are provided to illustrate the potential of the APIs integrating with scientific workflows and with the Jupyter Notebook environment. We believe the platform coupled with the derived multi-scale mobility data can assist human mobility monitoring and analysis during disaster events such as the ongoing COVID-19 pandemic and benefit both scientific communities and the general public in understanding human mobility dynamics.

Subject Areas: Population movement; Social media; SafeGraph; Workflow; Origin-destination-time cube

Availability: Li, Z., Huang, X., Hu, T., Ning, H., Ye, X., and Li, X. (2021). *ODT FLOW: A Scalable Platform for Extracting, Analyzing, and Sharing Multi-source Multi-scale Human Mobility*. arXiv preprint, arXiv:2104.05040 [cs.DC]. https://arxiv.org/abs/2104.05040

7.21. Title: Deriving the Traveler Behavior Information from Social Media: A Case Study in Manhattan with Twitter

Author(s): Zhang, Z.

Abstract: Social media platforms, such as Twitter, provide a totally new perspective in dealing with the traffic problems and is anticipated to complement the traditional methods. The geo-tagged tweets can provide the Twitter users' location information and is being applied in traveler behavior analysis. This paper explores the full potentials of Twitter in deriving travel behavior information and conducts a case study in Manhattan Area. A systematic method is proposed to extract displacement information from Twitter locations. Our study shows that Twitter has a unique demographics which combine not only local residents but also the tourists or passengers. For individual user, Twitter can uncover his/her travel behavior features including the time-of-day and location distributions on both weekdays and weekends. For all Twitter users, the aggregated travel behavior results also show that the time-of-day travel patterns in Manhattan Island resemble that of the traffic flow; the identification of OD pattern is also promising by comparing with the results of travel survey.

Subject Areas: Twitter; Displacement; Travel behavior; Manhattan; Travel survey

Availability: Zhang, Z. (2021). *Deriving the Traveler Behavior Information from Social Media: A Case Study in Manhattan with Twitter*. arXiv preprint, arXiv:2101.11482 [cs.SI]. https://arxiv.org/abs/2101.11482

7.22. Title: Inferring Twitters' Socio-demographics to Correct Sampling Bias of Social Media Data for Augmenting Travel Behavior Analysis

Author(s): Cui, Y. and He, Q.

Abstract: Many studies demonstrated that social media data, especially Twitter data, have significant potentials to develop models for estimating travel demand, managing operation, and conducting long-term planning purposes. However, it is well known that research with social media data is facing a looming challenge in sampling bias. The Twitter user's population has huge discrepancies compared with the overall population. Therefore, social media data, when it is directly used for travel behavior analysis, contains biases and errors to some degree. The objective of this study is to correct sampling bias of Twitter data for travel behavior analysis by inferring Twitter users' socio-demographics. This study first links travelers' Twitter account with their Facebook account, and verifies their socio-demographics by Facebook data, assuming that one's Facebook information is real. Second, several models are proposed for predicting socio-demographics, including gender, age, ethnicity, and education levels. Afterward, this paper resamples social media data and compares it to the 2009 California Household Travel Survey data. The resampled data show comparable characteristics to the survey data. This research shed light on tackling sampling bias issues when social media data are incorporated for augmenting travel behavior analysis and urban planning.

Subject Areas: Social media data; Twitter; Socio-demographics; Sampling bias correction; Travel behavior

Availability: Cui, Y. and He, Q. (2021). "Inferring Twitters' Socio-demographics to Correct Sampling Bias of Social Media Data for Augmenting Travel Behavior Analysis." *Journal of Big Data Analytics in Transportation*. https://doi.org/10.1007/s42421-021-00037-0

7.23. Title: Development of Grass-Roots Data Collection Methods in Rural, Isolated, and Tribal Communities

Author(s): Chang, K. and Hodgson, C.

Abstract: While extensive procedures have been developed for the collection and dissemination of motor vehicle volumes and speeds, these same procedures cannot always be used to collect pedestrian data, given the comparably unpredictable behavior of pedestrians and their smaller physical size. There is significant value to developing lower cost, lower intrusion methods of collecting pedestrian travel data, and these collection efforts are needed at the local or "grassroots" level. While previous studies have documented many different data collection methods, one newer option considers the use of drones. This study examined its feasibility to collect pedestrian data and used this technology as part of a school travel mode case study. Specific information with regard to the study methodology, permissions required, and final results are described in detail as part of this report.

This study concluded that while purchasing and owning a drone requires relatively minimal investment, the initial steps required to operate a drone, along with processing time required to analyze the data collected, represent up-front barriers that may prevent widespread usage at this time. However, the use of drones and the opportunities that it presents in the long-term offer promising outcomes.

Subject Areas: Drones; Pedestrian data collection; School travel mode

Availability: Chang, K. and Hodgson, C. (2021). *Development of Grass-Roots Data Collection Methods in Rural, Isolated, and Tribal Communities*. University of Alaska Fairbanks, Fairbanks, AK. https://cset.uaf.edu/media/284442/1904_cset_grassroots_final.pdf

7.24. Title: Application of the DNAS Framework Expansion to Occupant Population Synthesis

Author(s): Chandra Putra, H. and Hong, T.

Abstract: Research in occupant behavior is now using a more elaborate framework of building occupant interaction. Researchers often face challenges in collecting data, particularly for the data to meet the minimum number of required data points and the data interoperability requirements. Researchers address the first issue with the synthetic population and the latter with data ontologies. While synthetic population is commonly used to address the first issue, data ontology development is used to address the latter. The two solutions are complementary to each other. One of the known ontologies in building occupant behavior research is the Drivers-Needs-Actions-Systems (DNAS) ontology, which has been used by building modelers to describe energy-related occupant behavior. This paper describes the ontology-based synthetic population generation that can be used in the agent-based modeling (ABM) applications. This paper considers multiple data sources, including ASHRAE Thermal Comfort DB II and IEA Annex 66 datasets. A case study of an office building is used to present the workflow of DNAS framework expansion, synthetic population generation, and agent-based modeling.

Subject Areas: Occupant behavior; Data ontology; Drivers-Needs-Actions-Systems; Synthetic population generation; Agent-based modeling

Availability: Chandra Putra, H. and Hong, T. (2021). *Application of the DNAS Framework Expansion to Occupant Population Synthesis*. Lawrence Berkeley National Laboratory, Berkeley, CA. https://www.osti.gov/servlets/purl/1807527

7.25. Title: Deriving the Value of Time of Heterogenous Users for Toll Revenue Forecasting Using Multiple Criteria Decision Making

Author(s): Shelton, J.

Abstract: Mathematical traffic models replicate travel decisions and driver behavior. These traffic modeling tools have become more sophisticated, yet they remain simplified representations of more complex systems, including associated toll revenue forecasts. Literature review shows that a substantial amount of toll revenue forecasts has fallen short of actual road usage—sometimes as much as 50 percent. In recent years, simulation-based modeling tools have emerged as an innovative approach to regional traffic forecasting. They capture time-varying traffic conditions and represent more realistic traffic flow and congestion, but this type of travel forecasting is mostly used in university-based research.

One key variable in these traffic modeling tools is the value of time (VoT). The VoT represents how drivers perceive their monetary worth and their willingness to pay a toll to reduce their travel time. Quantifying the VoT is still not completely understood, but it is the governing factor in how toll revenue forecasts are calculated. The VoT used in traditional toll revenue forecasts is a single value for each vehicle class (e.g., single occupancy passenger vehicles) based on aggregated socioeconomic data (i.e., distribution among all income levels). However, encompassing additional factors, including trip purpose, can supplement VoT quantification.

How a traveler perceives his VoT per trip purpose varies based on different factors (e.g., congestion levels, destination). The variation of these factors suggests that trip purpose can be proportionally weighted. However, there is no literature on weighting trip purpose criteria, combined with zonal-based socioeconomic data, for toll revenue forecasting using a regional simulation-based modeling approach.

This research outlines a new multiple-criteria decision-making (MCDM) approach for deriving zone-based VoT for passenger cars using both trip purpose and zone-based socioeconomic data. MCDM is a branch of operations research models that deal with decision problems in the presence of multiple, often conflicting, criteria. One method of MCDM, analytical hierarchy process (AHP), uses structured techniques to organize complex decisions based on mathematics and psychology. AHP considers a set of evaluation criteria and a set of alternative options using pair-wise comparisons of each set of criteria. This research uses AHP to determine weights of alternative trip purposes (e.g., home-work, work-home, home-other) by decomposing a decision problem into a hierarchy of more easily comprehended subproblems. The weighted trip purpose is combined with zonal sociodemographic data to derive zone-based VoTs for toll revenue forecasting.

This methodology will be tested using a simulation-based dynamic traffic assignment (DTA) model. Models will be calibrated to before construction of toll road conditions using existing traffic data (volume). An alternative scenario is developed with a toll road constructed and the zone-based VoTs implemented into the tolling algorithm. The methodology was also utilized to develop road user costs during work zone construction.

Subject Areas: Value of time; Dynamic traffic assignment; Toll revenue forecasting; Multiple criteria decision making; Road user cost

Availability: Shelton, J. (2021). *Deriving the Value of Time of Heterogenous Users for Toll Revenue Forecasting Using Multiple Criteria Decision Making*. Doctoral Dissertation, New Mexico State University, Las Cruces, NM. https://www.proquest.com/openview/8898879fb6cfc0d47146a3fe984e5685/1.pdf?pq-origsite=gscholar&cbl=18750&diss=y

7.26. Title: How Does Traffic, or the Fear of It, Affect Housing Affordability? Examining the Effect of Traffic Impact Analysis on Housing Production and Affordability

Author(s): Ding, H. and Taylor, B.D.

Abstract: Traffic impact analysis (TIA), which estimates the traffic impacts of proposed land development, tends to bias against higher density developments in urban areas where traffic is often congested and travel alternatives plentiful. This has important implications for housing supply and affordability, suburban sprawl, and private vehicle dependence. We examine the understudied implication of TIA on housing by drawing on empirical evidence from distinct bodies of research in the transportation and land use planning literatures to describe the mechanisms through which TIA may affect housing market conditions. We conclude that TIAs likely have negative effects on urban housing production and affordability.

Subject Areas: Traffic impact analysis; Housing affordability; Traffic congestion

Availability: Ding, H. and Taylor, B.D. (2021). *How Does Traffic, or the Fear of It, Affect Housing Affordability? Examining the Effect of Traffic Impact Analysis on Housing Production and Affordability*. Working Paper, Institute of Transportation Studies, UCLA, Los Angeles, CA. https://escholarship.org/uc/item/6h47h1ts

7.27. Title: Modeling Intrazonal Distance and Duration in Addressing Limitation of Intrazonal Generalized Cost Commonly Applied in Transport Models

Author(s): Alam, S., Siddle, D., and Colleary, B.

Abstract: The intrazonal modeling parameters of distance, duration, and generalized cost (GC) are conventionally estimated from a fixed-fraction of interzonal parameters or using linear equations. In this study, the intrazonal GC that was developed in the National Transport Authority's (NTA's) regional modeling system using a conventional fixed-fraction method (base) was compared to intrazonal GCs for six travel modes (passenger cars, bus, cycle, walk, taxi [passenger] and light goods vehicles) that were estimated using zonal GC equations adopted from literature. The zone-specific distance and duration values for the parameters of the six equations were developed using a regression modeling approach. At first, National Household Travel Survey (NHTS) data, Open Street Map, and traffic zone data were used to generate regression models. The reported trip duration and distance of NHTS datasets were then replaced with the corresponding time and coordinate defined distances and durations from the Google Maps Journey Time and Distance Estimates (GMJTDE) records, and the estimated equations from this process produced better validation performance, and thus integrated with the six equations. In the comparison stage, intrazonal GC values were estimated for all six modes using two different analyses and compared against the base dataset. In the first analysis, average distances and duration were obtained for all zones containing intrazonal trips and were directly applied in the six equations to estimate intrazonal GCs. In the second analysis, intrazonal GCs were estimated using models based on the aforementioned NHTS-GMJTDE datasets. Results indicate that the intrazonal GC estimated using the second analysis matched the intrazonal GC from the conventional method and provided an indication of real-world situations to some extent. This study confirms that intrazonal parameters can be developed separately from the survey data, minimizing the efforts of calibration with sufficient accuracy that cannot be obtained directly from the survey data.

Subject Areas: Travel mode; Traffic impact analysis; Google Maps Journey Time and Distance Estimate; Intrazonal generalized cost

Availability: Alam, S., Siddle, D., and Colleary, B. (2021). "Modeling Intrazonal Distance and Duration in Addressing Limitation of Intrazonal Generalized Cost Commonly Applied in Transport Models." *Journal of Transportation Engineering, Part A: Systems*, *147*(10). https://ascelibrary.org/doi/abs/10.1061/JTEPBS.0000573

7.28. Title: Towards Resilience with Simulations for Accessing Recovery of Critical Infrastructure Systems from Natural Hazard Damage

Author(s): McElwee, M.L.

Abstract: As communities continue shifting toward urban lifestyles in the future, the impact of natural disasters grows significantly. This is because, while economic vitality should be an important factor for any population, an urban community offers a centralized location for people, vehicles, assets, and infrastructure to become quickly overwhelmed in the event of a disaster. After an event, communities must sustain resources (energy, transportation, communication, food, etc.) while adapting to and recovering from adverse economic, geographic, and climate-related catastrophes. A global analysis on 616 of the world's largest metropolitan areas exposed to flooding, wind hazards, earthquakes, and other disasters found that building cities that are more resilient is the priority. In the future, communities must be prepared to deal with multiple hazards.

Community resilience planners must coordinate hazard preparedness: prevention, mitigation, protection, response, and recovery. Impacts from extreme wind hazards remain a primary cause for last-mile distribution systems failures of above-ground electric power and telecommunication networks. Chapter 3 extends previous analysis developed by researchers at the Center for Risk-Based Community Resilience Planning, led by Colorado State University, by implementing a new infrastructure (telecommunication) and developing a restoration prioritization strategy. For new and future construction, resilience planning includes land use, codes and standards, and performance objectives related to the role, service, or function of the system in the community, including their recovery after disruptive events.

With communities continuing to shift toward living in urban areas, the threat of wildfire increases near the wild-land urban interface. This concentration of human-built structures and infrastructures are near areas prone to wildfire. Chapter 4 extends on work published in 2019 by using agent-based modeling of large-scale transportation networks to implement two dynamic traffic simulations as opposed to a static simulation. In evacuation transportation literature, dynamic traffic simulations are typically chosen for their ability to model congestion, which is crucial for understanding community travel patterns. Six in-person field trips were taken to the fire-impacted region to obtain crucial information for re-creating network dynamics (road closure, background traffic, and green light ratio). The field trips were integral in developing a preliminary timeline and identifying critical decision points in response operation. Interviews with key stakeholders, such as the mayor's office, fire department, law enforcement, and engineering services, provided many responses that became inputs for the model.

Located near the mouth of the Mississippi River, New Orleans is known for its inequities among racial groups. Hurricane Katrina was a call to action for Government and industry organizations the disastrous effects of inadequate support for vulnerable populations during and after a hazardous event. Prior to Hurricane Katrina in 2005, African Americans had long been viewed as disenfranchised and responsible for bearing more environmental consequences of natural hazards than their fellow residents. Much scholarship exists on examining the impact of natural hazards to communities like New Orleans. Chapter 5 is focused on quantifying the disproportionate impact groups such as African Americans have when facing natural hazards such as flash floods,

hurricanes, and coastal erosion. This research also contributes to the understanding of how shelter locations may negatively impact work trip flows after a significantly disruptive event.

After the introduction in chapter 1, chapter 2 presents a literature review on community resilience, environmental justice, and street network analysis. These topics are studied to define current knowledge and substantive finds as well as situate this work's contribution to existing knowledge. The origin, evolution, and issues of environmental justice that have plagued New Orleans are summarized in the literature review to set the motivation for work in chapter 5. Multiple open-source platforms and models are used to analyze resilience metrics for communities.

Subject Areas: Community resilience; Evacuation; Infrastructure; Environmental justice; Street network analysis; Agent-based modeling

Availability: McElwee, M.L. (2021). *Towards Resilience with Simulations for Accessing Recovery of Critical Infrastructure Systems from Natural Hazard Damage*. Doctoral Dissertation, University of California, Berkeley, CA. https://escholarship.org/uc/item/4p69t8d6

7.29. Title: High Performance Agent-Based Modeling to Study Realistic Contact Tracing Protocols

Author(s): Hoops, S. et al.

Abstract: Contact tracing (CT) is an important and effective intervention strategy for controlling an epidemic. Its role becomes critical when pharmaceutical interventions are unavailable. CT is resource intensive, and multiple protocols are possible, and therefore the ability to evaluate strategies is important. We describe a high-performance, agent-based simulation model for studying CT during an ongoing pandemic. This work was motivated by the COVID-19 pandemic; however, framework and design are generic and can be applied in other settings.

This work extends our HPC-oriented ABM framework EpiHiper to efficiently represent contact tracing. The main contributions are: (i) extension of EpiHiper to represent realistic CT processes and (ii) realistic case study using the VA network motivated by our collaboration with the Virginia Department of Health.

Subject Areas: Contact tracing; COVID-19; Epidemic control; Agent-based simulation model

Availability: Hoops, S. et al. (2021). *High Performance Agent-Based Modeling to Study Realistic Contact Tracing Protocols*. The 2021 Winter Simulation Conference, Phoenix, AZ. https://nssac.bii.virginia.edu/~swarup/papers/hoops_etal_wsc2021.pdf

7.30. Title: Large Carnivore Response to Human Road Use Suggests a Landscape of Coexistence

Author(s): Kautz, T.M., Fowler, N.L., Petroelje, T.R., Beyer, D.E., Svoboda, N.J., and Belant, J.L.

Abstract: Coexistence between humans and large carnivores may depend on carnivore adaptations to use developed landscapes while reducing human encounters. Roads are a widespread form of human development that carnivores may perceive as efficient travel routes or centers of human activity and associated risk. We compared the spatio-temporal responses of carnivores to human road use with high-resolution tracking of a large carnivore guild, including American black bears (*Ursus americanus*), bobcats (*Lynx rufus*), coyotes (*Canis latrans*), and wolves (*C. lupus*) in Michigan, USA. All carnivores selected for roads when traveling at night but avoided roads during the day when human activity was greatest. Human activity explained 90 percent of temporal variation in road use across carnivore species, with a 3.2- to 3.7-fold increase in road use at times of low human activity, which reduced carnivore activity overlap with humans by 27 to 42 percent. Similar but less pronounced activity changes occurred in areas up to 500 meters from roads. Bears and wolves increased nocturnal activity with more roads in their home range, but not bobcats or coyotes. Despite increased diurnal activity in areas farther from roads, temporal overlap among carnivores was high regardless of road proximity. Our results suggest that spatio-temporal responses to roads were similar among carnivores and emphasized avoidance of humans over other carnivore species. Further, we provide support that carnivores can be diurnally active while avoiding humans by using areas farther from roads. However, carnivores which are primarily diurnal (e.g., black bears) or have a strong proclivity for using roads (e.g., wolves) likely require greater behavioral changes to avoid humans. Behavioral adaptations allowing multiple species to use and cross roads while avoiding humans are encouraging for human-carnivore coexistence.

Subject Areas: *Canis latrans*; *Canis lupus*; Human disturbance; *Lynx rufus*; Movement ecology; Temporal activity; Roads; *Ursus americanus*

Availability: Kautz, T.M., Fowler, N.L., Petroelje, T.R., Beyer, D.E., Svoboda, N.J., and Belant, J.L. (2021). "Large Carnivore Response to Human Road Use Suggests a Landscape of Coexistence." *Global Ecology and Conservation*, *30*. https://doi.org/10.1016/j.gecco.2021.e01772

7.31. Title: Joint Optimization of School Bus Routes and Last-Mile Services

Author(s): Zhang, P., Wang, H., Hao, H., and Li, Z.

Abstract: School bus routing across multiple districts requires the coordination of many resources. In this project, the authors plan to understand the challenges in current school bus routing in Allegheny County, PA, and improve the mobility of students via decision analytical models and deployment of information technology tools. The main focus is to find efficient, safe, and implementable multimodal transportation methods to help children move to and from schools. Last-mile and first-mile transportation is an existing problem in this context due to the 1- to 2-mile walking distance between home and bus stops for some students, which poses safety and accessibility concerns. The goal is to design an analytical model to support the joint optimization of bus routes and last-mile and first-mile mobility services for students and provide a deployment technology that can help connect students, parents, buses, and ride-sharing services to achieve reliable transportation. In addition, the authors also provide an analytical tool to efficiently check the feasibility of route sharing between schools and school districts.

Subject Areas: Ride-sharing; Ride-sourcing; Routes and routing; School buses; School trips

Availability: Zhang, P., Wang, H., Hao, H., and Li, Z. (2021). *Joint Optimization of School Bus Routes and Last-Mile Services*. The National Academies of Sciences, Engineering, and Medicine, Washington, DC. https://trid.trb.org/view/1870305

7.32. Title: A Distributed Algorithm for Operating Large-Scale Ridesourcing Systems

Author(s): Zhang, R. and Masoud, N.

Abstract: With ride-sourcing services gaining popularity in the past few years, there has been growing interest in algorithms that could enable real-time operation of these systems. As ride-sourcing systems rely on independent entities to build the supply and demand sides of the market, they have been shown to operate more successfully in metropolitan areas where there is a high level of demand for rides as well as a high number of drivers and a large volume of trips occurring within a geographically constrained region. Despite the suitable ecosystem that metropolitan areas offer for ride-sourcing operations, there is a lack of methods that can provide high-quality matching solutions in real time. To fill this gap, this paper introduces a framework that allows for solving the large-scale matching problems by means of solving smaller problems in a distributed fashion. The proposed methodology is based on constructing approximately uniform clusters of trip requests, where vehicle tours form cluster centers. Using the New York Taxi dataset, we compare the performance of the proposed methodology against three benchmark methods to showcase its advantages in terms of solution quality and solution time.

Subject Areas: Ride-sourcing systems; Real-time operation; High-quality matching solutions; Approximately uniform clusters; New York Taxi dataset

Availability: Zhang, R. and Masoud, N. (2021). "A Distributed Algorithm for Operating Large-Scale Ridesourcing Systems." *Transportation Research Part E Logistics and Transportation Review*, *156*(3).
https://www.researchgate.net/publication/354693589_A_Distributed_Algorithm_for_Operating_Large-Scale_Ridesourcing_Systems

7.33. Title: Generating a Synthetic Probabilistic Daily Activity-Location Schedule Using Large-Scale, Long-Term and Low-Frequency Smartphone GPS Data with Limited Activity Information

Author(s): Cui, Y., He, Q., and Bian, L.

Abstract: Household travel survey data is a critical input to travel behavior modeling and it also can be used to generate trip schedules for activity-based traffic simulation. With emerging information and communication technology (ICT) tools like smartphones, the collection of passive datasets for travelers' real-time information becomes available. Smartphone GPS survey apps have emerged to be a popular tool for conducting household travel surveys. Most existing studies employ high-frequency smartphone GPS data and collect accurate activity information. However, their study periods are still rather short, ranging from a few days to a few weeks. For a long-term GPS survey, the issues of missing activity information and sparse GPS data are inevitable and must be addressed carefully. This paper uses 7-month low-frequency smartphone GPS data collected from over 2,000 participants, who report five most frequently visited locations weekly. The essential goal is to develop a synthetic model of daily activity-location scheduling to capture data with both known and unknown activities. To handle missing activity data, this research develops a new probabilistic approach, which measures the probability of visiting a place by three scores: global visit score (GVS), temporal visit score (TVS), and periodical visit score (PVS). Three different levels of activity-location schedule are modeled respectively. The first level handles only those data with known activities, while data with unknown activities are disregarded. The second takes unknown activities into account but combines all types of them into a single category. The third one models each location with unknown activities separately. These models are able to generate activity-location schedule in different levels of detail for activity-based traffic simulator. After developing activity-location schedule models, both individual and aggregated validation processes are performed with simulation. The validation result shows that the simulated proportion of activity types and activity duration are close to the survey data, indicating the effectiveness of the proposed approaches. This research sheds a light on building sustainable and long-term travel survey using GPS data with missing activity information. In addition, this study will be valuable to model infectious disease transmission, e.g., COVID-19, and assess health risk in urban areas.

Subject Areas: Smartphone GPS data; Travel survey; Activity-location schedule; Activity-based simulator

Availability: Cui, Y., He, Q., and Bian, L. (2021). "Generating a Synthetic Probabilistic Daily Activity-Location Schedule Using Large-Scale, Long-Term and Low-Frequency Smartphone GPS Data with Limited Activity Information." *Transportation Research Part C: Emerging Technologies*, *132*. https://doi.org/10.1016/j.trc.2021.103408

7.34. Title: Improvement of the Georgia Statewide Travel Demand Model (GSTDM): Phase 2

Author(s): Circella, G., Choi, S., Etezady, A., Widita, A., and Todd, K.

Abstract: This report details a number of proposed improvements in the Georgia Statewide Travel Demand Model (GSTDM) using the 2017 National Household Travel Survey (NHTS) and its Georgia add-on portion. These improvements include (1) the development of a vehicle ownership model and a time-of-day segmentation, (2) estimating and evaluating a destination choice model, and (3) investigating a mode choice model for the GSTDM. Considering the importance of these model improvements, the research team conducted extensive reviews of the state of research and practice on the mentioned topics, augmented the 2017 NHTS data with other relevant data sources, developed appropriate methodologies, and presented the results and discussed their application in the GSTDM in this report.

Subject Areas: Georgia Statewide Travel Demand Model; National Household Travel Survey; Travel demand; Mode choice; Vehicle ownership; Destination choice

Availability: Circella, G., Choi, S., Etezady, A., Widita, A., and Todd, K. (2021). *Improvement of the Georgia Statewide Travel Demand Model (GSTDM): Phase 2*. Final Report, Georgia Institute of Technology, Atlanta, GA. https://g92018.eos-intl.net/eLibSQL14_G92018_Documents/18-08.pdf

7.35. Title: Agent-Based Computational Epidemiological Modeling

Author(s): Bissett, K.R., Cadena, J., Khan, M., and Kuhlman, C.J.

Abstract: The study of epidemics is useful for not only understanding outbreaks and trying to limit their adverse effects, but also because epidemics are related to social phenomena, such as Government instability, crime, poverty, and inequality. One approach for studying epidemics is to simulate their spread through populations. In this work, we describe an integrated multi-dimensional approach to epidemic simulation, which encompasses (1) a theoretical framework for simulation and analysis; (2) synthetic population (digital twin) generation; (3) (social contact) network construction methods from synthetic populations; (4) stylized network construction methods; and (5) simulation of the evolution of a virus or disease through a social network. We describe these aspects and end with a short discussion on simulation results that inform public policy.

Subject Areas: Computational epidemiology; Discrete dynamical systems; Synthetic populations; Data-driven social network generation; Large-scale stylized network construction; Agent-based simulation; High-performance computing

Availability: Bissett, K.R., Cadena, J., Khan, M., and Kuhlman, C.J. (2021). "Agent-Based Computational Epidemiological Modeling." *Journal of the Indian Institute of Science*, *101*, pp. 303–327. https://doi.org/10.1007/s41745-021-00260-2

7.36. Title: The Transportation Energy and Mobility Pathway Options (TEMPO) Model: Overview and Validation of V1.0

Author(s): Muratori, M., Jadun, P., Bush, B., Hoehne, C., Yip, A., Ledna, C., and Vimmerstedt, L.

Abstract: After over a century of petroleum dominance, the transportation sector is on the verge of radical transformations driven by rapid technology advancements, automation, new mobility options and business models, and policies at all levels of Government. Migrating from a petroleum-based system to alternative fuels will introduce profound changes in technology adoption and create unprecedented integration opportunities.

Subject Areas: Transportation demand model; Time-resolved energy use; Dynamic passenger and freight demand; Technology adoption; Vehicle ownership decisions; Mode choice; Refueling infrastructure; Heterogenous multi-day mobility; Travel requirements

Availability: Muratori, M., Jadun, P., Bush, B., Hoehne, C., Yip, A., Ledna, C., and Vimmerstedt, L. (2021). *The Transportation Energy and Mobility Pathway Options (TEMPO) Model: Overview and Validation of V1.0*. National Renewable Energy Laboratory, Golden, CO. https://www.nrel.gov/docs/fy21osti/80819.pdf

7.37. Title: A Fast Response Multi-Objective Matching Algorithm for Ridesharing

Author(s): Sun, J., Han, N., Huang, J., Deng, J., and Geng, Y.

Abstract: In many metropolitans, especially during rush hours on holidays, thousands of riders will initiate travel orders at the same time, and the existing carpool matching model cannot handle large-scale travel orders quickly enough. For handling this problem, a fast and efficient multi-objective carpool matching algorithm (MOCMA) is put forward, which generates a set of different matching schemes suitable for different practical scenarios. First, the idea of partition is adopted to gather riders and drivers with similar journeys, and the relationship matrix construction algorithm (RMCA) is proposed; Then, from the perspective of riders and drivers, the maximum service quality and the maximum shared mileage are two objectives, and a set of non-dominated solution sets are generated using MOCMA. Finally, the simulation experiment results show that MOCMA proposed is suitable for different practical scenarios; the matching success rate is as high as 99.7 percent, and it has significant advantages over MOEA/D, SPEA2, and FastPGA.

Subject Areas: Ride-sharing; Ride-matching; Multi-objective optimization; Genetic algorithm

Availability: Sun, J., Han, N., Huang, J., Deng, J., and Geng, Y. (2021). "A Fast Response Multi-Objective Matching Algorithm for Ridesharing." *Journal of Internet Technology*, *22*(5), pp. 1109–1118. https://jit.ndhu.edu.tw/article/view/2581

7.38. Title: Efficient Estimation in NPIV Models: A Comparison of Various Neural Networks-Based Estimators

Author(s): Chen, J., Chen, X., and Tamer, E.

Abstract: We investigate the computational performance of artificial neural networks (ANNs) in semi-nonparametric instrumental variables (NPIV) models of high-dimensional covariates that are relevant to empirical work in economics. We focus on efficient estimation of and inference on expectation functionals (such as weighted average derivatives) and use optimal criterion-based procedures (sieve minimum distance, or SMD) and novel efficient score-based procedures (ES). Both these procedures use ANNs to approximate the unknown function. Then, we provide a detailed practitioner's recipe for implementing these two classes of estimators. This involves the choice of tuning parameters both for the unknown functions (that include conditional expectations) but also for the choice of estimation of the optimal weights in SMD and the Riesz representers used with the ES estimators. Finally, we conduct a large set of Monte Carlo experiments that compares the finite-sample performance in complicated designs that involve a large set of regressors (up to 13 continuous) and various underlying nonlinearities and covariate correlations. Some of the takeaways from our results include: (1) tuning and optimization are delicate, especially as the problem is nonconvex; (2) various architectures of the ANNs do not seem to matter for the designs we consider, and given proper tuning, ANN methods perform well; (3) stable inferences are more difficult to achieve with ANN estimators; (4) optimal SMD-based estimators perform adequately; (5) there seems to be a gap between implementation and approximation theory. Finally, we apply ANN NPIV to estimate average price elasticity and average derivatives in two demand examples.

Subject Areas: Artificial neural networks; Rectified linear units; Sigmoid; High-dimensional regressors; Nonparametric instrumental variables; Expectation functionals; Semiparametric efficiency; Price elasticity

Availability: Chen, J., Chen, X., and Tamer, E. (2021). *Efficient Estimation in NPIV Models: A Comparison of Various Neural Networks-Based Estimators*. arXiv preprint, arXiv:2110.06763v2 [econ.EM]. https://arxiv.org/abs/2110.06763v2

7.39. Title: Sociospatial Analysis of Food Pantry Access and Location in a Southwestern Frontier Community

Author(s): Schramski, S., Neighbors, C., Wood, N., and Reyes, F.

Abstract: We explore the relationship between food insecurity and geographic position in Silver City, NM. Using a survey of more than 100 respondents and desktop GIS analysis, we investigate whether distance, neighborhood, and socioeconomic status have a bearing on access and use of food pantries. Results indicate there is no pronounced relationship between recipience of Government benefits and food pantry use, recipience of Government benefits and neighborhood of residence, or household income and self-reported distance to a food pantry. Results may appear counterintuitive: Food pantry use has increased in the United States, but the profile of a pantry client is not axiomatic.

Subject Areas: Food insecurity; Food pantries; Southwest; Sociospatial; Socioeconomic surveys; Government benefits; Ideal location; Transportation analysis; Mobility

Availability: Schramski, S., Neighbors, C., Wood, N., and Reyes, F. (2021). "Sociospatial Analysis of Food Pantry Access and Location in a Southwestern Frontier Community." *Journal of Hunger & Environmental Nutrition*. https://doi.org/10.1080/19320248.2021.1976343

7.40. Title: Spatial Accessibility and Equity Analysis of Amazon Parcel Lockers Facilities

Author(s): Schaefer, J. and Figliozzi, M.

Abstract: The onset of the COVID-19 pandemic has accelerated the growth of e-commerce and home deliveries. Automated parcel lockers are a way to improve delivery efficiency, but despite their rapid growth, little is known about their accessibility and equity impacts. Among e-commerce players in the United States, Amazon stands out by its large market share. This research studies the location of Amazon lockers in Portland, OR, utilizing highway, land use, employment, and sociodemographic datasets. Geographical tools and cluster analysis are utilized to estimate accessibility and equity metrics. Lockers tend to be located in mixed-use areas and can be utilized by a large percentage of the population. However, the equity metrics indicate that the current distribution of lockers could be improved to reach traditionally underserved populations. Given the environmental and economic advantages of lockers, policymakers should encourage the expansion of this type of last-mile solution to avoid market failures in areas that are currently underserved.

Subject Areas: E-commerce; Parcel lockers; Last-mile and urban logistics; Accessibility; Equity; 45 market failure

Availability: Schaefer, J. and Figliozzi, M. (2021). "Spatial Accessibility and Equity Analysis of Amazon Parcel Lockers Facilities." *Journal of Transport Geography*, Forthcoming. https://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=1656&context=cengin_fac

7.41. Title: What Counts as Commute Travel? Identification and Resolution of Key Issues Around Measuring Complex Commutes in the National Household Travel Survey

Author(s): Kash, G. and Mokhtarian, P.L.

Abstract: We use travel diary data from the 2017 National Household Travel Survey (NHTS) Georgia subsample to address critical issues associated with analyzing complex work journeys. To define the work journey, we discuss the importance of defining commute anchors by both purpose and location. We then compare two alternate measures for determining what portion of each journey should be counted as commute distance: the last leg of the journey (the NHTS default), and a modeled counterfactual simple commute to estimate the distance that would have been traveled had no stops been made. The average complex commute distance obtained using the counterfactual method was 63 percent higher than the estimate based on using the last leg alone. Using the last-leg method may understate Georgia's annual commute distance by 2.6 billion miles (10 percent of the total, including both simple and complex commutes). We argue that the last-leg method is not an accurate gauge of work travel, particularly among populations such as women, who are more likely to trip chain on their commutes.

Subject Areas: Work travel; Trip chaining; Commuting; National Household Travel Survey

Availability: Kash, G. and Mokhtarian, P.L. (2021). "What Counts as Commute Travel? Identification and Resolution of Key Issues Around Measuring Complex Commutes in the National Household Travel Survey." *Transportation Research Record: Journal of the Transportation Research Board*. https://doi.org/10.1177%2F03611981211051346

7.42. Title: Household Travel Survey Method for Vehicle Kilometers Travel Estimations: A Case Study in a Developing Country

Author(s): Gunathilakaa, S., Amarasinghaa, N., Dissanayakeb, S., and Lakmalic, M.

Abstract: Vehicle kilometers traveled (VKT) represents number of kilometers traveled by vehicles during a specific period of time in a specific area of concern. Transportation planners, policymakers, urban planners, and estimators of vehicle emission, energy consumption, and fuel price, encourage the calculation of VKT for various analytical purposes. However, in most of the developing countries, VKT is not estimated due to data challenges. This study aimed at proposing a household travel survey method for estimating VKT in developing countries where timely VKT data are not available. Also, estimating personal kilometers traveled (PKT) seems important in developing countries, since the majority is using public and non-motorized transport modes rather than personal vehicles in those countries. This proposed method allows for the collection of data that are needed for estimating both VKT and PKT together with sociodemographic information. A case study was conducted in three different regions: northern, eastern, and southern areas of Sri Lanka, which is a developing country. Questions were asked regarding trips in a typical week, trips in holidays, special seasons or vacations, number of passengers traveled, travel modes, and sociodemographics of the respondent. Pilot surveys were conducted prior to the actual surveys to verify the efficiency of developed questionnaire. Samples were taken satisfying all the selected sociodemographic categories within the community. Collected data through surveys were aggregated to annual level and weighted using relevant Census and population data. Weighted VKT and PKT estimates were obtained under each selected sociodemographic category. Also, VKT estimates were statistically compared for studying the travel behavior of people across different regions. ANOVA and post hoc tests were employed for statistical comparisons. These findings can efficiently be used for transport planning, policymaking activities, emission calculations, energy consumption estimations, etc., by transport and environmental agencies of the country. The case study revealed the experience of utilizing the household travel survey method in Sri Lanka, making it possible to be replicated in other developing countries as well.

Subject Areas: Vehicle kilometers traveled; Developing countries; Household travel survey; Personal kilometers traveled; Transportation planners

Availability: Gunathilakaa, S., Amarasinghaa, N., Dissanayakeb, S., and Lakmalic, M. (2021). "Household Travel Survey Method for Vehicle Kilometers Travel Estimations: A Case Study in a Developing Country." *Transactions on Transport Sciences*, *12*(2), pp. 5–15. https://tots.upol.cz/artkey/tot-202102-0001_household-travel-survey-method-for-vehicle-kilometers-travel-estimations-a-case-study-in-a-developing-country.php

7.43. Title: How Does Machine Learning Compare to Conventional Econometrics for Transport Data Sets? A Test of ML Versus MLE

Author(s): Li, W. and Kockelman, K.M.

Abstract: Machine learning (ML) is being used regularly in many different fields. This paper compares traditional econometric methods that have better explanations of data analysis to ML methods, focusing on predicting, understanding, and unpacking ML methods, which have higher prediction accuracies of four key transport-planning variables: household vehicle-miles traveled (continuous variable), household vehicle ownership (count variable), mode choice (categorical variable), and land use change (categorical variable with strong spatial interactions). Here, the results of 10 ML methods are compared to methods of ordinary least squares (OLS), multinomial logit (MNL), negative binomial, and spatial auto-regressive (SAR). The United States' 2017 National Household Travel Survey and land use datasets from the Dallas-Ft. Worth region of Texas are used. Results suggest traditional econometric methods work pretty well on the more continuous responses (VMT and vehicle ownership), but the random forest (RF), gradient boosting decision trees (GBDTs), and extreme gradient boosting (XGBoost) methods delivered the best results, although the RF model required 30 to almost 60 times more computing time than XGBoost and GBDT methods. The RF, GBDT, XGBoost, light gradient boosting method (lightGBM), and CatBoost offer better results than other methods for the two "classification" cases, with lightGBM being the most time-efficient. Importantly, ML methods captured the plateauing effect modelers may expect when extrapolating covariate effects.

Subject Areas: Machine learning; Artificial intelligence; Econometric methods; Travel behavior prediction; Model estimation comparisons; Ensemble methods

Availability: Li, W. and Kockelman, K.M. (2021). "How Does Machine Learning Compare to Conventional Econometrics for Transport Data Sets? A Test of ML Versus MLE." *Growth and Change*. https://doi.org/10.1111/grow.12587

7.44. Title: Insights on Data Quality from a Large-Scale Application of Smartphone-Based Travel Survey Technology in the Phoenix Metropolitan Area, Arizona, USA

Author(s): Hong, S., Zhao, F., Livshits, V., Gershenfeld, S., Santos, J., and Ben-Akiva, M.

Abstract: Collecting accurate travel data is vital for transportation planning purposes. Regional travel demand forecasts as well as transportation system analyses depend on datasets that provide origins and destinations of travel for various modes, purposes of travel, socioeconomic characteristics of the system users, and other attributes critical for understanding travel demand. GPS-based household travel surveys emerged as a state-of-the-practice method to collect travel data with increased accuracy and detail. The Maricopa Association of Governments conducted a survey utilizing Future Mobility Sensing (FMS) technology. One hundred percent of the sample was collected with the FMS technology platform that combines mobile sensing through a smartphone app with machine learning and a user interface. The technology enables detailed, multi-day, multimodal, user-verified travel and activity behavior data to be obtained with a reduced burden on participants. The data collected through the survey were analyzed together with a comparable dataset obtained through traditional recall-based collection methods during the same time period. The broad conclusions are that the 100 percent of GPS-based surveys with the FMS technology platform provide greater accuracy, detail, and completeness of data, as well as greater flexibility than traditional data collection approaches that rely on participant recall. Emphasis was made on comparative analyses between traditionally collected data and the GPS survey with the FMS technology. The paper systematically identifies and explains differences and provides original analyses that can inform future decision making relevant to similar data collection exercises. The method is particularly applicable for monitoring mobility in the ongoing conditions of rapidly changing travel behavior, especially due to the COVID-19 pandemic.

Subject Areas: Household travel survey; GPS-based surveys; Sensor-based data collection; Future mobility sensing; Activity-based models; Machine learning; Smartphone-based survey

Availability: Hong, S., Zhao, F., Livshits, V., Gershenfeld, S., Santos, J., and Ben-Akiva, M. (2021). “Insights on Data Quality from a Large-Scale Application of Smartphone-Based Travel Survey Technology in the Phoenix Metropolitan Area, Arizona, USA.” *Transportation Research Part A: Policy and Practice*, *154*, pp. 413–429. https://doi.org/10.1016/j.tra.2021.10.002

7.45. Title: Challenges, Issues, and Opportunities in Household Travel Surveys

Author(s): Wang, K.

Abstract: Urban travel demand analysis efforts predominantly use household travel surveys for data supports. However, the data collection method is facing several challenges. First, online household travel surveys have been suffering declining completion rates, raising data quality issues. Second, the practice of large-scale household travel surveys has been plagued by proxy biases and under-representations for specific subgroups of populations for decades. The thesis examines the causality and implications of high survey incompletion rates in online travel surveys and makes recommendations for future practice. The thesis also proposes a hybrid data fusion approach to reduce proxy biases and under-representation in large-scale household travel survey datasets. Besides challenges, online household travel surveys bring unprecedented opportunities due to their operational ease compared to traditional telephone-based surveys. The thesis also presents a case study of an online household travel survey conducted to facilitate policymaking during the COVID-19 pandemic.

Subject Areas: Transportation planning; Travel demand analysis; Travel survey method

Availability: Wang, K. (2021). *Challenges, Issues, and Opportunities in Household Travel Surveys*. Master's Thesis, University of Toronto, Toronto, Canada.
http://hdl.handle.net/1807/109151

7.46. Title: A Systematic Literature Review of Ride-Sharing Platforms, User Factors and Barriers

Author(s): Mitropoulos, L., Kortsari, A., and Ayfantopoulou, G.

Abstract: Aim: Ride-sharing is an innovative on-demand transport service that aims to promote sustainable transport, reduce car utilization, and increase vehicle occupancy and public transport ridership. By reviewing ride-sharing studies around the world, this paper aims to map major aspects of ride-sharing, including online platforms, and user factors and barriers that affect ride-sharing services, and extract useful insights regarding their successful implementation.

Method: A systematic literature review is conducted on scientific publications in the English language. Articles are eligible if they report a study on user factors affecting ride-sharing use and/or barriers preventing ride-sharing implementation; ride-sharing online platforms in these articles are also recorded and are further explored through their official websites. A database is built that organizes articles per author, year, and location; summarizes online platform attributes; and groups user factors associated with the likelihood to ride-share.

Findings: The review shows that the term "ride-sharing" is used in the literature for both profit and non-profit ride-sharing services. In total, 29 ride-sharing online platforms are recorded and analyzed according to specific characteristics. Sixteen user factors related to the likelihood to ride-share are recorded and grouped into sociodemographic, location, and system factors. Although location and system factors are found to follow a pattern among studies, mixed findings are recorded on the relationship between sociodemographic factors and ride-sharing. Factors that may hinder the development of ride-sharing systems are grouped into economic, technological, business, behavioral, and regulatory barriers.

Conclusion: Opportunities exist to improve the quality of existing ride-sharing services and plan successful new ones. Future research efforts should focus toward studying ride-sharing users; trip purpose (i.e., work, university, shopping, etc.), investigating factors associated to ride-sharing before and after implementation of the service, and perform cross-case studies between cities and countries of the same continent to compare findings.

Subject Areas: Ride-sharing; User factors; Platform; Carpooling

Availability: Mitropoulos, L., Kortsari, A., and Ayfantopoulou, G. (2021). "A Systematic Literature Review of Ride-Sharing Platforms, User Factors and Barriers." *European Transport Research Review*, *13*. https://doi.org/10.1186/s12544-021-00522-1

7.47. Title: Predicting Mode Choice on Urban Work Trips by Non-Private Vehicles

Author(s): Chao, Y.

Abstract: In the great metropolitan area, under the low carbon transportation framework and imbalanced job-housing situation, some people choose to travel through non-private vehicles. Some governments would endorse such behavior by all means as congestion gets worse. For this study, the 2017 National Household Travel Survey is selected, targeting the individuals in urban areas who travel by walking, bicycling, public transit, and taxis for their work trips. A discrete choice (multinomial logit), unsupervised (k-means clustering and principal component analysis), and supervised (naïve Bayes classifier and random forest) models are fitted to test the predictive performance, with the vision to deeply master the system partial demand and design a better traveling system for citizens indirectly. The results show that unsupervised methods for predicting work trip mode choices needs to be further discussed while some supervised learning methods could be considered as a promising reference for predicting travel modes.

Subject Areas: Transportation planning; Predicting travel modes; Urban mobility; Non-private vehicles

Availability: Chao, Y. (2021). "Predicting Mode Choice on Urban Work Trips by Non-Private Vehicles." *21st COTA International Conference of Transportation*. https://doi.org/10.1061/9780784483565.208

7.48. Title: The CanBikeCO Mini Pilot: Procedure and Preliminary Results

Author(s): Shankari, K., Duvall, A., and Boyce, L.

Abstract: Presentation.

Subject Areas: COVID-19; Shared mobility; Micromobility; Trips; E-bike program; OpenPATH platform

Availability: Shankari, K., Duvall, A., and Boyce, L. (2021). *The CanBikeCO Mini Pilot: Procedure and Preliminary Results*. Center for Integrated Mobility Sciences, National Renewable Energy Laboratory, Washington, DC. https://www.nrel.gov/docs/fy22osti/80445.pdf

7.49. Title: Combining Probability and Non-Probability Samples

Author(s): Elliott, M., Rafei, A., and Flannagan, C.

Abstract: Presentation.

Subject Areas: Survey sampling methods; Probability and non-probability samples; Applications

Availability: Elliott, M., Rafei, A., and Flannagan, C. (2021). *Combining Probability and Non-Probability Samples*. University of Michigan, Ann Arbor, MI. https://surveydatascience.isr.umich.edu/sites/default/files/Mike%20Elliott%20SLIDES%2012.01.2021_0.pdf

7.50. Title: Integrate Transportation Planning Models with Machine Learning Algorithms: A Computational Graph Framework in a Data-Rich Environment

Author(s): Kim, T.

Abstract: With the advent of new mobility services and technologies, the complexity of understanding the mobility patterns has been gradually intensified. The availability of large datasets, in conjunction with the transportation revolution, has been increased and incurs high computing costs. These two critical challenges require us to methodologically handle complex transportation problems with numerical performance: fast, high-precision solutions and reliable structure under different impact factors. That is, it is imperative to introduce a new type of modeling strategy, advancing the conventional transportation planning models.

In order to do this, we leverage the backbone of the underlying algorithm behind machine learning (ML): computational graph (CG) and automatic differentiation (AD). CG is a directed acyclic graph (DAG) where each vertex represents a mathematical operation, and each edge represents data transfer. AD is an efficient algorithm to analytically compute gradients of necessary functionality. Embedding the two key algorithms into the planning models, specifically parametric-based econometric models and network optimization models, we theoretically and practically develop different types of modeling structures and reformulate mathematical formulations on basis of the graph-oriented representation.

Three closely related analytical and computational frameworks are presented in this dissertation, based on a common modeling methodology of CG abstraction. First, a two-stage interpretable machine learning framework developed by a linear regression model, coupled with a neural network layered by long short-term memory (LSTM) shows the capability of capturing statistical characteristics with enhanced predictability in the context of day-to-day streaming datasets. Second, AD-based computation in estimating for discrete choice models proves more efficiency of handling complex modeling structure than the standard optimization solver relying on numerical gradients, outperforming the standard methods, Biogeme and Apollo. Lastly, CG allows modelers to take advantage of a special problem structure for the feedback loops, a new class of problem reformulation developed through Lagrangian relaxation (LR), which makes the CG-based model well suited for reaching a high degree of the integrated demand-supply consistency.

Overall, the deep integration of the practically important planning models with the underlying computationally efficient ML algorithms can enhance behavioral understanding of interactions in real-world urban systems, and the proposed differentiable mathematical structures will enable transportation decision makers to accurately evaluate different demand-side and supply-side scenarios with a higher degree of convergency and optimality in more complex transportation systems.

Subject Areas: Machine learning algorithms; Large datasets; Computational efficiency

Availability: Kim, T. (2021). *Integrate Transportation Planning Models with Machine Learning Algorithms: A Computational Graph Framework in a Data-Rich Environment*. Doctoral

Dissertation, Arizona State University, Tempe, AZ.
https://www.proquest.com/openview/4a17e287fcde8b41b2a1c9d750ad9aa2/1?pq-origsite=gscholar&cbl=18750&diss=y

7.51. Title: Tolling Lessons Learned for Road Usage Charge

Author(s): Chakraborty, D.

Abstract: Even though plug-in electric vehicles can reduce the problem of greenhouse gas emissions from the transportation sector, externalities like congestion and road damage will exist. Therefore, State transportation agencies will need pricing mechanisms like a per-mile road user charge (RUC), to deal with these externalities while accounting for the transition to an EV-dominated fleet. In this project, focusing on electronic toll collection (ETC) methods, we aim to conduct a thorough review of lessons learned from established tolling systems across the United States and the tolling system in Singapore and London. Post literature review, a multi-criteria performance framework of different tolling mechanisms will be formulated based on criteria such as accuracy of data collection, complexity for regulators and users, compatibility across policy objectives (primarily RUC), and equity. Finally, we aim to identify the best practices in the existing tolling systems for offsetting some of the costs for low-income drivers and demonstrate their effectiveness using travel behavior data from the National Household Travel Survey. A good understanding of the pros and cons of the existing tolling systems will help State transportation agencies investigate the trade-offs of the different tolling systems while designing an RUC.

Subject Areas: Pricing; Toll collection; Toll roads; Urban highways; Construction

Availability: Chakraborty, D. (2021). *Tolling Lessons Learned for Road Usage Charge*. Research in Progress, The National Academies of Sciences, Engineering, and Medicine, Washington, DC. https://rip.trb.org/view/1862632

7.52. Title: Deep Neural Networks for Choice Analysis: A Statistical Learning Theory Perspective

Author(s): Wang, S., Wang, Q., Bailey, N., and Zhao, J.

Abstract: Although researchers increasingly use deep neural networks (DNNs) to analyze individual choices, overfitting and interpretability issues remain obstacles in theory and practice. This study presents a statistical learning theoretical framework to examine the tradeoff between estimation and approximation errors and between the quality of prediction and interpretation. It provides an upper bound on the estimation error of the prediction quality in DNNs, measured by zero-one and log losses, shedding light on why DNN models do not overfit. It proposes a metric for interpretation quality by formulating a function approximation loss that measures the difference between true and estimated choice probability functions. It argues that the binary logit (BNL) and multinomial logit (MNL) models are the specific cases of DNNs, since the latter always has smaller approximation errors. We explore the relative performance of DNN and classical choice models through three simulation scenarios comparing DNN, BNL, and binary mixed logit models (BXL), as well as one experiment comparing DNN to BNL, BXL, MNL, and mixed logit (MXL) in analyzing the choice of trip purposes based on the National Household Travel Survey 2017. The results indicate that DNN can be used for choice analysis beyond the current practice of demand forecasting because it has the inherent utility interpretation and the power of automatically learning utility specification. Our results suggest DNN outperforms BNL, BXL, MNL, and MXL models in both prediction and interpretation when the sample size is large ($\geq O(10^4)$), the input dimension is high, or the true data generating process is complex, while perform worse when the opposite is true. DNN outperforms BNL and BXL in zero-one, log, and approximation losses for most of the experiments, and the larger sample size leads to greater incremental value of using DNN over classical discrete choice models. Overall, this study introduces the statistical learning theory as a new foundation for high-dimensional data, complex statistical models, and non-asymptotic data regimes in choice analysis, and the experiments show the effective prediction and interpretation of DNN for its applications to policy and behavioral analysis.

Subject Areas: Deep neural networks; Choice modeling; Statistical learning theory; Interpretability

Availability: Wang, S., Wang, Q., Bailey, N., and Zhao, J. (2021). "Deep Neural Networks for Choice Analysis: A Statistical Learning Theory Perspective." *Transportation Research Part B: Methodological*, *148*, pp. 60–81. https://doi.org/10.1016/j.trb.2021.03.011

Chapter 8. Traffic Safety

8.1. Title: Societal Impacts of Smart, Digital Platform Mobility Services—An Empirical Study and Policy Implications of Passenger Safety and Security in Ride-Hailing

Author(s): Acheampong, R.A.

Abstract: Smart, digital platform mobility solutions, such as Internet-based ride-hailing, are becoming common in Global South cities. Empirical research on their wider societal impacts is however, limited. This study explores a critical dimension of societal impact, which is passenger safety and security. The paper uses a large sample qualitative survey data (n = 548) on the perceptions and experiences of users and non-users of Internet-based ride-hailing services in Ghana. Through an inductive analysis, seven factors are identified that reflect heterogeneous safety and security perceptions and experiences in ride-hailing. Some individuals perceived a high sense of security and safety from ride-hailing platforms' inbuilt features, including "driver and vehicle identification" and real-time journey "trackability and traceability." Additionally, they derived a sense of safety and security from the "privacy and lone travel" in ride-hailing, as well as ride-hailing use in "emergency" situations when other emergency services are not readily available. Others, however, expressed "distrust" in the platforms' inbuilt security features and believed that they enable exposure to "malicious and criminal activities" that compromise their safety when using ride-hailing services. Moreover, safety risks were experienced through "driver behaviours," such as reckless driving, distractions by smartphone usage while driving, as well as fare pricing practices that are considered intransparent by passengers, leading to clashes between them and ride-hailing drivers. The implications of the findings are discussed in terms of their fundamental conceptual and empirical value to research on smart mobility, transport safety and travel-related well-being, as well as practical relevance for transport policy and governance in the age of smart mobility transitions.

Subject Areas: Smart mobility; Smart cities; Ride-hailing; Passenger safety; Security; Platform mobility

Availability: Acheampong, R.A. (2021). "Societal Impacts of Smart, Digital Platform Mobility Services—An Empirical Study and Policy Implications of Passenger Safety and Security in Ride-Hailing." *Case Studies on Transport Policy*, *9*(1), pp. 302–314.
https://doi.org/10.1016/j.cstp.2021.01.008

8.2. Title: What Causes Teen-Related Car Accidents?

Author(s): McCann, R.E.

Abstract: Blog.

Subject Areas: Teenagers; Motor vehicle accident; Common distractions; Drunk driving; Safety tips

Availability: McCann, R.E. (2021). "What Causes Teen-Related Car Accidents?" *Lawyers.com*. https://blogs.lawyers.com/attorney/automobile-accidents/what-causes-teen-related-car-accidents-67277/

8.3. Title: The Effect of Human Mobility and Control Measures on Traffic Safety During COVID-19 Pandemic

Author(s): Zhang, J., Feng, B., Wu, Y., Xu, P., Ke, R., and Dong, N.

Abstract: As mobile device location data become increasingly available, new analyses are revealing the significant changes of mobility pattern when an unplanned event happened. With different control policies from local and state government, the COVID-19 outbreak has dramatically changed mobility behavior in affected cities. This study has been investigating the impact of COVID-19 on the number of people involved in crashes accounting for the intensity of different control measures using Negative Binomial (NB) method. Based on a comprehensive dataset of people involved in crashes aggregated in New York City during January 1, 2020, to May 24, 2020, people involved in crashes with respect to travel behavior, traffic characteristics and socio-demographic characteristics are found. The results show that the average person miles traveled on the main traffic mode per person per day, percentage of work trip have positive effect on person involved in crashes. On the contrary, unemployment rate and inflation rate have negative effects on person involved in crashes. Interestingly, different level of control policies during COVID-19 outbreak are closely associated with safety awareness, driving and travel behavior, and thus has an indirect influence on the frequency of crashes. Comparing to other three control policies including emergence declare, limits on mass gatherings, and ban on all nonessential gathering, the negative relationship between stay-at-home policy implemented in New York City from March 20, 2020, and the number of people involved crashes is found in our study.

Subject Areas: Mobile device location data; Mobility pattern; COVID-19; Negative binomial; Crashes; New York City; Traffic characteristics; Socio-demographic characteristics

Availability: Zhang, J., Feng, B., Wu, Y., Xu, P., Ke, R., and Dong, N. (2021). "The Effect of Human Mobility and Control Measures on Traffic Safety During COVID-19 Pandemic." *PLoS ONE*, *16*(3). https://doi.org/10.1371/journal.pone.0243263

8.4. Title: Enhancing Non-motorized Safety by Simulating Trip Exposure Using a Transportation Planning Approach

Author(s): Yasmin, S., Bhowmik, T., Rahman, M., and Eluru, N.

Abstract: Traditionally, in developing non-motorized crash prediction models, safety researchers have employed land use and urban form variables as surrogate for exposure information (such as pedestrian, bicyclist volumes and vehicular traffic). The quality of these crash prediction models is affected by the lack of "true" non-motorized exposure data. High-resolution modeling frameworks such as activity-based or trip-based approach could be pursued for evaluating planning level non-motorist demand. However, running a travel demand model system to generate demand inputs for non-motorized safety is cumbersome and resource intensive. The current study is focused on addressing this drawback by developing an integrated non-motorized demand and crash prediction framework for mobility and safety analysis. Towards this end, we propose a three-step framework to evaluate non-motorists' safety: (1) develop aggregate level models for non-motorist generation and attraction at a zonal level, (2) develop non-motorists trip exposure matrices for safety evaluation, and (3) develop aggregate level non-motorists crash frequency and severity proportion models. The framework is developed for the Central Florida region using non-motorist demand data from National Household Travel Survey (2009) Florida add-on and non-motorist crash frequency and severity data from Florida. The applicability of the framework is illustrated through extensive policy scenario analysis.

Subject Areas: Pedestrian; Bicycle; Active travel; Travel demand; Safety; Negative binomial; Fractional split; Non-motorist

Availability: Yasmin, S., Bhowmik, T., Rahman, M., and Eluru, N. (2021). "Enhancing Non-motorized Safety by Simulating Trip Exposure Using a Transportation Planning Approach." *Accident Analysis & Prevention*, *165*. https://doi.org/10.1016/j.aap.2021.106128

8.5. Title: An Analysis of Pedestrian Crash Trends and Contributing Factors in Texas

Author(s): Bernhardt, M. and Kockelman, K.

Abstract: Introduction & research objectives: Pedestrian crash rates and deaths have risen across the United States over the past decade in contrast to motor vehicle traffic crash counts and rates. Analysis of pedestrian crash rates per vehicle-miles traveled and walk-miles traveled (VMT and WMT) illuminates the impacts of homelessness, land development densities, income, weather, and many other variables across the State of Texas, helping to propel more effective safety policies.

Methods: This study examines key factors for and countermeasures against pedestrian crashes, while predicting pedestrian crash rates per VMT and WMT, as sourced from the Texas DOT (TxDOT) and the 2017 National Household Travel Survey (NHTS) add-on sample. Crash data from TxDOT's Crash Records Information System (CRIS) database were analyzed using an ordinary least-squares (OLS) regression by controlling for a variety of socioeconomic, climate, and roadway design variables, including homelessness, which has emerged as a serious issue along freeway rights-of-way in many U.S. urban areas.

Results: At the county level in Texas, there is a moderately positive relationship between job density and pedestrian crash rates but a practically significant and negative relationship with population density. Median income and homelessness have very practically significant, positive impacts on pedestrian crash and fatality rates. For example, a 1 standard deviation increase in homelessness per 1,000 residents is associated with a +14.4% of 1 standard deviation rise in the total pedestrian crash rate per WMT at the county level, all else constant. Similarly, pedestrian crashes per WMT rise in a notable way with the share of children under age 17 and rates of homelessness.

Conclusions: These results suggest significant positive relationships between pedestrian crash rates per VMT and per WMT with respect to household incomes and homelessness, at the county level. Pedestrian crashes and pedestrian deaths per WMT also reveal practically significant contributions by larger youth populations and poverty rates. A weaker but still practically significant relationship exists between crash rates per VMT and population growth rate, warranting further investigation on the relationship between exurban land use patterns and pedestrian crashes.

Subject Areas: Pedestrian crashes; Pedestrian fatalities; Road safety; Crash countermeasures; Homelessness; Texas traffic

Availability: Bernhardt, M. and Kockelman, K. (2021). "An Analysis of Pedestrian Crash Trends and Contributing Factors in Texas." *Journal of Transport & Health*, *22*. https://doi.org/10.1016/j.jth.2021.101090

8.6. Title: Shaping the Habits of Teen Drivers

Author(s): Moore, T.J. and Morris, T.

Abstract: Teens are risky drivers and often subject to extra restrictions. We examine the effects of an Australian intervention banning first-year drivers from carrying multiple passengers between 11:00 p.m. and 4:59 a.m., which had represented 3% of their accidents and 18% of their fatalities. Using daytime outcomes to account for counterfactual crash risks, we find the reform more than halves targeted crashes, casualties and deaths. The restriction also lowers crashes earlier in the evening and beyond the first year, suggesting it has broad and persistent effects on driving behavior. Overall, this targeted intervention delivers gains comparable to harsher restrictions that delay teen driving.

Subject Areas: Teen driving; Accidents; Driving behavior; Targeted intervention

Availability: Moore, T.J. and Morris, T. (2021). *Shaping the Habits of Teen Drivers*. Working Paper 28707, National Bureau of Economic Research, Cambridge, MA.
https://www.nber.org/papers/w28707

8.7. Title: How Do Novel Seat Positions Impact Usability of Child Restraints?

Author(s): Tremoulet, P.D., Belwadi, A., Corr, B., Sarfare, S., Seacrist, T., and Tushak, S.

Abstract: Autonomous driving technology and changes in regulations may create an environment that allows novel vehicle interiors. It is important to consider impact on all types of passengers when contemplating interior design, particularly for vehicles that may be used by families with children. We developed a fixture that enables us to change the orientation of each of 4 car seats and used it to simulate three different vehicle interiors. Ten families with children aged 3 months to 7 years interacted with each of the simulated interiors as part of a usability study. Times to install and remove child restraint systems were not significantly different across the three simulated vehicle interiors, but parents were able to release children fastest when using the "X" configuration, which had all seats on a diagonal facing the middle of the vehicle. While overall experience ratings didn't differ significantly, seven out of ten parents indicated that they liked the "X" configuration better than the other two configurations tested. Reasons included: ability to interact with other passengers, ability to see the road, and legroom/comfort. However, many participants disliked having some passengers not facing forward. Overall, parents liked facing their children, but several said that they would only be comfortable if they could see out of the front windshield; meanwhile, children liked seeing their parents' faces but also preferred to face forward. Child restraint system and vehicle manufacturers could benefit from considering this study when designing new products.

Subject Areas: Autonomous vehicles; Child restraint systems; Child passengers; Usability; Human factors

Availability: Tremoulet, P.D., Belwadi, A., Corr, B., Sarfare, S., Seacrist, T., and Tushak, S. (2021). "How Do Novel Seat Positions Impact Usability of Child Restraints?" *Transportation Research Interdisciplinary Perspectives*, *10*. https://doi.org/10.1016/j.trip.2021.100372

8.8. Title: Examining the Effect of Pedestrian Crashes on Vulnerable Populations in North Carolina

Author(s): Harmon, K.J., Peticolas, K., Redding, E.M., Ising, A., and Waller, A.E.

Abstract: Background: Over the last several years, pedestrian fatalities have increased in North Carolina; however, fatalities represent a small proportion of the total number of nonfatally injured pedestrians. Therefore, we linked statewide motor vehicle crash (MVC) and emergency department (ED) visit data to better understand the circumstances and characteristics of pedestrians treated in North Carolina emergency departments (EDs) for injuries related to crashes.

Methods: We linked information for pedestrians and bicyclists from 2017 North Carolina police-reported MVCs to population-based ED visit data using hierarchical deterministic methods.

Results: We linked 45 percent of pedestrian crash records to ED visit records (N = 1383 incident ED visits). The rate of pedestrians treated in North Carolina EDs for their injuries was 13.6 ED visits per 100,000 person years. For pedestrian injuries treated in North Carolina EDs, rates (per 100,000 person-years in parentheses) were higher among men (15.5) and Black pedestrians (22.7) than women (10.6) and White pedestrians (8.2). Sociodemographic characteristics associated with serious injuries included age, sex, race/ethnicity, and expected source of payment for the ED visit. Crash characteristics associated with serious injuries included posted speed limit, ambient light, number of lanes, and striking vehicle type.

Limitations: The study involved the use of secondary data, not collected specifically for pedestrian injury surveillance.

Conclusions: Pedestrian injuries and fatalities place a considerable burden on the population of North Carolina, especially among persons of color and older adults. Injury prevention programs are actively addressing this problem, but more needs to be done.

Subject Areas: Pedestrian fatalities; Emergency departments; Treatment; Sociodemographic characteristics; Crash characteristics; Injury prevention

Availability: Harmon, K.J., Peticolas, K., Redding, E.M., Ising, A., and Waller, A.E. (2021). "Examining the Effect of Pedestrian Crashes on Vulnerable Populations in North Carolina." *North Carolina Medical Journal*, *82*(4), pp. 237–243. https://doi.org/10.18043/ncm.82.4.237

8.9. Title: Nighttime Pedestrian Fatalities: A Comprehensive Examination of Infrastructure, User, Vehicle, and Situational Factors

Author(s): Ferenchak, N.N. and Abadi, M.G.

Abstract: Introduction: Pedestrian fatalities in the United States increased 45.5 percent between 2009 and 2017. More than 85 percent of those additional pedestrian fatalities occurred at night.

Method: We examine Fatality Analysis Reporting System (FARS) data for fatal pedestrian crashes that occurred in the dark between 2002 and 2017. Within-variable and before/after examinations of crashes in terms of infrastructure, user, vehicle, and situational characteristics are performed with one-way analysis of variance (ANOVA) and two-sample *t* tests. We model changes in crash characteristic proportions between 2002–2009 and 2010–2017 using linear regressions and test for autocorrelation with Breusch-Godfrey tests.

Results: The increase in fatal nighttime pedestrian crashes is most strongly correlated with infrastructure factors: non-intersection unmarked locations (80.8 percent of additional fatalities); 40–45 mph roads (54.6 percent); five-lane roads (40.7 percent); urban (99.7 percent); and arterials (81.1 percent). In addition, SUVs were involved in 39.7 percent of additional fatalities, overrepresenting their share of the fleet. Increased pedestrian alcohol and drug involvement warrant further investigation. The age of pedestrians killed increased more (18.1 percent) than the national average (3.2 percent).

Conclusions: By identifying factors related to the increase in nighttime pedestrian fatalities, this work constitutes a vital first step in making our streets safer for pedestrians.

Practical Applications: More research is needed to understand the efficacy of different solutions, but this paper provides guidance for such future research. Engineering solutions, such as road diets or traffic calming, may be used to improve identified infrastructure issues by reducing vehicle speeds and road widths. Rethinking vehicle design, especially high front profiles, may improve vehicle issues. However, the problems giving rise to these pedestrian fatalities are likely a result of not only engineering issues but also interrelated social and political factors. Solutions may be correspondingly comprehensive, employing non-linear, systems-based approaches such as Safe Systems.

Subject Areas: Pedestrian; Fatality; Injury; Safety; Night; Dark; Infrastructure; Arterial; Drug; Alcohol

Availability: Ferenchak, N.N. and Abadi, M.G. (2021). “Nighttime Pedestrian Fatalities: A Comprehensive Examination of Infrastructure, User, Vehicle, and Situational Factors.” *Journal of Safety Research*, *79*, pp. 14–25. https://doi.org/10.1016/j.jsr.2021.07.002

8.10. Title: Analysis of Potential Collisions Between Pedestrians and Personal Transportation Devices in a University Campus: An Application of Unmanned Aerial Vehicles

Author(s): Kim, D. and Park, K.

Abstract: Objective: To identify factors that contribute to near-miss collisions between pedestrians and personal transportation devices (PTDs) in a university campus using a novel data collection method, unmanned aerial vehicle (UAV).

Participants: A total of 3,349 pedestrians and 173 PTD riders were detected through UAV observations.

Methods: The researchers employed UAV technology to capture and geocode the interactions and behavior of pedestrians and PTD riders. Then, a multilevel logistic regression model examined factors that contribute to near-miss collisions between pedestrians and PTDs.

Results: The model outputs indicate that higher speed, non-bicycle PTDs (e.g., skateboard and scooter), and some preventive actions, such as reducing speed, deviating, and weaving, increase the probability of a PTD rider getting involved in a near-miss collision.

Conclusions: Findings can guide campus planners to redesign the streets as a safe environment for all transportation modes and implement appropriate regulations and education programs, especially for non-bicycle PTD riders.

Subject Areas: Bicycle; Near-miss collision; Pedestrian; Personal transportation devices (PTDs); Unmanned aircraft systems (UAS)

Availability: Kim, D. and Park, K. (2021). "Analysis of Potential Collisions Between Pedestrians and Personal Transportation Devices in a University Campus: An Application of Unmanned Aerial Vehicles." *Journal of American College Health*. https://doi.org/10.1080/07448481.2021.1967358

8.11. Title: Data Fusion for Nonmotorized Safety Analysis

Author(s): Sener, I.N., Munira, S., and Zhang, Y.

Abstract: This project explored an emerging research territory, the fusion of nonmotorized traffic data for estimating reliable and robust exposure measures. Fusion mechanisms were developed to combine five bike demand data sources in Austin, TX, and the fused estimate was applied in two crash analyses. The research was divided into three sequential stages. The first stage involved developing and applying a guideline to process and homogenize available data sources to estimate annual average daily bike volume at intersections. The second stage was focused on developing and applying the fusion framework—demonstrating the efficacy of multiple fusion algorithms, including two novel mechanisms, suited to the data characteristics and based on the availability of actual counts. The analysis of actual and simulated data illustrated that the fusion methods outperformed the individual estimates in most cases. In the third stage, the fused data were applied in both macro (hotspot analysis in block group level) and micro (individual safety-related perception) models in Austin to ascertain the significance of incorporating exposure in safety analysis. While the fusion framework contributes to the research in the field of decision fusion, the demand and crash models provide insights to help stakeholders formulate policies to encourage bike activity and reduce crashes.

Subject Areas: Fusion; Exposure; Nonmotorized activity; Demand models; Safety analysis; Crowd-sourced data; Dempster-Shafer

Availability: Sener, I.N., Munira, S., and Zhang, Y. (2021). *Data Fusion for Nonmotorized Safety Analysis*. Final Research Report, Texas A&M University, College Station, TX.
https://safed.vtti.vt.edu/wp-content/uploads/2021/08/03-049_SAFE-D-final-Ready-for-Site2.pdf

8.12. Title: Head Protection in Electric Micromobility: A Critical Review, Recommendations, and Future Trends

Author(s): Serra, G.F., Fernandes, F.A., Noronha, E., and de Sousa, R.J.A.

Abstract: Traffic jams are a burden in urban areas, being time-consuming and contributing to stressful driving and CO_2 emissions. To implement the United Nations' 2030 agenda for sustainable development, governmental strategies aim to accelerate the shift to sustainable and smart mobility. Consequently, e-micromobility (EMM) appeared as a practical solution for short-distance commuters, and it is growing at upsetting rates thanks to the introduction of sharing services. In fact, urban mobility has drastically changed over the last decade, and electric mobility and micromobility changed the panorama in larger metropolises, given their accessibility, large availability, and the potential to be a time saver in short trips and a potentially sustainable alternative in particular scenarios. The downside of portable e-transportation is the rapid increase in injuries and fatalities. Focusing on standing e-scooters, head injuries are becoming one of the most common, as shown by research conducted in different urban emergency departments, alongside bone fractures, skin abrasions, and lacerations. In this work, a comprehensive review is carried out focusing on head protection for EMM, mostly for e-scooters, and the respective target markets, safety measures, and existing regulations. In the end, a critical assessment is given with recommendations for legislators and future research. Users are mostly males from 18 to 40 years old, upper-to-middle income, with elevated levels of educational attainment. Their motivation to use e-scooters is mainly to replace short walking trips. EMM, in particular e-scooters, will continue to grow thanks to its potential to substitute other micromobility alternatives. The evolution of safety measures and regulations did not keep pace with such a drastic change in mobility trends. This is evident considering how some countries are struggling with vehicle categories and regulations for helmet use and testing. The lack of legal obligation to wear a helmet and the absence of an adequate and feasible concept of protective equipment for sharing services are the main barriers to helmet use among riders. Mitigation measures have been implemented by the EMM sharing companies to improve the safety of its users by checking if they wear helmets and by offering vehicle-integrated solutions.

Subject Areas: Electric mobility; E-scooter; Sharing service; Road safety; Head injury; Head protection

Availability: Serra, G.F., Fernandes, F.A., Noronha, E., and de Sousa, R.J.A. (2021). "Head Protection in Electric Micromobility: A Critical Review, Recommendations, and Future Trends." *Accident Analysis & Prevention*, *163*. https://doi.org/10.1016/j.aap.2021.106430

8.13. Title: Lighting the Way: IIHS Headlight Ratings Predict Nighttime Crash Rates

Author(s): Brumbelow, M.L.

Abstract: Introduction: Vehicle headlights are the primary means of providing visibility illumination for drivers at night, when crash rates are several times higher than during the day. Based on research indicating a wide range of headlight performance in the passenger vehicle fleet and the absence of a comprehensive and objective consumer evaluation program, the Insurance Institute for Highway Safety (IIHS) began testing and rating headlight systems in 2015. The purpose of this study was to examine the relationship between headlight visibility, as quantified by IIHS, and real-world crash occurrence.

Material and methods: Poisson regression was used to estimate the effects of the headlight rating and the underlying demerits on the rate of nighttime single-vehicle crashes per vehicle mile traveled, while controlling for differences in daytime crash rates and other factors.

Results: Vehicles with better headlight visibility have lower nighttime crash rates. Achieving 10 fewer visibility demerits, the equivalent of one overall rating band, was estimated to reduce the nighttime crash rate by 4.6 percent (95 percent confidence interval [CI]: 2.1 to 7.0% percent). Although statistical significance was limited by small sample sizes, good-rated headlights were estimated to reduce crash rates by 12 to 29 percent relative to those with poor ratings for the different types of single-vehicle crashes studied. Among different components of the IIHS rating, the assessments of low- and high-beam curve visibility were associated with the greatest crash rate reductions.

Conclusion: This study demonstrates that the IIHS evaluation program encourages headlight designs that reduce the risk of nighttime single-vehicle crashes.

Subject Areas: Headlights; Headlight ratings; Nighttime driving; Single-vehicle crashes

Availability: Brumbelow, M.L. (2021). *Lighting the Way: IIHS Headlight Ratings Predict Nighttime Crash Rates*. Insurance Institute for Highway Safety, Ruckersville, VA. https://www.iihs.org/topics/bibliography/ref/2239

8.14. Title: Drug Recognition Experts (DREs) and Case Outcomes: A Case Study Examination of the Role of DRE Evaluations and Involvement in Spokane, Washington

Author(s): Solensten, B. and Willits, D.W.

Abstract: The current report explores the impact DRE evaluations and officers have on DUI case outcomes. Case outcome data from the Washington State Administrative Office of the Courts were merged with 3 years of DUI case data from the Spokane Police Department. Due to a small number of complete DRE evaluations, cases with heavy DRE involvement were also analyzed. Results show that DRE evaluations and involvement have minimal to no impact on DUI case outcomes. However, this could be due to multiple factors, including higher complexity of cases that DREs are more likely to be involved in, and data limitations.

Subject Areas: Drug Recognition Experts (DREs); Drug Evaluation and Classification Program (DEC); Driving under the influence (DUI); DUI trial; DUI evidence

Availability: Solensten, B. and Willits, D.W. (2021). *Drug Recognition Experts (DREs) and Case Outcomes: A Case Study Examination of the Role of DRE Evaluations and Involvement in Spokane, Washington*. Washington State University, Pullman, WA. http://wtsc.wa.gov/wp-content/uploads/dlm_uploads/2021/07/DRE-Case-Outcomes-in-Spokane-WA_Jul2021.pdf

8.15. Title: Understanding Pedestrian Injuries and Social Equity

Author(s): Roll, J. and McNeil, N.

Abstract: Past research and planning has highlighted the existence of pedestrian injury disparities throughout the United States, and some local agencies have performed cursory analysis in Oregon. However, no statewide analysis of pedestrian injuries in Oregon has been completed to see how these injury outcomes differ by race and income. This report aims to help better understand the factors that result in disparate pedestrian injury outcomes for different sociodemographic groups. This report uses data from a variety of sources to understand pedestrian injuries by social equity measures, including income, poverty, race, ethnicity, disability, and English proficiency. The authors conclude that Black, Indigenous, and people of color (BIPOC) experience a higher rate of pedestrian injury compared to the statewide average. This report also documents pedestrian injuries at the Census tract level and measures factors that influence pedestrian injury risk. Sociodemographic risk factors associated with pedestrian injury risk include race, income, disability, and limited English proficiency. Traffic exposure factors include arterial vehicles miles traveled, miles of roadways with 35 miles per hour posted speed, transit stops, and workers commuting by transit and walking. Built environment risk factors include density of jobs, intersection density, and the density of alcohol establishments. This report concludes that, at both the State and neighborhood level, incorporating social equity measures, including race, disability, and income, are important to understanding pedestrian injuries and the likely location of these incidents. Race is an important factor in large part due to the relationship with income and the lack of economic opportunities afforded to BIPOC. Income is important to consider because low-income people are more likely to walk and take transit in neighborhoods with more vehicle traffic moving at higher speeds.

Subject Areas: Social equity; Pedestrian injury; Disparity; Ecological analysis; Age-adjusted rates; Generalized linear regression; Mixed effects models

Availability: Roll, J. and McNeil, N. (2021). *Understanding Pedestrian Injuries and Social Equity*. Final Report, Oregon Department of Transportation, Salem, OR.
https://www.oregon.gov/odot/Programs/ResearchDocuments/SPR%20841Injuries-Equity.pdf

Chapter 9. Transit Planning

9.1. Title: Defining Public Transit Commuters Based on Their Work Tour Choice

Author(s): Rafiq, R. and McNally, M.G.

Abstract: Public transit often offers less flexibility and mobility than a private car in chaining non-work activities with work due to its temporal and spatial constraints. However, it is a sustainable mode of transport that can reduce automobile dependency and can provide environmental, economic, and societal benefits. Its widespread adoption is arguably dependent on its ability to offer effective chaining of trips particularly when it is utilized in a work commute. Unfortunately, little is known about trip chaining behavior of transit commuters in the United States. This study tries to reduce this gap and proposes a tour choice model for transit commuters. The model, constructed using structural equation modeling (SEM), characterizes transit commuters based on the complexity of work tours and enables to assess the impact of socio-demographic characteristics, built environment, and activity-travel variables on the likelihood of a transit commuter choosing a particular type of work tour. Based on data from the 2017 National Household Travel Survey, the study results suggest that married men with no children and high vehicle ownership living in low-density areas tend to make simple work tours, whereas non-millennial women with children are more likely to make complex work tours. Last, Caucasian millennial men of high income and high education living in denser areas are more likely to make complex tours with work-based sub-tours. The findings of this study will help transit agencies and planning organizations to identify the transit commuters who have complex travel needs, thus helping them to formulate policies ensuring better work non-work linkages.

Subject Areas: Public transit; Automobile dependency; Trip chain; Work commute; Transit commuters

Availability: Rafiq, R. and McNally, M.G. (2021). *Defining Public Transit Commuters Based on Their Work Tour Choice.* Transportation Research Board 100th Annual Meeting—A Virtual Event, Washington, DC. https://annualmeeting.mytrb.org/OnlineProgram/Details/15655

9.2. Title: Evaluating the Impacts of Transit-oriented Developments (TODs) on Household Transportation Expenditures in California

Author(s): Dong, H.

Abstract: This study evaluates the impact of transit-oriented development (TOD) on household transportation expenditures in California by comparing TOD households with two groups of control households that are identified by propensity score matching. When controlling for household demographics, TOD households own fewer and more fuel-efficient cars, drive fewer miles, and use transit more. On average, they save $1,232 per year on transportation expenditures than non-TOD households with similar demographics, accounting for 18% of their total annual transportation expenditures. When controlling for both demographics and neighborhood environment, TOD households still own slightly fewer and more fuel-efficient cars and use transit more. But they drive similar amount of miles as non-TOD households do. TOD households save $429 per year on transportation expenditures than non-TOD households with similar demographics and neighborhood environment, accounting for about 6% of their total annual transportation expenditures. TOD households save money on transportation costs mainly because they own fewer cars than non-TOD households. About two thirds of the savings can be attributed to transit-friendly neighborhood environment and one third to their access to rail transit, suggesting the importance of integrating a rail transit system with supportive land use planning and neighborhood design.

Subject Areas: Transit oriented development; Transportation expenditure; Propensity score matching; Rail transit

Availability: Dong, H. (2021). “Evaluating the Impacts of Transit-oriented Developments (TODs) on Household Transportation Expenditures in California.” *Journal of Transport Geography*, *90*. https://doi.org/10.1016/j.jtrangeo.2020.102946

9.3. Title: Transit Economic Equity Index: Developing a Comprehensive Measure of Transit Service Equity

Author(s): Lyons, T. and Choi, D.

Abstract: In this study, an index is developed called the Transit Economic Equity Index, to enable quantitative assessment of transit service equity. The index measures convenience of travel for work trips for advantaged and disadvantaged populations, based on travel speed, using a multimodal network that includes transit lines, stop locations, transit schedules, and pedestrian connections via the street network. Non-peak hour service is compared with peak hour service to determine the degree to which operating resources are concentrated in times that might have greater benefits to advantaged populations. Finally, accessibility to the transit system is compared in relation to the number of transit stops in neighborhoods and employment centers, and these figures are compared between advantaged and disadvantaged locations. The scores for these three components are combined to create a single measure of transit economic equity. Disadvantage is defined using criteria established in Title VI of the *Civil Rights Act of 1964*. The index is constructed in a way that balances a robust and meaningful measure of transit equity that is decipherable by practitioners so that they can assess the equity of their systems as well as how potential service changes affect equity.

Subject Areas: Transit Economic Equity Index; Non-peak and peak hour service; Accessibility

Availability: Lyons, T. and Choi, D. (2021). "Transit Economic Equity Index: Developing a Comprehensive Measure of Transit Service Equity." *Transportation Research Record: Journal of the Transportation Research Board*. https://doi.org/10.1177%2F0361198120970529

9.4. Title: Sources of and Gaps in Data for Understanding Public Transit Ridership

Author(s): Wasseman, J. and Taylor, B.D.

Abstract: This report presents and reviews the available sources of data on public transit riders and ridership. We intend it to be a resource for those who manage or simply wish to understand U.S. transit. In conducting this review, we consider the advantages and disadvantages of publicly available data on transit from a variety of public and private sources. We consider as well the relatively scarcer and less available sources of data on other providers of shared mobility, like ride-hail services, that compete with and complement public transit, as well as pieces we see as missing from the transit analytics pie. We conclude by discussing how data gaps both align with existing inequities and enable them to continue, unmeasured, and how the COVID-19 pandemic has made closing these gaps all the more important.

Subject Areas: Transit; Ridership; Data; Data gaps

Availability: Wasseman, J. and Taylor, B.D. (2021). *Sources of and Gaps in Data for Understanding Public Transit Ridership.* UCLA Institute of Transportation Studies, Los Angeles, CA. https://www.researchgate.net/deref/http%3A%2F%2Fdx.doi.org%2F10.17610%2FT66893

9.5. Title: If Rush Hour Dies, Does Mass Transit Die with It?

Author(s): Grabar, H.

Abstract: Blog.

Subject Areas: Transit; Rush hour; Peak commuters

Availability: Grabar, H. (2021). "If Rush Hour Dies, Does Mass Transit Die with It?" *Slate*. https://slate.com/business/2021/02/mass-transit-subways-after-pandemic.html

9.6. Title: Who Lives in Transit-Friendly Neighborhoods? An Analysis of California Neighborhoods Over Time

Author(s): Paul, J. and Taylor, B.D.

Abstract: In this paper, we examine social and economic trends in California's transit-friendly neighborhoods since 2000. In particular, we explore the relationship between high-propensity transit users – who we define here as members of households classified as poor, immigrant, African-American, and without private vehicles – and high-transit-propensity places – which are neighborhoods that regularly host high levels of transit service or use. As housing costs have increased dramatically in California and neighborhoods change, many planners and transit advocates reasonably worry that in transit-friendly neighborhoods, lower-propensity transit users may replace residents who tend to ride transit frequently. Such changes in residential patterns could help to explain sharp transit ridership declines in California in the 2010s ahead of much sharper pandemic-related ridership losses in 2020. Indeed, we find that California's most transit-friendly neighborhoods have changed in ways that do not bode well for transit use. The State's shares of poor, immigrant, African American, and zero-vehicle households have all declined modestly to substantially since 2000. Collectively, these trends point to changes in California's most transit-friendly neighborhoods that are not very, well, transit-friendly.

Subject Areas: Transit ridership; Neighborhood change; Spatial inequality; Transportation equity

Availability: Paul, J. and Taylor, B.D. (2021). "Who Lives in Transit-Friendly Neighborhoods? An Analysis of California Neighborhoods Over Time." *Transportation Research Interdisciplinary Perspectives*, *10*. https://doi.org/10.1016/j.trip.2021.100341

9.7. Title: Gender Responsiveness in Public Transit: Evidence from the 2017 US National Household Travel Survey

Author(s): Jin, H. and Yu, J.

Abstract: Public transportation plays an important role in urban sustainability. To increase public transit usage, it is essential to understand the underlying reasons that discourage people from using transit through the perspectives of different users. Drawing on the 2017 US National Household Travel Survey, this study aims to explore gender-sensitive factors in transit usage by socio-demographics and trip attributes for both men and women through a combination of descriptive analyses and econometric methods. Results show that, statistically speaking, significant factors for both women's and men's transit usage are similar, including being in a household with children, at an older age, with a high household income, car access, low-density residence, no heavy rail, travel for the purpose of maintenance or recreation, frequent daily trips, and short trip distance. The Chow test follows to further reveal that compared with trips made by men, trips by women are less likely to use transit when the women are 40 years old or more, with a high household income (>$100,000), with low residence density (i.e., <10,000 persons/mi^2), or when recreation is the purpose of the trip. This research may assist policymakers, administrators, and responsible agencies to make better sustainable transport policies by refining gender-specific transit services in attracting both men and women to use public transit.

Subject Areas: Public transit; Urban sustainability; Gender; Built environment; Demographics

Availability: Jin, H. and Yu, J. (2021). "Gender Responsiveness in Public Transit: Evidence from the 2017 US National Household Travel Survey." *Journal of Urban Planning and Development*, *147*(3). https://doi.org/10.1061/(ASCE)UP.1943-5444.0000699

9.8. Title: Transit Accessibility and Residential Segregation

Author(s): Akbar, P.A.

Abstract: Residential segregation by income and race is a salient feature of most U.S. cities. An important determinant of residential location choice is access to desirable urban amenities via affordable travel modes. The first chapter of the dissertation studies residential and travel mode choices of commuters in U.S. cities to estimate the heterogenous demand for access to neighborhoods offering faster commutes and to characterize what that means for how the gains from mass transit improvements are distributed among rich and poor commuters. I show that cities where transit improvements would be most effective at generating new transit ridership and overall welfare gains are ones where the gains accrue more to higher income commuters.

Within cities, who gentrify transit-accessible neighborhoods and ride mass transit depends on the type (e.g., bus versus rail) and location of the transit improvements. The second chapter of this dissertation models household choices of where to live and how to travel in a stylized city with a competitive housing market. I characterize when and where marginal improvements in transit access reduce residential segregation by income instead of exacerbating it, and I show that an urban planners trying to maximize transit ridership is often incentivized to expand the transit network where it increases income segregation.

Residential segregation has important implications for inequality. The third chapter of the dissertation studies how racially segregated housing markets have historically exacerbated racial inequality in U.S. cities. The Great Migration of Black families from the rural South to northern cities in the 1930s saw a growing number of segregated city blocks transition racially. Over a single decade, while rental prices soared on city blocks that transitioned from all white to majority Black and pioneering Black families paid large premiums to buy homes on majority white blocks, such homes quickly lost value on blocks that transitioned from majority white to majority Black. These findings suggest that segregated housing markets eroded much of the gains for black families moving out of ghettos.

Subject Areas: Travel mode choice; Residential location choice; Mass transit; Public transportation; Income sorting; Segregation

Availability: Akbar, P.A. (2021). *Transit Accessibility and Residential Segregation.* Doctoral Dissertation, University of Pittsburgh, Pittsburgh, PA. http://d-scholarship.pitt.edu/40475/

9.9. Title: Using Random Undersampling Boosting Classifier to Estimate Mode Shift Response to Bus Local Network Expansion and Bus Rapid Transit Services

Author(s): Li, Q., Huerta, A.K.R., Mao, A.C., and Qiao, F.

Abstract: This study proposed a machine learning-based classification method to accurately predict mode choice in response to potential strategies for transit promotion in a sprawling region. The method consists of a machine learning classifier, a genetic feature selection process, and statistical analysis process. The Random Undersampling Boosting Algorithm is adopted for imbalanced datasets in sampling. The genetic algorithm is applied to optimize the combination of independent variables grounded on the principle of maximum relevance and minimum redundancy. The 2017 National Household Travel Survey and the add-on samples data for the Houston metropolitan statistical area in Texas, USA, were utilized to build the mode choice classifier, which shows 99.22% classification accuracy for auto mode and 98.90% for transit mode. Based on a comprehensive study of commuters' trip characteristics and socio-demographics of the study region, bus transit network expansion and bus rapid transit strategies were proposed to stimulate the predominant single occupancy vehicle mode to be shifted to public transit. Results show that the bus rapid transit, providing higher trip speeds for medium- and long-distance commuters, can significantly increase transit mode share by 8.24% and 8.95%, respectively. When the bus rapid transit is available to all the medium- and long-distance commuters, the total mode shift can increase to 15.96% in the study region. The walking distance to the nearest transit access is linearly associated with the mode shift to transit; up to 2.4% of current auto trips shifted to transit mode for those within a 5-min walking distance in the urban area.

Subject Areas: Bus rapid transit; Mode shift; Imbalanced data; RUSBoost algorithm; Urban sprawl

Availability: Li, Q., Huerta, A.K.R., Mao, A.C., and Qiao, F. (2021). "Using Random Undersampling Boosting Classifier to Estimate Mode Shift Response to Bus Local Network Expansion and Bus Rapid Transit Services." *International Journal of Civil Engineering*. https://doi.org/10.1007/s40999-021-00635-7

9.10. Title: Can Mobility on Demand Bridge the First-Last Mile Transit Gap? Equity Implications of Los Angeles' Pilot Program

Author(s): Brown, A., Manville, M., and Weber, A.

Abstract: Transit agencies and advocates see removing or bridging the first-last mile gap as an important way to increase transit ridership and reduce vehicle use. Some transit agencies see the advent of ride-hail services like Uber and Lyft as an opportunity for a nimble and flexible solution to first-last mile problems able to deliver more riders to and from transit stations. While agencies across the United States have piloted such programs, limited evaluation to date means the outcomes of such partnerships remain unknown. Using just over a year of trip data from the Los Angeles Metro Mobility on Demand (MOD) pilot program, we answer two related questions about ride-hailing and transit access: first, do people use ride-hailing to go to and from transit stops? And second, what are the equity implications of such a program? In other words, do such programs boost access to transit among populations historically excluded or underserved by transportation systems? Our findings suggest that the MOD program successfully delivered thousands of riders to and from transit stations during its first year. Whether these rides were delivered to vulnerable groups with limited access to the transit system, however, is less clear. Survey results suggest that compared to transit riders as whole, program users overall were whiter and more likely to own smartphones and have bank accounts. Thus while people are clearly interested and willing to use subsidized ride-hail services to access transit, the program in its current design does not appear to meaningfully increase access for disadvantaged groups. This result may stem more from the design of the pilot itself, as opposed to suggesting the limited potential of ride-hailing more broadly to solve access problems.

Subject Areas: First-last mile; Transit access; Equity; Mobility on demand; Ride-hail

Availability: Brown, A., Manville, M., and Weber, A. (2021). "Can Mobility on Demand Bridge the First-Last Mile Transit Gap? Equity Implications of Los Angeles' Pilot Program." *Transportation Research Interdisciplinary Perspectives*, *10*. https://doi.org/10.1016/j.trip.2021.100396

9.11. Title: Rating the Composition: Deconstructing the Demand-Side Effects on Transit Use Changes in California

Author(s): Schouten, A., Blumenberg, E., and Taylor, B.D.

Abstract: Transit use in the United States has been sliding since 2014, well before the onset of the COVID-19 pandemic. The largest State, California, was also losing transit riders despite substantial public investment and increased service in the pre-pandemic period. This downturn prompted concern among transit managers and planners interested in service-side interventions to reverse the decline. However, relatively little is known about changes in the demand for public transit and how shifts in demand-side factors have affected patronage. Drawing on California data from the 2009 and 2017 National Household Travel Survey, we quantify demand-side changes as a function of two factors—changes in ridership rates of various classes of transit riders ("rate effects") and changes in the composition of those rider classes ("composition effects"). Statewide, we find that while shifts in the population composition were in some cases associated with lower levels of ridership, the largest declines in transit patronage were associated with falling ridership rates. Specifically, those with limited automobile access and Hispanic travelers rode transit far less frequently in 2017 compared to 2009. Transit ridership rates and rider composition in the San Francisco Bay Area were relatively stable during the study period, while both rate and compositional changes in the Los Angeles area were associated with much lower levels of total ridership. Overall, our findings demonstrate the important role of demand-side factors in understanding aggregate transit use, and suggest that planners and managers may have limited policy tools at their disposal when seeking to bolster ridership levels.

Subject Areas: Public transit; Ridership; Travel demand; Demographic change

Availability: Schouten, A., Blumenberg, E., and Taylor, B.D. (2021). "Rating the Composition: Deconstructing the Demand-Side Effects on Transit Use Changes in California." *Travel Behaviour and Society*, *25*, pp. 18–26. https://doi.org/10.1016/j.tbs.2021.05.007

9.12. Title: McKinleyville Transit Study Final Report

Author(s): Hamre, A., Kack, D., Fisher, J., and Fiske, C.

Abstract: The purpose of this project was to provide the Humboldt County Association of Governments ("HCAOG") and Humboldt Transit Authority ("HTA") with guidance to inform future investments in public transportation in and around McKinleyville. This project is also an opportunity to assess aspects of the regional public transportation system and explore affordable and innovative investments to improve public transportation offerings. The primary motivation for this project was an interest in assessing an investment in fixed route transit service within McKinleyville, similar to what is available in the City of Eureka via the Eureka Transit Service and the City of Arcata via the Arcata & Mad River Transit System.

Over the course of this study, the research team evaluated planning documents, conducted public outreach, and analyzed existing conditions and services. Two themes emerged from our review of planning documents: (1) there is strong interest in improving HTA's Redwood Transit System ("RTS"); and (2) there is recognition that McKinleyville could use its own service, separate from RTS. The research team collaborated with the project's Public Outreach lead, Colin Fiske of the Coalition for Responsible Transportation Priorities, to conduct public outreach throughout the course of the project. The public submitted more than 40 comments via the project website between October 2020 and June 2021, and provided numerous additional comments during committee, stakeholder, and public meetings. Public comments provided helpful insight into McKinleyville's transit needs (including service both within McKinleyville as well as between McKinleyville and other parts of Humboldt County); identified areas of improvement for current transit service; and offered feedback on different service types for new local transit service. A survey conducted online between May 26, 2021, and June 25, 2021, was designed as an opportunity for the general public to provide feedback on the project team's draft analysis and recommendations. The survey responses suggested a higher level of confidence in the fit of flexible transit for the McKinleyville community, with 78% of survey respondents indicating they thought flexible transit would work well in McKinleyville, compared to 39% for fixed transit. Flexible transit was also the transit improvement most commonly ranked 1 (most preferred), while fixed transit was the transit improvement most commonly ranked 4 (least preferred). Using weighted averages of transit improvement rankings, flexible transit was the most preferred transit improvement for McKinleyville, followed by expanded Dial-a-Ride ("DAR"), expanded RTS, and fixed transit.

Subject Areas: Regional public transportation system; Investment assessment; Public comments; Tradeoff; Microtransit; Demand

Availability: Hamre, A., Kack, D., Fisher, J., and Fiske, C. (2021). *McKinleyville Transit Study Final Report.* Western Transportation Institute, Cornell University, Bozeman, MT. https://www.mckinleyvilletransitstudy.com/uploads/1/3/3/7/133791725/2021_mckinleyville_transit_study_final_report_for_hcaog.pdf

9.13. Title: Public Transit Use in the United States in the Era of COVID-19: Transit Riders' Travel Behavior in the COVID-19 Impact and Recovery Period

Author(s): Parker, M.E., Li, M., Bouzaghrane, M.A., Obeid, H., Hayes, D., Frick, K.T., Rodríguez, D.A., Sengupta, R., Walker, J., and Chatman, D.G.

Abstract: COVID-19 has upended travel across the world, disrupting commute patterns, mode choices, and public transit systems. In the United States, changes to transit service and reductions in passenger volume due to COVID-19 are lasting longer than originally anticipated. In this paper, we examine the impacts of the COVID-19 pandemic on individual travel behavior across the United States. We analyze mobility data from January to December 2020 from a sample drawn from a nationwide smartphone-based panel curated by a private firm, Embee Mobile. We combine this with a survey that we administered to that sample in August 2020. Our analysis provides insight into travel patterns and the immediate impacts of the COVID-19 pandemic on transit riders.

We investigate three questions. First, how do transit riders differ sociodemographically from non-riders? Second, how has the travel behavior of transit riders changed due to the pandemic in comparison to non-riders, controlling for other factors? And third, how has this travel behavior varied across different types of transit riders?

The travel patterns of transit riders were more significantly disrupted by the pandemic than the travel of non-riders, as measured by the average weekly number of trips and distance traveled before and after the onset of the pandemic. This was calculated using GPS traces from panel member smartphones. Our survey of the panel revealed that of transit riders, 75 percent reported taking transit less since the pandemic, likely due to a combination of being affected by transit service changes, concerns about infection risk on transit, and trip reductions due to shelter-in-place rules. Less than 10 percent of transit riders in our sample reported that they were comfortable using transit despite COVID-19 infection risk and were not affected by transit service reductions. Transit riders were also more likely to have changed their travel behavior in other ways, including reporting an increase in walking. However, lower income transit riders were different from higher income riders in that they had a significantly smaller reduction in the number of trips and distance traveled, suggesting that these lower income households had less discretion over the amount of travel they carried out during the pandemic. These results have significant implications for understanding the way welfare has been affected for transportation-disadvantaged populations during the course of the pandemic and insight into the recovery of U.S. transit systems.

The evidence from this unique dataset helps us understand the future effects of the pandemic on transit riders in the United States, either in further recovery from the pandemic with the anticipated effects of mass vaccination or in response to additional waves of COVID-19 and other pandemics.

Subject Areas: Public transit; Travel behavior; COVID-19; Recovery period; Transportation justice

Availability: Parker, M.E., Li, M., Bouzaghrane, M.A., Obeid, H., Hayes, D., Frick, K.T., Rodríguez, D.A., Sengupta, R., Walker, J., and Chatman, D.G. (2021). "Public Transit Use in the United States in the Era of COVID-19: Transit Riders' Travel Behavior in the COVID-19 Impact and Recovery Period." *Transport Policy*, *111*, pp. 53–62. https://doi.org/10.1016/j.tranpol.2021.07.005

9.14. Title: COVID-19 Pandemic Impacts on Essential Transit Riders: Findings from a U.S. Survey

Author(s): He, Q., Rowangould, D., Karner, A., Palm, M., and LaRue, S.

Abstract: The COVID-19 pandemic has decimated public transit service across the United States and caused significant decreases in ridership. Adapting to the pandemic has been more challenging for some transit riders than for others. Little is known about the reasons for pandemic-era mode shifts and the impacts of pandemic-related transit reductions on riders' day-to-day lives. Using a national survey of U.S. transit riders (n = 500), this study examines changes in transit use since the pandemic began, the reasons for transit reductions, and the effects of reduced transit use and transit service on transit riders' ability to meet their travel needs. The COVID-19 pandemic has exacerbated existing transportation burdens for essential transit riders, pointing to shortcomings inherent in current transit financing policy. We close with recommendations for strengthening the transit service for these groups in the long term as we recover from the pandemic.

Subject Areas: Transportation justice; COVID-19; Public transit; Essential transit riders; Travel behavior; Equity

Availability: He, Q., Rowangould, D., Karner, A., Palm, M., and LaRue, S. (2021). *COVID-19 Pandemic Impacts on Essential Transit Riders: Findings from a U.S. Survey*. SocArXiv 3km9y, Center for Open Science, Charlottesville, VA. https://ideas.repec.org/p/osf/socarx/3km9y.html

9.15. Title: Heterogeneity in Activity-Travel Patterns of Public Transit Users

Author(s): Rafiq, R. and McNally, M.G.

Abstract: Public transit is considered a sustainable mode of transport that can address automobile dependency and provide environmental, economic, and societal benefits. However, with typical temporal and spatial constraints, such as fixed routes and schedules, transfer requirements, waiting times, and access/egress issues, public transit offers lower accessibility and mobility services than private vehicles, and thus it is considered a less attractive mode to many prospective users. To improve the performance of transit and, in turn, to increase its usage, a broader understanding of the daily activity-travel patterns of transit users is fundamental. In this context, this study analyzed transit-based activity-travel patterns by classifying users via Latent Class Analysis (LCA). Using data from the 2017 National Household Travel Survey, the LCA model suggested that transit users could be split into five distinct classes where each class has a representative activity-travel pattern. Class 1 constituted employed White males who made transit-dominant simple work tours. Class 2 was composed of employed White females who made complex work tours. Employed White millennials comprised Class 3 and made multimodal complex tours. Transit Class 4 were non-White younger or older adult groups who made transit-dominant simple non-work tours. Last, Class 5 members made complex non-work tours with recurrent transit use and comprised single older women. This study provided insights regarding the variations of activity-travel patterns and the associated market segments of transit users in the United States. The results can assist transit agencies in identifying transit user groups with particular activity patterns and to consider market strategies that can address their travel needs.

Subject Areas: Public transit; Tours; Activity-travel pattern; Pattern classification; Latent class analysis; National Household Travel Survey

Availability: Rafiq, R. and McNally, M.G. (2021). "Heterogeneity in Activity-Travel Patterns of Public Transit Users." *Transportation Research Part A: Policy and Practice*, *152*, pp. 1–18. https://doi.org/10.1016/j.tra.2021.07.011

9.16. Title: Mitigating Increased Driving After the COVID-19 Pandemic: An Analysis on Mode Share, Travel Demand, and Public Transport Capacity

Author(s): Ciuffini, F., Tengattini, S., and Bigazzi, A.Y.

Abstract: Reduced transit capacity to accommodate social distancing during the COVID-19 pandemic was a sudden constraint that, along with a large reduction in total travel volume and a shift in activity patterns, contributed to abrupt changes in transportation mode shares across cities worldwide. There are major concerns that as the total travel demand rises back toward pre-pandemic levels, the overall transport system capacity with transit constraints will be insufficient for the increasing demand. This paper uses city-level scenario analysis to examine the potential increase in post-COVID-19 car use and the feasibility of shifting to active transportation, based on pre-pandemic mode shares and varying levels of reduction in transit capacity. An application of the analysis to a sample of cities in Europe and North America is presented. Mitigating an increase in driving requires a substantial increase in active transportation mode share, particularly in cities with high pre-COVID-19 transit ridership; however, such a shift may be possible based on the high percentage of short-distance motorized trips. The results highlight the importance of making active transportation attractive and reinforce the value of multimodal transportation systems as a strategy for urban resilience. This paper provides a strategic planning tool for policymakers facing challenging transportation system decisions in the aftermath of the COVID-19 pandemic.

Subject Areas: Planning and Analysis; Transportation planning policy and processes; Multimodal; Multimodal planning; Travel choices; Public transportation; Planning and development

Availability: Ciuffini, F., Tengattini, S., and Bigazzi, A.Y. (2021). "Mitigating Increased Driving After the COVID-19 Pandemic: An Analysis on Mode Share, Travel Demand, and Public Transport Capacity." *Transportation Research Record: Journal of the Transportation Research Board*. https://doi.org/10.1177%2F03611981211037884

9.17. Title: Investigating the Relationship Between Transit Planning for Leisure and Household Vehicle Ownership in King County

Author(s): Young, G.A.

Abstract: Historically, transportation planning has focused on accommodating peak hour commuting behavior, but in reality, these trips represent just 15 percent of daily travel (Holden & Linnerud, 2011; Bureau of Transportation Statistics, 2017). Meaningful efforts to curb emissions from the transportation sector must consider a wider range of trip types. Leisure travel makes up an estimated 27 percent of everyday trip-making behavior in the United States and is typically more spatiotemporally complicated than commuting, increasing the likelihood of driving (Bureau of Transportation Statistics, 2017; BeirÃ£o & Cabral, 2010). This research investigates how transit planning for accessing leisure opportunities impacts household-level car ownership in King County through binary logistic modeling built around three key independent variables: average travel time and the transit/auto travel time ratio to nearby leisure destinations, and evening and weekend transit service area. Additionally, k-means clustering of households by leisure style reveals how activity preferences may impact the likelihood of owning one or more vehicles. Results indicate that household car ownership increases with longer average travel times to leisure-specific destinations and, less so, decreases with larger transit access sheds.

Subject Areas: Public transit; Transportation planning; Transit planning; Leisure travel; Binary logistic; Vehicle ownership

Availability: Young, G.A. (2021). *Investigating the Relationship Between Transit Planning for Leisure and Household Vehicle Ownership in King County*. Master's Thesis, University of Washington, Seattle, WA. https://digital.lib.washington.edu/researchworks/handle/1773/47718

9.18. Title: Evaluating Spatial Justice in Rail Transit: Access to Terminals by Foot

Author(s): Adli, S.N., Chowdhury, S., and Shiftan, Y.

Abstract: There has been a growing interest to improve urban rail services for increasing a city's economic competitiveness. While accessibility provided by rail services has been the focus of many studies, determining accessibility to rail stations is less investigated. The present study examines how accessibility to rail stations via walking has social justice implications. Accessibility can be measured by socioeconomic background, trip characteristics, self-selection, and neighborhood characteristics. Commuters from two rail stations in Auckland, New Zealand—a transit-oriented development (TOD) and a local station—participated in an interactive online survey. Spatial and statistical measures were used to assess the ease of access to the two stations. Under the developed framework, which evaluates social justice in transit, minimum accessibility should be provided (sufficientarianism) and accessibility should disproportionately benefit the less well-off (egalitarianism). The findings show that minimum accessibility was not met for either station, but the TOD station provides better access for low-income individuals. This study contributes by demonstrating the use of a developed framework to evaluate accessibility to rail stations via walking from a social justice perspective. This can be adapted to analyze the accessibility to rail stations in an urban environment of any city.

Subject Areas: Urban rail services; Accessibility to rail stations; Walking to train stations; Social justice implications; Transit-oriented development; Framework

Availability: Adli, S.N., Chowdhury, S., and Shiftan, Y. (2020). "Evaluating Spatial Justice in Rail Transit: Access to Terminals by Foot." *Journal of Transportation Engineering, Part A: Systems*, *146*(9). https://doi.org/10.1061/JTEPBS.0000419

9.19. Title: Rhythm of Transit Stations: Uncovering the Activity-Travel Dynamics of Transit-Oriented Development in the U.S.

Author(s): Fan, Z., Zhang, F., and Loo, B.P.Y.

Abstract: Existing transit-oriented-development (TOD) classification studies primarily focus on the static characteristics around transit stations to measure the built environment's density, diversity, and design. As a community development model, time-variant variables, dynamic human activities throughout different times of the day and week matter in further unpacking the characteristics of TODs. Given that this aspect has been under-discussed in most previous TOD literature, this research provides an activity-based framework to classify commuter transit station areas by considering the degree of local vibrancy—the temporal visiting pattern of all points of interest (POIs) that fall within the station areas. We apply a two-step semi-unsupervised clustering algorithm to classify 4,290 station areas from 54 metropolitan areas across the United States. This method produces 13 distinct station area types. Next, we further examine the connection between station area types and neighborhood travel behavior. A cross-sectional comparison reveals that stations with consistent active morning activities are associated with a higher ratio of commuting by walking and biking and lower automobile usage measured in vehicle miles traveled (VMT). Using stations opened after 2009, we show that active weekend activity patterns are associated with a more significant increase in commuting by public transit.

Subject Areas: Transit-oriented development (TOD); Human dynamics; Clustering analysis; Urban areas; Planning; Space stations; Employment; Density measurement

Availability: Fan, Z., Zhang, F., and Loo, B.P.Y. (2021). "Rhythm of Transit Stations: Uncovering the Activity-Travel Dynamics of Transit-Oriented Development in the U.S." *IEEE Transactions on Intelligent Transportation Systems* (Early Access), pp. 1–15.
https://doi.org/10.1109/TITS.2021.3115103

9.20. Title: Investigating the Association Between Mass Transit Adoption and COVID-19 Infections in U.S. Metropolitan Areas

Author(s): Thomas, M.M., Mohammadi, N., and Taylor, J.E.

Abstract: Urbanization introduces the threat of increased epidemic disease transmission resulting from crowding on mass transit. The coronavirus disease 2019 (COVID-19) pandemic, which has directly led to more than 600,000 deaths in the United States as of July 2021, triggered mass social distancing policies to be enacted as a key deterrent of widespread infections. Social distancing can be challenging in confined spaces required for transportation, such as mass transit systems. Little is published regarding the degree to which mass transit system adoption effects impacted the rise of the COVID-19 pandemic in urban centers. Taking an ecological approach where areal data are the unit of observation, this national-scale study aims to measure the association between the adoption of mass transit and COVID-19 spread through confirmed cases in U.S. metropolitan areas. National survey-based transit adoption measures are entered in negative binomial regression models to evaluate differences between areas. The model results demonstrate that mass transit adoption in U.S. metropolitan areas was associated with the magnitude of outbreaks. Higher incidence of COVID-19 early in the pandemic was associated with survey results conveying higher transit use. Increasing weekly bus transit usage in metropolitan statistical areas by one scaled unit was associated with a 1.38 (95 percent CI: [1.25, 1.90]) times increase in incidence rate of COVID-19; a one scaled unit increase in weekly train transit usage was associated with an increase in incidence rate of 1.54 (95 percent CI: [1.42, 2.07]) times. These conclusions should inform early action practices in urban centers with busy transit systems in the event of future infectious disease outbreaks. Deeper understanding of these observed associations may also benefit modeling efforts by allowing researchers to include mathematical adjustments or better explain caveats to results when communicating with decision makers and the public in the crucial early stages of an epidemic.

Subject Areas: SARS-CoV-2; COVID-19; Transit; Disease transmission; Public health; Public transportation

Availability: Thomas, M.M., Mohammadi, N., and Taylor, J.E. (2021). "Investigating the Association Between Mass Transit Adoption and COVID-19 Infections in U.S. Metropolitan Areas." *Science of The Total Environment*, *811*. https://doi.org/10.1016/j.scitotenv.2021.152284

9.21. Title: Evaluating and Optimizing Shared Mobility Services to Improve Public Transit Efficiency, Accessibility and Reliability

Author(s): Grahn, R.R.

Abstract: Shared mobility services will play an important role in addressing congestion, CO_2 emissions, and equity in a rapidly changing transportation system. This thesis focused on two emerging shared mobility services (transportation network companies and first-mile last-mile services) due to their potential to provide benefits to transportation system users and society.

Transportation network companies (TNCs), such as Uber and Lyft, have observed significant ridership growth since they began offering rides in 2010 and 2012, respectively. However, their impacts on the greater transportation system are unclear. This thesis provides a comprehensive understanding about TNC travel behavior, their impacts on public transit ridership, and their potential future roles in a quickly transitioning transportation sector. The first study used the 2017 National Household Travel Survey to analyze socioeconomic, demographic, and usage characteristics of TNC users. As of 2017, 10 percent of the adult population reported TNC use in the previous month; however, use frequency was low (3–4 times/month on average). Younger, well-educated, higher income, White populations living in urban areas used TNC services at higher rates. Public transit users and zero-car households also used TNCs at higher frequencies. Overall, findings from study 1 suggested that TNCs were predominately used by specific population segments in regions with strong public transit. These findings have both equity and sustainability implications. Study 2 collected high-resolution transportation network data to analyze the relationship between public transit and TNCs in Pittsburgh. The relationship—substitutional or complementary—was evaluated by measuring changes in public transit ridership as a function of TNC fare. A substitutional relationship was assumed if bus ridership changes were significant during periods of elevated TNC fares. Substitutional relationships occurred at both university locations and along the dedicated busway during the evening hours. These results corroborate previous findings that younger, well-educated populations are using TNCs at greater rates. Additionally, substitutional behaviors along the dedicated busway might indicate that TNCs were being used for last-mile connections.

The final two studies analyzed and optimized first-mile last-mile (FMLM) services as transit connectors from both user cost (wait time, travel time, reliability) and agency cost ($) perspectives. User costs were based on the weighted sum of wait time and in-vehicle time because traveler disutility varies between the two trip segments (e.g., $\alpha\cdot$ wait time + $\beta\cdot$ in-vehicle time, where $\alpha > \beta$). 95th percentile wait time and travel time were used to quantify system reliability because wait times (or travel times) that exceed this value only occur 5 percent of the time (in other words, 95 percent of observations fall below the 95th percentile).

In study 3, a real-time operations model was developed to optimize and simulate operations for an existing FMLM service in Robinson Township, PA. Four operational policies were selected—coordination with mainline transit, advanced requests, predictive routing, trip prioritization—to evaluate system performance. User costs decreased in all cases; however, the magnitude of improvements varied from minimal (2 to 4 percent) for the predictive routing case to large (50 percent) if all reservations were made in advance. Ninety-fifth percentile travel times were also reduced for time inflexible trips through trip prioritization. In study 4, the real-time operations model

was modified to integrate TNCs with existing on-demand shuttles to help further improve system performance. The flexibility of the hybrid design contributed to reliability improvements and lower costs. The hybrid system was also more effective at responding to variations in demand due to payment and supply flexibility (shuttles: higher capacity, per hour fees. TNCs: larger fleet, per trip fees). This feature allowed the system to balance user and agency costs during daily demand fluctuations.

Subject Areas: Shared mobility; Transportation network companies; Public transit ridership; First-mile last-mile; Cost; Transportation system performance; Case study

Availability: Grahn, R.R. (2021). *Evaluating and Optimizing Shared Mobility Services to Improve Public Transit Efficiency, Accessibility and Reliability*. Doctoral Dissertation, Carnegie Mellon University, Pittsburgh, PA.
https://www.proquest.com/openview/5b900dd043b475822eb1799366b790ca/1?pq-origsite=gscholar&cbl=18750&diss=y

9.22. Title: Who's on Board? Examining the Changing Characteristics of Transit Riders Using Latent Profile Analysis

Author(s): Schouten, A., Taylor, B.D., and Blumenberg, E.

Abstract: Subsidies of public transit have more than doubled since the late 1980s, with a disproportionate share of funds going to rail services. These investments have important implications, including how they affect both the composition of transit users and their travel behavior. To investigate how transit users and use are changing, we use Latent Profile Analysis and data from the 2009 and 2017 National Household Travel Surveys to examine changes in transit users in the United States and in five major metropolitan areas. Nationwide, we find that the share of transit dependents grew by 17 percent to account for two-thirds of all transit users in 2017. These least advantaged riders were more likely over time to reside in very poor households and to be carless. There was a corresponding decline in occasional transit users, for whom transit is part of a multi-modal travel profile. Higher income, mostly car-owning choice transit riders increased slightly over time but accounted for less than 1 in 10 transit riders in 2017. Their growth was concentrated in a few large metropolitan areas where densities and land use are most transit-supportive. Although increased rail transit service has shifted riders away from buses, transit's role as a redistributive social service that provides mobility to disadvantaged travelers has grown over time. Efforts to draw more multi-modal and car-owning travelers onto transit have been less successful. As transit systems struggle to recover riders following the pandemic, transit's waxing role of providing mobility for those without will likely become even more prominent.

Subject Areas: Public transportation; Transit users; Ridership; Rail transit service; Mobility; Disadvantaged travelers

Availability: Schouten, A., Taylor, B.D., and Blumenberg, E. (2021). "Who's on Board? Examining the Changing Characteristics of Transit Riders Using Latent Profile Analysis." *Transportation Research Record: Journal of the Transportation Research Board*, *2675*(7), pp. 1–10. https://doi.org/10.1177%2F0361198120987225

9.23. Title: Rural Transit Fact Book, 2021

Author(s): Mattson, J. and Mistry, D.

Abstract: Public transportation plays a fundamental role in the livability of communities of all sizes. *The Rural Transit Fact Book* provides information on transit service availability and cost to help the transit industry in the United States provide efficient and effective service to meet rural community mobility needs. Financial and operating statistics can be used by agency managers, local decision makers, State directors, the Federal Transit Administration (FTA), and lawmakers to assist in policymaking, planning, managing operations, and evaluating performance.

The *Rural Transit Fact Book* serves as a national resource for statistics and information on rural transit in America. This publication includes rural demographic and travel behavior data as well as financial and operating statistics for agencies receiving section 5311 funding. In addition to national-level data, statistics are presented by State, FTA region, tribe, and mode, as well as other agency characteristics.

The rural transit data presented in this report were obtained from the Rural National Transit Database (NTD). The 2011 edition of *The Rural Transit Fact Book* was the first published by SURTC/SURCOM and included Rural NTD data for 2007–2009. Since 2011, updates have been made to the book to provide updated data. The 2021 edition includes 2019 data from the NTD as well as additional data from the American Community Survey and National Household Travel Survey.

As noted, this publication presents data for transit providers receiving section 5311 Non-Urbanized Area Formula Program funding. This program provides funding to States to support public transportation in rural areas with populations of less than 50,000. A number of rural transit providers also receive funding under the section 5310 Enhanced Mobility of Seniors and Individuals with Disabilities Program. However, nationwide data for 5310 services are not available, as providers are not required to report such data to the NTD. Therefore, rural transit providers not funded by the 5311 program but receiving funding from section 5310 are not included in this report. Also excluded from the report are providers that receive strictly non-Federal funding and those receiving both section 5311 funds and section 5307 Urbanized Area Formula Program funding and report their data in the urban NTD.

Subject Areas: Transit service availability; Mobility in rural community; 5311 Non-Urbanized Area Formula Program; Rural demographic; Travel behavior; Operating statistics

Availability: Mattson, J. and Mistry, D. (2021). *Rural Transit Fact Book, 2021*. North Dakota State University, Fargo, ND. https://www.ugpti.org/resources/reports/downloads/surtcom21-07.pdf

9.24. Title: A Spatiotemporal Analysis of E-Scooters' Relationships with Transit and Station-Based Bikeshare

Author(s): Yan, X., Yang, W., Zhang, X., Xu, Y., Bejleri, I., and Zhao, X.

Abstract: To address the policy question of how e-scooters interact with existing public mobility options, we conduct a spatiotemporal analysis of e-scooters' relationships with public transit and station-based bike-share in Washington, DC. Results suggest that e-scooters have both competing and complementary effects on transit and bike-share. The service areas of the three modes largely overlap, and most e-scooter trips could have been made by transit or bike-share. A travel-time-based analysis further reveals that when choosing e-scooters over transit, travelers pay a price premium but save some travel time. The price premium was greater during COVID-19, but the associated travel-time savings were smaller. This implies that public health considerations rather than time-cost tradeoffs were the main determinant of travel behavior during COVID-19. In addition, we find that e-scooters enhance mobility services for some underserved neighborhoods. Before COVID-19, about 10 percent of all e-scooter trips were taken to connect with the Metrorail system.

Subject Areas: Micromobility; E-scooter; Public transit; Bike-share; Spatiotemporal analysis; COVID-19

Availability: Yan, X., Yang, W., Zhang, X., Xu, Y., Bejleri, I., and Zhao, X. (2021). "A Spatiotemporal Analysis of E-Scooters' Relationships with Transit and Station-Based Bikeshare." *Transportation Research Part D: Transport and Environment*, *101*. https://doi.org/10.1016/j.trd.2021.103088

Chapter 10. Travel Behavior

10.1. Title: Urban Recreational Travel

Author(s): Cheng, L. and Witlox, F.

Abstract: The growth in population and the increased leisure time and affluence are exerting ever-increasing pressure on recreational sources and the transport system. Urban recreational travel accounts for a significant and growing number of daily trips made by citizens. Recreation is an activity conducted during leisure time for the purpose of satisfaction, enjoyment, and pleasure. Recreation demand, supply, and transport interplay shaping the temporal, spatial and modal choice patterns of recreational trips. Empirical studies have well recognized the benefits and risks of recreational trips in term of social, economic, health, and environmental effects. In the era of mobile Internet, the growing use of information and communication technology has profound impacts on recreational travel, acting as a replacement, facilitator, or modifier.

Subject Areas: Recreation; Leisure; Tourism; Temporal and spatial distribution; Travel mode; Demand and supply; Social and economic benefits; Health and wellbeing; Environmental impacts; Information and communication technology (ICT); Substitution; Generation; Modification

Availability: Cheng, L. and Witlox, F. (2021). "Urban Recreational Travel." *International Encyclopedia of Transportation*, Elsevier, Amsterdam, Netherlands. https://www.researchgate.net/publication/345250654_Urban_recreational_travel

10.2. Title: E-shopping Changes and the State Of E-Grocery Shopping in The US - Evidence from National Travel and Time Use Surveys

Author(s): Xu, L. and Saphores, J.

Abstract: In spite of the popularity of e-shopping, only 16% of US adults have ordered groceries online, and 7 out of 10 of those who currently buy groceries online do so at most twice a month. Understanding the determinants of e-grocery shopping is important for grocers, supply chain managers, and urban planners. In this context, we first explore how deliveries from online shopping have been changing over time. From our analysis of the 2009 and 2017 National Household Travel Surveys, we found that online shopping has been embraced by increasingly diverse households, although income, education, and some racial/ethnic differences persist. Our analysis of the 2017 American Time Use Survey shows that Americans are 24 times more likely to shop for groceries in stores than online. Moreover, in-store grocery shoppers are more likely to be female and unemployed, but less likely to belong to younger generations, to have less than a college degree, or to be African American. The gender imbalance in grocery shopping is larger online than in stores, but e-grocery shoppers do not otherwise differ from the general population. Future travel and e-shopping surveys (especially for e-grocery) should combine time use and travel questions with retrospective questions about online purchases.

Subject Areas: e-grocery; Online shopping; National household travel survey; American Time use survey

Availability: Xu, L. and Saphores, J. (2021). "E-shopping Changes and the State Of E-Grocery Shopping in The US - Evidence from National Travel and Time Use Surveys." *Research in Transportation Economics*, *87*. https://doi.org/10.1016/j.retrec.2020.100864

10.3. Title: Effects of Multidimensional Disadvantages on Daily Trips for Three Out-of-Home Activities

Author(s): Wang, S., Kim, J., and Xu, Y.

Abstract: As limited daily trips may reduce social interactions and access to opportunities and resources, understanding the effects of multidimensional disadvantages on daily trips is important. Using the 2017 U.S. National Household Travel Survey data, we examined the effects of demographic, economic, Internet use, and transportation disadvantages on the trips of recreational, work, and social participation purposes on weekdays and the weekends, respectively. We found while disadvantages were overall negatively associated with daily trips, their associations varied by the type of disadvantages, trip purpose, and trip day. For example, the poor were more likely to make a work-related trip on the weekend and a social participation trip during a weekday, indicating that the goal of a social participation trip on a weekday may be unique for the poor. We discuss various policy approaches to improve social interactions and opportunities among the disadvantaged.

Subject Areas: Daily trips; Trip purpose; Demographic; Internet use; Transportation disadvantages

Availability: Wang, S., Kim, J., and Xu, Y. (2021). *Effects of Multidimensional Disadvantages on Daily Trips for Three Out-of-Home Activities.* Transportation Research Board 100th Annual Meeting—A Virtual Event, Washington, DC. https://annualmeeting.mytrb.org/OnlineProgram/Details/15626

10.4. Title: The Effects of High-skilled Firm Entry on Incumbent Residents

Author(s): Qian, F. and Tan, R.

Abstract: What happens to incumbent residents following the entry of a large high-skilled firm? To study this, we construct a dataset of 391 such entries in the United States from 1990–2010. We follow incumbent residents over 13 years using rich micro-data on individual address histories, property characteristics, and financial records. First, we estimate the effects of the firm entry on incumbent residents' consumption, finances, and mobility. To do so, we compare outcomes for residents living close to the entry location with those living far away, while controlling for their proximity to potential high-skilled firm entry sites. Next, we decompose welfare from changes in wages, rents, and amenities for incumbent residents using a model of individual home and work location choice. Taken together, our results show high-skilled incumbents, especially homeowners, benefit. Low-skilled owners benefit less than high-skilled owners. Low-skilled renters are harmed. In the medium to long run, they incur an annual welfare loss that is equivalent to a 0.2 percent decline in their wages 1 year prior to the entry.

Subject Areas: Large high-skilled firm; Incumbent residents; Household characteristics; High-skilled and lower-skilled workers

Availability: Qian, F. and Tan, R. (2021). *The Effects of High-skilled Firm Entry on Incumbent Residents.* Working Paper, Stanford University, Stanford, CA.
https://web.stanford.edu/~zqian1/files/firm_entry_JMP.pdf

10.5. Title: Modeling Household Online Shopping Demand in the U.S.: A Machine Learning Approach and Comparative Investigation between 2009 and 2017

Author(s): Barua, L., Zou, b., Zhou, Y., and Liu, Y.

Abstract: Despite the rapid growth of online shopping and research Interest in the relationship between online and in-store shopping, national-level modeling and investigation of the demand for online shopping with a prediction focus remain limited in the literature. This paper differs from prior work and leverages two recent releases of the U.S. National Household Travel Survey (NHTS) data for 2009 and 2017 to develop machine learning (ML) models, specifically gradient boosting machine (GBM), for predicting household-level online shopping purchases. The NHTS data allow for not only conducting nationwide investigation but also at the level of households, which is more appropriate than at the individual level given the connected consumption and shopping needs of members in a household. We follow a systematic procedure for model development including employing Recursive Feature Elimination algorithm to select input variables (features) in order to reduce the risk of model overfitting and increase model explainability. Extensive post-modeling investigation is conducted in a comparative manner between 2009 and 2017, including quantifying the importance of each input variable in predicting online shopping demand, and characterizing value-dependent relationships between demand and the input variables. In doing so, two latest advances in machine learning techniques, namely Shapley value-based feature importance and Accumulated Local Effects plots, are adopted to overcome inherent drawbacks of the popular techniques in current ML modeling. The modeling and investigation are performed both at the national level and for three of the largest cities (New York, Los Angeles, and Houston). The models developed and insights gained can be used for online shopping-related freight demand generation and may also be considered for evaluating the potential impact of relevant policies on online shopping demand.

Subject Areas: Online shopping demand; Gradient boosting machine; Prediction; National Household Travel Survey; Shapley value-based feature importance; Accumulated local effects

Availability: Barua, L., Zou, B., Zhou, Y., and Liu, Y. (2021). "Modeling household online shopping demand in the U.S.: a machine learning approach and comparative investigation between 2009 and 2017." *Transportation*. https://doi.org/10.1007/s11116-021-10250-z

10.6. Title: Comparing Hundreds of Machine Learning Classifiers and Discrete Choice Models in Predicting Travel Behavior: An Empirical Benchmark

Author(s): Wang, S., Mo, B., Hess, S., and Zhao, J.

Abstract: Researchers have compared machine learning (ML) classifiers and discrete choice models (DCMs) in predicting travel behavior, but the generalizability of the findings is limited by the specifics of data, contexts, and authors' expertise. This study seeks to provide a generalizable empirical benchmark by comparing hundreds of ML and DCM classifiers in a highly structured manner. The experiments evaluate both prediction accuracy and computational cost by spanning 4 hyper-dimensions, including 105 ML and DCM classifiers from 12 model families, 3 datasets, 3 sample sizes, and 3 outputs. This experimental design leads to an immense number of 6,970 experiments, which are corroborated with a meta dataset of 136 experiment points from 35 previous studies. This study is hitherto the most comprehensive and almost exhaustive comparison of the classifiers for travel behavioral prediction. We found that the ensemble methods and deep neural networks achieve the highest predictive performance, but at a relatively high computational cost. Random forests are the most computationally efficient, balancing between prediction and computation. While discrete choice models offer accuracy with only 3-4 percentage points lower than the top ML classifiers, they have much longer computational time and become computationally impossible with large sample size, high input dimensions, or simulation-based estimation. The relative ranking of the ML and DCM classifiers is highly stable, while the absolute values of the prediction accuracy and computational time have large variations. Overall, this paper suggests using deep neural networks, model ensembles, and random forests as baseline models for future travel behavior prediction. For choice modeling, the DCM community should switch more attention from fitting models to improving computational efficiency, so that the DCMs can be widely adopted in the big data context.

Subject Areas: Machine learning; Choice modeling; Travel behavior; Prediction

Availability: Wang, S., Mo, B., Hess, S., and Zhao, J. (2021). *Comparing Hundreds of Machine Learning Classifiers and Discrete Choice Models in Predicting Travel Behavior: An Empirical Benchmark*. arXiv preprint, arXiv:2102.01130 [cs.LG]. https://arxiv.org/abs/2102.01130

10.7. Title: Targeted Investment for Food Access

Author(s): Novak, D.C., Sullivan, J.L., and Niles, M.T.

Abstract: This project focuses on modeling access to food locations by identifying the most critical roadway links in a transportation network. This project extends the Critical Closeness Accessibility (CCA) measure developed by Novak and Sullivan (2014) to identify the roadway infrastructure components that are most critical with respect to food accessibility. Specifically, origin and destination weighting are included for the application of food security, where origins are weighted according to household vulnerability and destinations are weighted by retail-grocery square footage. The CCA is further extended by calibrating the trip impedance constant, ω, in the original formulation of the CCA with actual grocery-shopping data from the National Household Travel Survey. This calibration modifies the functional form of the accessibility measure to address trips focused on food access and thus incorporates realistic travel expectations for retail grocery familiarity of households. The project also provides a unique method for estimating household-level vulnerability characteristics using population synthesis. The modification of the CCA to address food accessibility can be used to support more targeted investment in transportation assets, as the CCA is indexed to specific roadway links in the network. The methodology is demonstrated using the Travel Demand Model of Chittenden County, VT.

Subject Areas: Accessibility; Food access; Vulnerability; Network disruption; Critical closeness accessibility; Infrastructure; Rural communities

Availability: Novak, D.C., Sullivan, J.L., and Niles, M.T. (2021). *Targeted Investment for Food Access.* National Center for Sustainable Transportation, University of California, Davis, CA. https://doi.org/10.7922/G2FT8JBR

10.8. Title: Factors Affecting Home Deliveries Before and During COVID-19 Lockdown: Accessibility, Environmental Justice, Equity, and Policy Implications

Author(s): Figliozzi, M.A. and Unnikrishnan, A.

Abstract: During the COVID-19 lockdowns, home deliveries have changed from being a desirable luxury or comfortable solution to a health-supporting and essential service for many COVID-19 at-risk populations. However, not all households are equal in terms of access to home deliveries. The onset of COVID-19 has brought to light access inequalities that preceded the pandemic and that the COVID-19 lockdown has exacerbated and made visible. The concept of home-based accessibility (HBA) is introduced, and novel research questions are addressed: (i) What type of households had zero home deliveries before COVID-19 lockdown? (ii) How the COVID-19 lockdown affected the type of households that receive home deliveries? and (iii) What are the implications of no access to home delivery services in terms of equity and environmental justice? To answer the first two questions, exploratory and confirmatory models are estimated utilizing data collected from an online survey representative of the population in the Portland metropolitan region. Policy and environmental equity implications are discussed using the concept of home-based accessibility (HBA). The results indicate that traditionally underserved populations, especially low-income populations, are less likely to benefit from home-based delivery services and that COVID-19 may have worsened home delivery inequalities.

Subject Areas: COVID-19; Economic aspects; e-Commerce; Social aspects; Delivery of goods; Equity; Social justice

Availability: Figliozzi, M.A. and Unnikrishnan, A. (2021). "Factors Affecting Home Deliveries Before and During COVID-19 Lockdown: Accessibility, Environmental Justice, Equity, and Policy Implications." *Transportation Research Part D: Transport and Environment*. https://archives.pdx.edu/ds/psu/34787

10.9. Title: Residential Relocations and Changes in Vehicle Ownership

Author(s): Schouten, A.

Abstract: While the relationship between automobile ownership and the built environment is well established, less is known about how household relocations—specifically, moves between urban and suburban geographies—affect the likelihood of owning an automobile. Using the Panel Study of Income Dynamics and a refined neighborhood typology, I examine the relationship between inter-geography moves and transitions into and out of carlessness. Results suggest that among low-income households, urban-to-suburban movers have an increased likelihood of becoming car owners; those moving in the "opposite" direction—from suburban to urban neighborhoods—show a high propensity to transition into carlessness. Patterns among higher-income households, while similar, are more pronounced. In particular, higher-income carless households that make urban-to-suburban moves are far more likely to become car owners than their low-income counterparts. This highlights the ease with which higher-income households adjust their car ownership levels to suit their post-move neighborhoods. Higher-income suburban-to-urban movers are also more likely to transition into carlessness than low-income households. Importantly, however, only households at the bottom end of the "higher income" distribution have an increased propensity to become carless; suburban-to-urban movers with more financial resources maintain vehicle ownership rates similar to households that remain in the suburbs.

Subject Areas: Car ownership; Residential location; Built environment

Availability: Schouten, A. (2021). "Residential Relocations and Changes in Vehicle Ownership." *Transportation*. https://link.springer.com/article/10.1007%2Fs11116-021-10167-7

10.10. Title: To Be Online or In-store: Analysis of Retail, Grocery, and Food Shopping in New York City

Author(s): Kim, W. and Wang, X.

Abstract: With advances in information technology, online shopping for a parcel (retail), grocery, and food (i.e., prepared meal) have become a part of daily life, and they are expected to continue to grow in the future. Accordingly, shopping behaviors, i.e., shopping channels, are becoming more complex than ever. However, the current research focus is still mainly on traditional parcel delivery, and little is known for food and grocery deliveries and their impacts on transportation systems. To have a better understanding of deliveries and their impacts on transportation systems, using the survey data from NYC DOT Citywide Mobility Survey in 2018, this paper investigated (a) factors affecting the three types of deliveries (retail, grocery, and food) by developing a seemingly unrelated model and (b) the relationships between deliveries and in-store shopping trips by different modes using multiple simultaneous equations models. The results showed that factors affecting deliveries vary by the type of delivery, and the three deliveries are positively correlated by common unobserved factors. In addition, the relationships between delivery and shopping trip vary not only by delivery type but also by trip mode (driving/walking). The findings would provide valuable insights into travel demand modeling and curbside management.

Subject Areas: Online shopping; Parcel delivery; Grocery delivery; Food delivery; In-store trip; Shopping behavior

Availability: Kim, W. and Wang, X. (2021). "To Be Online or In-store: Analysis of Retail, Grocery, and Food Shopping in New York City." *Transportation Research Part C: Emerging Technologies*, *126*. https://doi.org/10.1016/j.trc.2021.103052

10.11. Title: Assessing the VMT Effect of Ridesourcing Services in the US

Author(s): Wu, X. and MacKenzie, D.

Abstract: The net effect of ridesourcing (RS) services on vehicle miles traveled (VMT) is ambiguous. With 2017 U.S. National Household Travel Survey data, this study measures and compares the heterogeneous VMT effects of RS across population groups with various levels of household vehicle access and RS usage. A propensity score matching method was implemented to match RS non-users, occasional users, and frequent users based on observable sociodemographic traits. The results suggest that among drivers with household vehicle access, frequent RS users generate the least VMT, but occasional users actually generate more VMT. Those without a driver's license or a household vehicle generate lower VMT while use more transit, and increasing RS use uniformly increases their overall VMT generation. We estimate that overall, RS generated a net increase of 7.8 million daily VMT in the US, compared with a counterfactual case in which all NHTS 2017 respondents were non-users of RS.

Subject Areas: Vehicle miles traveled; Ridesourcing; U.S. National Household Travel Survey; Propensity score matching

Availability: Wu, X. and MacKenzie, D. (2021). "Assessing the VMT Effect of Ridesourcing Services in the US." *Transportation Research Part D: Transport and Environment*, *94*. https://doi.org/10.1016/j.trd.2021.102816

10.12. Title: Travel Behavior Modeling: Taxonomy, Challenges, and Opportunities

Author(s): Sharma, A., Gani, A., Asirvatham, D., Ahmed, R., Hamzah, M., and Asli, M.F.

Abstract: Personal daily movement patterns have a longitudinal impact on the individual's decision-making in traveling. Recent observation on human travel raises concerns on the impact of travel behavior changes on many aspects. Many travel-related aspects like traffic congestion management and effective land-use were significantly affected by travel behavior changes. Existing travel behavior modeling (TBM) were focusing on assessing traffic trends and generate improvement insights for urban planning, infrastructure investment, and policymaking. However, literature indicates limited discussions on recent TBM adaptation towards future technological advances like the integration of autonomous vehicles and intelligent traveling. This survey paper aims to provide overview insights on recent advances of TBM including notable classifications, emerging challenges, and rising opportunities. In this survey, we reviewed and analyzed recently published works on TBM from high-quality publication sources. A taxonomy was devised based on notable characteristics of TBM to guide the classification and analysis of these works. The taxonomy classifies recent advances in TBM based on type of algorithms, applications, data sources, technologies, behavior analysis, and datasets. Furthermore, emerging research challenges and limitations encountered by recent TBM studies were characterized and discussed. Subsequently, this survey identified and highlights open issues and research opportunities arise from recent TBM advances for the future undertaking.

Subject Areas: Travel behavior; Travel behavior modeling; Prediction modeling; Intelligent traveling

Availability: Sharma, A., Gani, A., Asirvatham, D., Ahmed, R., Hamzah, M., and Asli, M.F. (2021). "Travel Behavior Modeling: Taxonomy, Challenges, and Opportunities." *International Journal of Advanced Computer Science and Applications*, *12*(5).
https://dx.doi.org/10.14569/IJACSA.2021.0120590

10.13. Title: Effects of Land Use and Transportation Infrastructure on Distance to Work in Individual Car Riders

Author(s): Pouladi, R

Abstract: Studying travel behavior has become a means of addressing car dependency, greenhouse gas emission, and environmental protection. Many studies have examined the effects of socioeconomic and built environmental factors on vehicle miles traveled (VMT), but there is a limited literature examining the role of these factors on home-to-work distance. If one of the concepts of developing new freeways and toll roads is providing faster and more reliable commutes, then it is assumed that new high-speed road infrastructure will lead to a higher commuting distance. This study used the 2017 National Household Travel Survey, U.S. Census, GIS, and Longitudinal Employer-Household Dynamics (LEHD) data to develop two models to analyze the effects of total mileage of limited access roads (tollway and highway) in urban areas on home-to-work distance. In addition, other socioeconomic, built environment, demographic, and behavioral factors were considered in these models as control variables. The findings indicated that an individual's longer home-to-work distance is associated with more available mileage of limited access roads in the urban area of their home location. Meanwhile, more density, land use diversity, home value, and job/housing balance in the block group of the individual's home location has an inverse effect on the individual's home-to-work distance. In addition, individuals who have a higher household income, are older, or are male have a longer home-to-work distance.

Subject Areas: Total mileage of limited access roads; Home-to-work distance; Socioeconomics; Built environment; Demographics; Behavioral factors

Availability: Pouladi, R. (2021). *Effects of Land Use and Transportation Infrastructure on Distance to Work in Individual Car Riders.* Doctoral Dissertation, University of Texas, Arlington, TX. https://rc.library.uta.edu/uta-ir/handle/10106/29914

10.14. Title: Who (Never) Makes Overnight Leisure Trips? Disentangling Structurally Zero Trips from Usual Trip Generation Processes

Author(s): Kim, S.H. and Mokhtarian, P.L.

Abstract: This study examines long-distance (overnight) travel behavior by residents of the State of Georgia. Based on a survey conducted in 2017–2018, we modeled the number of domestic leisure long-distance (LD) trips over the past 12 months by air and car modes. We posited that there are two types of zero trips – structural zeros (by people who essentially never travel LD) and incidental zeros (by people who simply happened not to have traveled LD within the past 12 months) – and used zero-inflated negative binomial models to endogenously segment people into a structural zero-trip regime versus a trip-making regime. Selected demographics, attitudes, and geographical characteristics played important roles in explaining the segmentation into regimes and the amount of long-distance travel. We present separate models by mode, and they show different sensitivities to the pertinent factors. In particular, the presence of children and distance to nearest major airport had different roles in the two models. For example, the presence of children acted as a barrier to belonging to the trip-making regime for air travel, but it was a facilitator of doing so for car travel. However, it was negatively associated with the number of trips by both modes. Not surprisingly, accessibility to airports does matter. As distance to airport increased, both entry into the trip-making regime and number of trips were inhibited for air travel, but car travel exhibited the opposite effects. In addition, it is not simply the accessibility to any nearest airport that is most relevant, but rather the accessibility to major airports, which provide more options with respect to departure times and destinations. We present and discuss the shares and profiles of cases in the structural zero, incidental zero, and non-zero groups. Finally, we suggest some avenues of future research.

Subject Areas: Long-distance travel; Leisure travel; Zero-inflated model; Negative binomial model; Confirmatory latent class model; Social disadvantage

Availability: Kim, S.H. and Mokhtarian, P.L. (2021). "Who (Never) Makes Overnight Leisure Trips? Disentangling Structurally Zero Trips from Usual Trip Generation Processes." *Travel Behaviour and Society*, *25*, pp. 78–91. https://doi.org/10.1016/j.tbs.2021.05.011

10.15. Title: The Interaction between E-Shopping and Shopping Trips: An Analysis with 2017 NHTS

Author(s): Xue, C., Wu, Q., Sun, M., Bai, P., and Chen, Y.

Abstract: Advances in information and communication technologies (ICTs) have dramatically changed the nature of shopping and the way people travel. As this technology becomes deeply rooted in people's lives, understanding the interplay between this way and personal travel is becoming increasingly important for planners. Using travel diary data from the 2017 National Household Travel Survey (NHTS) data for structural equation modeling (SEM) analysis, it revealed the interaction between e-shopping and shopping trips and the factors that affect this bidirectional relationship. Results show that e-shopping motivates shopping trips, and in-store shopping inhibits online shopping. It can be obtained that the increase of one standard deviation of e-shopping will increase the shopping trip by 0.17 standard deviation. When shopping trips increase by one standard deviation, e-shopping behavior also decreases by 0.12 standard deviation. The results also demonstrated that e-shopping and shopping travel behavior is heterogeneous across a variety of exogenous factors such as personal attributes, household characteristics, geography, travel distance/duration, and travel mode. Identifying the interaction may help formulate better transportation policies and lay the foundation for travel demand management strategies to reduce the stress on the transportation system and meet individual travel needs.

Subject Areas: Long-distance travel; Leisure travel; Zero-inflated model; Negative binomial model; Confirmatory latent class model; Social disadvantage

Availability: Xue, C., Wu, Q., Sun, M., Bai, P., and Chen, Y. (2021). "The Interaction between E-Shopping and Shopping Trips: An Analysis with 2017 NHTS." *Complexity*, *2021*. https://doi.org/10.1155/2021/8247158

10.16. Title: Analyzing Georgians' Travel Patterns Using Mobile Phone Location Data During COVID-19

Author(s): Duran, B.P.

Abstract: Cellphone GPS data acquired from SafeGraph were used to analyze travel patterns during the COVID-19 pandemic in Georgia from January 2020 to January 2021, where we explored the relationships between foot-traffic data and COVID-19 with time-lagged effects using statistical and geospatial software. The study found an increase in cases in each of the surges in Georgia as travel increased and dwell times decreased where there was a short period of reaction that was accompanied by an inversed response in mobility. A multivariate analysis revealed dwell times had the strongest correlation coefficients to COVID-19 with values of .76 to .68. Bivariate nonlinear regression models supported this, with dwell times and raw visits having the best fit to the models and statistical significance. Our mobility analysis found that "Other Services" had the highest dwell times throughout the State, with correlation coefficients from .8 to .69 within the incubation period of the virus.

Subject Areas: COVID-19; Geospatial; Mobile phone data; SafeGraph; SARS-CoV-2; Travel

Availability: Duran, B.P. (2021). *Analyzing Georgians' Travel Patterns Using Mobile Phone Location Data During COVID-19*. Master's Thesis, University of Georgia, Athens, GA. https://esploro.libs.uga.edu/esploro/outputs/9949375246002959

10.17. Title: Counting Vehicle Miles Traveled: What Can We Learn from the NHTS?

Author(s): Alberini, A., Burra, L.T., Cirillo, C., and Shen, C.

Abstract: An accurate estimate of vehicle miles traveled (VMT) is an essential input into a variety of emissions, climate change, energy, and infrastructure-planning models. We examine different measures of annual miles driven from the 2017 National Household Travel Survey (NHTS), which includes a self-reported and an imputed measure of annual VMT for a nationally representative sample of U.S. households. We compute two additional estimates from the odometer reading and the trip diary information contained in the NHTS, respectively. We compare these four measures of annual VMT, seek to identify low/high mileage segments of the fleet, and examine the quality of the data and their internal validity. The price elasticity of VMT (−0.275 to −0.20) is comparable across these four measures. Quantile regressions indicate that the households with higher driving intensity are less responsive to the fuel cost per mile. As cars get older, the difference between the four VMT measures tends to increase; this implies large discrepancies in the CO_2 emissions that would be saved, for example, when older cars are removed from the fleet due to natural turnover or when "cash-for-clunkers" programs are implemented.

Subject Areas: Vehicle miles traveled (VMT); Price elasticity of VMT; National Household Travel Survey (NHTS); Travel diaries; "Cash-for-clunkers" programs

Availability: Alberini, A., Burra, L.T., Cirillo, C., and Shen, C. (2021). "Counting Vehicle Miles Traveled: What Can We Learn from the NHTS?" *Transportation Research Part D: Transport and Environment*, *98*. https://doi.org/10.1016/j.trd.2021.102984

10.18. Title: Impacts of Online Shopping on Travel Demand: A Systematic Review

Author(s): Le, H.T.K., Carrel, A.L., and Shah, H.

Abstract: The rise of e-commerce has led to substantial changes in personal travel and activities. We systematically reviewed empirical studies on the relationship between online shopping and personal travel behavior. We synthesized and assessed the evidence for four types of effects on various travel outcomes, including trip frequency, travel distance, trip chaining, mode choice, and time use. In 42 articles reviewed, we found more evidence that online shopping substitutes for shopping travel. Most studies to date have focused on trip frequency but neglected other travel outcomes. Very few studies have considered the modification effect, which has significant implications for travel demand management. In sum, previous studies have not reached a consensus on the dominant effect of online shopping, in part due to the diversity in variable measurements, types of goods, study areas, and analytic methods. A limitation of previous studies is the reliance on cross-sectional surveys, which hinders the distinction between short- and long-term behaviors and between modification, complementarity, and substitution effects. Our study provides an agenda for future research on this topic and discusses policy implications related to land use, behavioral changes, data collection, and modeling for practitioners who wish to incorporate e-commerce in planning for sustainable urban systems.

Subject Areas: E-tail; Information communication technology; Travel behavior; E-shopping; Telemobility

Availability: Le, H.T.K., Carrel, A.L., and Shah, H. (2021). "Impacts of Online Shopping on Travel Demand: A Systematic Review." *Transport Reviews*.
https://doi.org/10.1080/01441647.2021.1961917

10.19. Title: Impact of TNC on Travel Behavior and Mode Choice: A Comparative Analysis of Boston and Philadelphia

Author(s): Dong, X., Guerra, E., and Daziano, R.A.

Abstract: We compare responses from an online survey among 700 customers of transportation network companies (TNC) in Boston and Philadelphia to investigate TNC's impact on vehicle ownership, trip making, and mode choice. We first use a qualitative comparative analysis to examine changes in respondents' travel behavior and vehicle ownership after adopting TNC. We then use a random parameter logit regression analysis to investigate customers' preferences between transit and TNC based on a choice experiment. We find that in both cities, TNC allows customers, including those who currently do not own a car, to either delay purchasing a car or forgo a car altogether. TNC enables customers across income levels to take trips that they otherwise would not have taken. Meanwhile, TNC substitutes for more than complementing transit. The random parameter logit analysis indicates that when choosing between TNC and transit, individuals in both cities consider waiting time and overall travel time for transit to be more burdensome than those for TNC. Bostonians perceive the time spent walking to and from transit to be less burdensome, and the time spent traveling in vehicle to be more burdensome than do Philadelphians. Differences in built environment, mode share within transit systems, and income likely contribute to respondents' different values of time between the two cities. Our paper is the first to compare individual trade-off between transit and TNC in two cities with different urban settings and transit services. The findings have implications on transit service planning, station area improvements, parking regulations, and traffic management.

Subject Areas: Boston; Mixed logit; Philadelphia; Survey; Transportation network companies; Transit

Availability: Dong, X., Guerra, E., and Daziano, R.A. (2021). "Impact of TNC on Travel Behavior and Mode Choice: A Comparative Analysis of Boston and Philadelphia." *Transportation*. https://doi.org/10.1007/s11116-021-10220-5

10.20. Title: Exploring Individual Activity-Travel Patterns Based on Geolocation Data from Mobile Phones

Author(s): Yin, B. and Leurent, F.

Abstract: Data mining techniques can extract useful activity and travel information from large-scale data sources such as mobile phone geolocation data. This paper aims to explore individual activity-travel patterns from samples of mobile phone users using a 2-week geolocation dataset from the Paris region in France. After filtering the dataset, we propose techniques to identify individual stays and activity places. Typical activity places, such as the primary anchor place and the secondary place, are detected. The daily timeline (i.e., activity-travel program) is reconstructed with the detected activity places and the trips in between. Based on user-day timelines, a three-stage clustering method is proposed for mobility pattern analysis. In the method framework, activity types are first identified by clustering analysis. In the second stage, daily mobility patterns are obtained after clustering the daily mobility features. Activity-travel topologies are statistically investigated to support the interpretation of daily mobility patterns. In the last stage, we analyze statistically the individual mobility patterns for all samples over 14 days, measured by the number of days for all kinds of daily mobility patterns. All individual samples are divided into several groups where people have similar travel behaviors. A k-means++ algorithm is applied to obtain the appropriate number of patterns in each stage. Finally, we interpret the individual mobility patterns with statistical descriptions and reveal home-based differences in spatial distribution for the grouped individuals.

Subject Areas: Mobile phone geolocation data; Clustering method; Mobility pattern; Activity-travel topologies

Availability: Yin, B. and Leurent, F. (2021). "Exploring Individual Activity-Travel Patterns Based on Geolocation Data from Mobile Phones." *Transportation Research Record: Journal of the Transportation Research Board*, *2675*(12), pp. 771–783. https://doi.org/10.1177%2F03611981211031234

10.21. Title: Integrating Plug-In Electric Vehicles (PEVs) into Household Fleets: Factors Influencing Miles Traveled by PEV Owners in California

Author(s): Chakraborty, D., Hardman, S., and Tal, G.

Abstract: In this study, we investigate BEVs and PHEVs, collectively referred to as plug-in electric vehicles (PEVs). Using statistical and econometric methods, we analyze the VMT of PEVs as part of household travel demand to understand how much PEVs are being used and the factors that influence their use in a household fleet. We use data from a repeat survey of PEV owners in California. The first survey was conducted in 2015–2018, shortly after the participants purchased their PEVs, and the repeat survey, of 4,925 PEV owners, was conducted in 2019. This approach allowed us to obtain two odometer readings leading to more accurate VMT measures. Exploratory analysis of the VMT estimated from the two odometer readings suggest that BEVs were driven on average 11,250 miles per year. Long-range BEVs (>200-mile electric range) travel around 13,000 miles per year while short-range BEVs (<120 miles of electric range) travel around 10,250 miles. PHEVs in the sample traveled on average approximately 12,000 miles. These results show that PEVs travel a similar number of miles per year as conventional vehicles.

Subject Areas: Social and behavioral sciences; Electric vehicles; Zero emission vehicles; Vehicle miles traveled

Availability: Chakraborty, D., Hardman, S., and Tal, G. (2021). *Integrating Plug-In Electric Vehicles (PEVs) into Household Fleets: Factors Influencing Miles Traveled by PEV Owners in California*. Research Report, Institute of Transportation Studies, University of California, Davis, CA. https://escholarship.org/content/qt2214q937/qt2214q937.pdf

10.22. Title: The Impact of COVID-19 on Trips to Urban Amenities: Examining Travel Behavior Changes in Somerville, MA

Author(s): Sevtsuk, A., Hudson, A., Halpern, D., Basu, R., Ng, K., and de Jong, J.

Abstract: While there has been much speculation on how the pandemic has affected work location patterns and home location choices, there is sparse evidence regarding the impacts that COVID-19 has had on amenity visits in American cities, which typically constitute over half of all urban trips. Using aggregate app-based GPS positioning data from smartphone users, this study traces the changes in amenity visits in Somerville, MA, from January 2019 to December 2020, describing how visits to particular types of amenities have changed as a result of business closures during the public health emergency. Has the pandemic fundamentally shifted amenity-oriented travel behavior, or is consumer behavior returning to pre-pandemic trends? To address this question, we calibrate discrete choice models that are suited to Census block group–level analysis for each of the 24 months in a 2-year period and use them to analyze how visitors' behavioral responses to various attributes of amenity clusters have shifted during different phases of the pandemic. Our findings suggest that in the first few months of the pandemic, amenity-visiting preferences significantly diverged from expected patterns. Even though overall trip volumes remained far below normal levels throughout the remainder of the year, preferences toward specific cluster attributes mostly returned to expected levels by September 2020. We also construct two scenarios to explore the implications of another shutdown and a full reopening, based on November 2020 consumer behavior. While Government restrictions have played an important role in reducing visits to amenity clusters, our results imply that cautionary consumer behavior has played an important role as well, suggesting a likely long and slow path to economic recovery. By drawing on mobile phone location data and behavioral modeling, this paper offers timely insights to help decision makers understand how this unprecedented health emergency is affecting amenity-related trips and where the greatest needs for intervention and support may exist.

Subject Areas: Amenity visits; Travel behavior shifts; Mobile phone location data; Behavioral modeling; Health emergency

Availability: Sevtsuk, A., Hudson, A., Halpern, D., Basu, R., Ng, K., and de Jong, J. (2021). "The Impact of COVID-19 on Trips to Urban Amenities: Examining Travel Behavior Changes in Somerville, MA." *PLoS ONE*, *16*(9). https://doi.org/10.1371/journal.pone.0252794

10.23. Title: Exploring the Impact of Socio-Demographic Characteristics, Health Concerns, and Product Type on Home Delivery Rates and Expenditures During a Strict COVID-19 Lockdown Period: A Case Study from Portland, OR

Author(s): Figliozzi, M. and Unnikrishnan, A.

Abstract: E-commerce volumes and home deliveries have experienced steady growth in the last two decades. Strict COVID-19 lockdowns made home delivery an essential service and a lifeline for many households that, for travel restrictions or health concerns, were not able to utilize traditional shopping methods. This research studies the impact of sociodemographic variables and e-commerce attitudes on household deliveries for seven product categories (groceries; meals; electronics; household and office goods; recreational items; fashion, beauty, and personal care products; and medicine/health-related products) during the lockdown period in the greater Portland metropolitan region. To understand these impacts, exploratory factor analysis and choice models with latent variables are estimated utilizing data collected from an online survey representing the population in the greater Portland metropolitan region. The results indicate that each factor has a unique profile in terms of significant sociodemographic variables. A novel contribution of this research is to study the impact on home deliveries of non-traditional variables like health and safety concerns and the presence of household members with disabilities during a pandemic. The results show that health concerns are very influential and that there are substantial differences across factors on delivery rate and expenditure levels. Key findings and perspectives regarding future delivery rates and implications for transportation agencies and logistics companies are discussed.

Subject Areas: Home deliveries; Product type; Health and safety concerns; COVID-19; Delivery rate; Expenditures

Availability: Figliozzi, M. and Unnikrishnan, A. (2021). "Exploring the Impact of Socio-Demographic Characteristics, Health Concerns, and Product Type on Home Delivery Rates and Expenditures During a Strict COVID-19 Lockdown Period: A Case Study from Portland, OR." *Transportation Research Part A: Policy and Practice*, *153,* pp. 1–19. https://doi.org/10.1016/j.tra.2021.08.012

10.24. Title: Analysis of the Georgia Add-On to the 2016–2017 National Household Travel Survey

Author(s): Kash, G., Mokhtarian, P.L., and Circella, G.

Abstract: Through an extensive analysis of the Georgia subsample of the 2016–2017 National Household Travel Survey, this report provides an in-depth snapshot of the travel behavior of Georgians of all ages. It documents differences in travel needs and behavior by region and between demographic groups, focuses on measurement challenges and improved techniques, and identifies areas where future data collection is needed. In addition to an overview of key travel trends in the State, the report includes chapters on work travel; work flexibility (teleworking and flexible scheduling); new technologies and services, including alternative-fuel vehicles, shared mobility, and online shopping; social inclusion and equity; nonmotorized and access/egress travel; and travel for its own sake.

Subject Areas: Travel behavior; Travel patterns; Vehicle ownership; Commuting; Teleworking; Flexible work schedules; Online shopping; Shared mobility; New technology; Alternative-fuel vehicles; Nonmotorized travel; Social inclusion; Equity; Travel for its own sake

Availability: Kash, G., Mokhtarian, P.L., and Circella, G. (2021). *Analysis of the Georgia Add-On to the 2016–2017 National Household Travel Survey*. Final Report, Georgia Institute of Technology, Atlanta, GA. https://rosap.ntl.bts.gov/view/dot/57499

10.25. Title: What Is Your Shopping Travel Style? Heterogeneity in US Households' Online Shopping and Travel

Author(s): Shah, H., Carrel, A.L., and Le, H.T.K.

Abstract: Although online shopping has been shown to interact with travel behavior in several ways, most studies to date focused on individual-level behavior in non-representative, geographically limited samples, making it difficult to derive clear profiles of shoppers. Using the 2017 U.S. National Household Travel Survey, which included information on online shopping frequency, we estimated a latent class model to identify different shopper types (classes) that exhibited distinct travel and online shopping behavior. We found four classes—time-pressured shoppers, dual-channel shoppers, traditional shoppers, and infrequent shoppers and travelers—that differed in terms of sociodemographic characteristics and stages of life. Our results suggest that this heterogeneity may extend to the effects of online shopping on shopping travel, for instance, with substitution effects being dominant for one class whereas complementarity effects may be dominant for another. These findings can inform the design of tailored policies to mitigate the sustainability impacts of online shopping while also addressing the various classes' needs. Further research is needed to untangle the complex relationships between online shopping and travel behavior, especially considering this heterogeneity and the modification effect.

Subject Areas: E-commerce; Information and communication technology; Travel demand; Built environment; Urban form; Lifestyle

Availability: Shah, H., Carrel, A.L., and Le, H.T.K. (2021). "What Is Your Shopping Travel Style? Heterogeneity in US Households' Online Shopping and Travel." *Transportation Research Part A: Policy and Practice*, *153*, pp. 83–89. https://doi.org/10.1016/j.tra.2021.08.013

10.26. Title: Equity Implications of Ride-Hail Travel During COVID-19 in California

Author(s): Brown, A. and Williams, R.

Abstract: COVID-19 has shocked every system in the United States, including transportation. In the first months of the pandemic, driving and transit use fell far below normal levels. Yet people still need to travel for essential purposes, like medical appointments, buying groceries, and—for those who cannot work from home—work. For some, the pandemic may exacerbate extant travel challenges as transit agencies reduce service hours and frequency. As travelers reevaluate modal options, it remains unclear how one mode—ride-hailing—fits into the transportation landscape during COVID-19. In particular, how does the number of ride-hail trips vary across neighborhood characteristics before versus during the pandemic? And how do patterns of essential trips pre-pandemic compare with those during COVID-19? To answer these questions, we analyzed aggregated Uber trip data before and during the first 2 months of the COVID-19 pandemic across four regions in California. We find that during these first months, ride-hail trips fell at levels commensurate with transit (82 percent), whereas trips serving identified essential destinations fell by less (62 percent). Changes in ride-hail use were unevenly distributed across neighborhoods, with higher income areas and those with more transit commuters and higher shares of zero-car households showing steeper declines in the number of trips made during the pandemic. Conversely, neighborhoods with more older (aged 45+) residents, and a greater proportion of Black, Hispanic/Latinx, and Asian residents still appear to rely more on ride-hail during the pandemic compared with other neighborhoods. These findings further underscore the need for cities to invest in robust and redundant transportation systems to create a resilient mobility network.

Subject Areas: Data and data science; Urban transportation data and information systems; Ride-hailing data; Planning and analysis; Effects of information and communication technologies (ICT) on travel choices; Shared mobility; Public transportation; Innovative public transportation services and technologies; Transportation network companies (TNC)

Availability: Brown, A. and Williams, R. (2021). "Equity Implications of Ride-Hail Travel During COVID-19 in California." *Transportation Research Record*.
https://doi.org/10.1177%2F03611981211037246

10.27. Title: Equality of Opportunity in Travel Behavior Prediction with Deep Neural Networks and Discrete Choice Models

Author(s): Zheng, Y., Wang, S., and Zhao, J.

Abstract: Although researchers increasingly adopt machine learning to model travel behavior, they predominantly focus on prediction accuracy, ignoring the ethical challenges embedded in machine learning algorithms. This study introduces an important missing dimension—computational fairness—to travel behavior analysis. We first operationalize computational fairness by equality of opportunity and then differentiate between the bias inherent in data and the bias introduced by modeling. We then demonstrate the prediction disparities in travel behavior modeling using the 2017 National Household Travel Survey (NHTS) and the 2018–2019 My Daily Travel Survey in Chicago. Empirically, deep neural networks (DNNs) and discrete choice models (DCMs) reveal consistent prediction disparities across multiple social groups: Both over-predict the false-negative rate of frequent driving for the ethnic minorities, the low-income, and the disabled populations and falsely predict a higher travel burden of the socially disadvantaged groups and the rural populations than reality. Comparing DNN with DCM, we find that DNN can outperform DCM in prediction disparities because of DNN's smaller misspecification error. To mitigate prediction disparities, this study introduces an absolute correlation regularization method, which is evaluated with synthetic and real-world data. The results demonstrate the prevalence of prediction disparities in travel behavior modeling, and the disparities still persist regarding a variety of model specifics, such as the number of DNN layers, batch size, and weight initialization. Since these prediction disparities can exacerbate social inequity if prediction results without fairness adjustment are used for transportation policymaking, we advocate for careful consideration of the fairness problem in travel behavior modeling and the use of bias mitigation algorithms for fair transport decisions.

Subject Areas: Machine learning; Deep neural network; Travel behavior; Discrete choice models; Fairness in artificial intelligence

Availability: Zheng, Y., Wang, S., and Zhao, J. (2021). *Equality of Opportunity in Travel Behavior Prediction with Deep Neural Networks and Discrete Choice Models*. arXiv preprint, arXiv:2109.12422 [stat.ML]. https://arxiv.org/abs/2109.12422

10.28. Title: Impact of Ride-Hailing Usage on Vehicle Ownership in the United States

Author(s): Wang, Y., Shi, W., and Chen, Z.

Abstract: Ride-hailing as an innovative urban mobility service has received increasing attention in the recent decade. Using data from the 2017 National Household Travel Survey, we investigate the relationship between ride-hailing usage and household vehicle ownership from 42 metropolitan areas across the United States. Previous studies have shown mixed findings on this relationship. Our study contributes to the literature by estimating a bivariate ordered probit model with considerations of the recursive effect between ride-hailing usage and household vehicle ownership. We find that compared to occasional users, regular and active users are more likely to own fewer vehicles. Also, we find no significant difference in possessing vehicles between regular and active users.

Subject Areas: Ride-hailing service; Vehicle ownership; National Household Travel Survey; Bivariate ordered probit model

Availability: Wang, Y., Shi, W., and Chen, Z. (2021). "Impact of Ride-Hailing Usage on Vehicle Ownership in the United States." *Transportation Research Part D: Transport and Environment*, *101*. https://doi.org/10.1016/j.trd.2021.103085

10.29. Title: Variability of Daily Car Usage and the Frequency of Long-Distance Driving

Author(s): Plötz, P. and Sprei, F.

Abstract: The limited electric range of battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) requires an understanding of the variation in day-to-day driving and the frequency of long-distance driving. Existing literature suggests high regularity of human mobility. However, large longitudinal mobility samples for empirical tests are hardly available. Here, we analyze the regularity of daily vehicle kilometers traveled (VKT) of 10,000 vehicles observed between 2 months and several years and quantify the regularity of daily VKT and the frequency of long-distance driving. Our results indicate limited regularity of daily VKT beyond one day of time lag (mean autocorrelation ≤ 0.11). Long-distance driving with daily km more than 100 km (200 km) typically take place on less than 20 percent (5 percent for 200 km) of driving days but make up 40 percent (18 percent) of annual VKT. Our results have implications for sustainable transport research and the design of travel surveys.

Subject Areas: Electric vehicle; Regularity of driving; Long-distance driving; Daily driving distance

Availability: Plötz, P. and Sprei, F. (2021). "Variability of Daily Car Usage and the Frequency of Long-Distance Driving." *Transportation Research Part D: Transport and Environment*, *101*. https://doi.org/10.1016/j.trd.2021.103126

10.30. Title: Assessing Individual Activity-Related Exposures to Traffic Congestion Using GPS Trajectory Data

Author(s): Kan, Z., Kwan, M., Liu, D., Tang, L., Chen, Y., and Fang, M.

Abstract: Accurately assessing individual exposures to traffic congestion and traffic-related emissions is important for evaluating the impact of traffic congestion on human health. Existing studies on individual exposures to traffic congestion focus mainly on commuting trips, while our understanding of individual exposures to traffic congestion during different types of trips is very limited. This study examines individual exposures to traffic congestion during various types of trips by using taxi GPS trajectory and POI datasets in Wuhan, China. We first infer individual trip purposes from the GPS trajectories based on the attractiveness of the POIs and Bayesian rules. Individual exposures to traffic congestion associated with different types of trips are then evaluated. We also estimate exposures to excessive traffic-related emissions due to traffic congestion associated with different types of trips. The results show that individual exposures to traffic congestion are more related to the space-time rhythm of traffic flows than the types of trips or activities conducted. The findings indicate that only considering commuting trips would underestimate individual exposures to traffic congestion and excessive traffic-related emissions. This study provides a more detailed picture of how people conducting different types of trips and activities are exposed to traffic congestion. It advances our understanding of individual exposures to activity-related traffic congestion in space and time.

Subject Areas: Traffic congestion exposure; Taxi trajectory data; Trip purpose; Space-time pattern; Traffic emissions

Availability: Kan, Z., Kwan, M., Liu, D., Tang, L., Chen, Y., and Fang, M. (2021). "Assessing Individual Activity-Related Exposures to Traffic Congestion Using GPS Trajectory Data." *Journal of Transport Geography*, *98*. https://doi.org/10.1016/j.jtrangeo.2021.103240

10.31. Title: Activity Sequence Generation Using Universal Mobility Patterns

Author(s): Ectors, W., Kochan, B., Janssens, D., Bellemans, T., and Wets, G.

Abstract: Previous work has established that rank-ordered single-day activity sequences from various study areas exhibit a universal power law distribution called Zipf's law. By analyzing datasets from across the world, evidence was provided that it is in fact a universal distribution. This study focuses on a potential mechanism that leads to the power law distribution that was previously discovered. It makes use of 15 household travel survey (HTS) datasets from study areas all over the world to demonstrate that reasonably accurate sets of activity sequences (or "schedules") can be generated with extremely little information required; the model requires no input data and contains few tunable parameters. The activity sequence generation mechanism is based on sequential sampling from two universal distributions: (i) the distributions of the number of activities (trips) and (ii) the activity types (trip purposes). This paper also attempts to demonstrate the universal nature of these distributions by fitting several equations to the 15 HTS datasets. The lightweight activity sequence generation model can be implemented in any (lightweight) transportation model to create a basic set of activity sequences, saving effort and cost in data collection and in model development and calibration.

Subject Areas: Zipf 's law; Activity sequences; Universal distributions; Trip purpose; Number of trips; Daily activity pattern

Availability: Ectors, W., Kochan, B., Janssens, D., Bellemans, T., and Wets, G. (2021). "Activity Sequence Generation Using Universal Mobility Patterns." *Transportation Research Record*. https://doi.org/10.1177%2F03611981211062483

10.32. Title: A Double Jeopardy: COVID-19 Impacts on the Travel Behavior and Community Living of People with Disabilities

Author(s): Park, K., Chamberlain, B., Song, Z., Esfahani, H.N., Sheen, J., Larsen, T., Novack, V.L., Licon, C., and Christensen, K.

Abstract: The COVID-19 pandemic response has had a significant impact on the general population's ability to participate in their communities. Individuals with disabilities, an already socially disadvantaged population, are more vulnerable to and have likely been disproportionately impacted by COVID-19 response conditions. Yet, the extent to which the daily community living activities of people with disabilities have been impacted is unknown. Thus, this study assesses their travel behavior and community living during the COVID-19 pandemic conditions compared with those of the general population. A web survey was conducted using Qualtrics's online panel data (respondents included 232 people with disabilities and 161 people without disabilities). Regression models found that people with disabilities reduced their daily travel to a greater extent but at varying degrees, depending on the destination types and travel modes. Reductions in taxi rides (including ride-hailing services) were most significant among people with cognitive and sensory (e.g., vision and hearing) disabilities. By place type, cognitive disability was associated with a trip reduction for multiple destination types—grocery, restaurants, outdoor recreation, indoor recreation, and healthcare providers. Findings from this study could contribute to decision- and policymaking in planning, transportation, and community services during the remainder of the COVID-19 pandemic, in future major public health crises, and post-COVID, because the adjustments in travel behavior and community living might be longer term.

Subject Areas: Individuals with disabilities; Disabled people; Activities of daily community living; Pandemic

Availability: Park, K., Chamberlain, B., Song, Z., Esfahani, H.N., Sheen, J., Larsen, T., Novack, V.L., Licon, C., and Christensen, K. (2021). "A Double Jeopardy: COVID-19 Impacts on the Travel Behavior and Community Living of People with Disabilities." *Transportation Research Part A: Policy and Practice*, *156*, pp. 24–35. https://doi.org/10.1016/j.tra.2021.12.008

10.33. Title: Travellers' Use and Perception of Travel Time in Long-Distance Trips in Europe

Author(s): Malichová, E., Cornet, Y., and Hudák, M.

Abstract: Long-distance travel represents a small share of trips but a growing and disproportionately high share of carbon emissions. While the tourism and high-speed rail literature provides some insights characterizing demand on various existing long-distance transport links, new app-based methods for collecting travel data offer the potential to analyze trips on a wider geographical scale and to uncover the factors influencing travel demand from the traveler perspective. This research presents the results of such analysis based on a multimodal dataset consisting of 733 long-distance trips in eight European countries. It confirms that car travel still represents a high share of long-distance trips, which typically consist of fewer legs than by other modes, such as the train, bus, or plane. However, it also shows that long-distance car or plane travelers are less likely to evaluate trips as worthwhile than train or bus travelers. The research brings new insights in terms of the top factors affecting the quality of travel and the preferred activities by travelers while on the move, which provides actionable policy pathways to make more sustainable long-distance modes more attractive. The train offers promising possibilities for higher quality travel time in long-distance door-to-door trips, but more research is needed to understand better the role of transfers and first- and last-mile in the overall perceived value of travel time. The paper suggests a renewed focus on the experience of travel time in transport assessment and policy to nurture a shift toward low-carbon transport for long-distance travel.

Subject Areas: Long-distance travel; Perceived value of travel time; Worthwhile travel time; Travel experience; Trip satisfaction

Availability: Malichová, E., Cornet, Y., and Hudák, M. (2021). "Travellers' Use and Perception of Travel Time in Long-Distance Trips in Europe." *Travel Behaviour and Society*, *27*, pp. 95–106. https://doi.org/10.1016/j.tbs.2021.12.003

10.34. Title: Spatial Microanalysis and Equity Assessment of Joint Relationships Among Destination Choice, Activity Duration, and Mode Choice

Author(s): Goulias, K.

Abstract: This project combines multiple strands of research and develops a new integrated framework for spatial choice modeling and simulation. We use ideas emerging from our own research in motif and sequence analysis based on the 2017 National Household Travel Survey for California. This is then complemented with other external data at the business establishment microlevel. We develop a structural behavioral model that shows spatial correlation among destinations, duration of activity at each destination, and the mode chosen to travel to each activity location considered as forming activity chains/tours. Then, we post process the data to identify segments of the population that face unsurmountable barriers in activity participation and therefore become de facto excluded from opportunities. In this model development, we take advantage of new techniques in time geography and network development. This project advances science in the combination of built environment data with individual/household behavior and in the formulation of a new generation of core models for modeling and simulation for large-scale urban simulation model systems. The methods we develop here have applications in equity analysis, and we will demonstrate examples in this project. In Task 1 we assemble the NHTS data and combine with the NETS data; in Task 2 we develop trip chain/tour typologies at the person and household levels; in Task 3 we develop motifs and sequence analysis typologies; in Task 4 we correlate the typologies of Tasks 2 and 3 with spatial opportunities; in Task 5 we perform segmentation analysis; and in Task 6 we develop and present findings and policy recommendations. The ultimate outcome are behavioral models to use in simulation and policy recommendations for planning agencies. This project will also draw inferences about the behavioral impact of land use planning actions. Lessons learned from the computation and guidelines will be provided in a final report, a webinar, and two papers.

Subject Areas: Activity choices; Spatial analysis; Equity based land use; Spatial network analysis; Multimodal urban transport systems

Availability: Goulias, K. (2021). *Spatial Microanalysis and Equity Assessment of Joint Relationships Among Destination Choice, Activity Duration, and Mode Choice*. Research in Progress, The National Academies of Sciences, Engineering, and Medicine, Washington, DC.
https://rip.trb.org/view/1862624

10.35. Title: 3: Lessons from the 2017 National Household Travel Survey

Author(s): Jiao, J.

Abstract: Through shared mobility services, users gain access to a certain type of transportation for a short period of time, typically using a mobile phone–based application. This chapter will assess the association that exists between the usage of shared mobility services and individual's trip-making behavior, from the outlook of how shared technology services affect people's travel behaviors. Drawing upon data from the 2017 National Household Travel Survey (NHTS), the chapter draws conclusion regarding how ride-hailing app usage does have a statistically significant effect on the number of trips made per day on both weekends and weekdays, although the effect appears to be slightly more significant on weekdays than weekends, while bike-sharing and car-sharing do not appear to have an association with daily trip generation behavior on either weekends or weekdays.

Subject Areas: Transportation network company; Shared mobility; Shared economy; Trip generation; Travel behavior; National Household Travel Survey (NHTS)

Availability: Jiao, J. (2021). "3: Lessons from the 2017 National Household Travel Survey." *Shared Mobility*, Elsevier, pp. 21–38. https://doi.org/10.1016/B978-0-12-822900-2.00003-2

Chapter 11. Trend Analysis and Market Segmentation

11.1. Title: Planning for Driving Retirement: The Effect of Driving Perceptions, Driving Events, and Assessment of Driving Alternatives

Author(s): Vivoda, J.M., Cao, J., Koumoutzis, A., Harmon, A.C., and Babulal, G.M.

Abstract: Most older adults will eventually stop driving, but few engage in planning for driving retirement. This study assessed whether driving stress, enjoyment, confidence, concerning driving events, and assessment of driving alternatives influence planning. Demographic factors were also included. Data were collected via a mailed transportation survey, with a final sample of 551 older adults who currently drive. Linear regression analyses revealed that more driving retirement planning was associated with greater driving stress, less driving confidence, and a more positive view of driving alternatives. Driving enjoyment and recent concerning driving events were not significantly related. Among the control variables, race and income were significantly related to planning, suggesting that lower income and identifying as Black race were associated with more planning. Gender only approached significance, suggesting that females may plan more than males. Overall, these findings suggest that more driving retirement planning is warranted. Some of the groups known to be at increased risk for driving reduction and cessation plan more for that eventuality than their counterparts. Implications of the study and suggestions for future research are discussed.

Subject Areas: Driving reduction; Driving cessation; Transportation; Driving stress; Driving confidence

Availability: Vivoda, J.M., Cao, J., Koumoutzis, A., Harmon, A.C., and Babulal, G.M. (2021). "Planning for Driving Retirement: The Effect of Driving Perceptions, Driving Events, and Assessment of Driving Alternatives." *Transportation Research Part F: Traffic Psychology and Behaviour*, *76*, pp. 193–201. https://doi.org/10.1016/j.trf.2020.11.007

11.2. Title: Trip-Activity Chain Complexity, Technology Use, and Their Impacts on Ride-Hail Usage: A Structural Equation Model Approach

Author(s): Ahmed, T. and Hyland, M.

Abstract: This study aims to model and analyze the use of ride-hail in trip chains considering the effects of trip chain complexity and technology usage, in addition to traditional socio-demographic, travel, and built environment characteristics. To meet this objective and investigate multiple causal relationships between trip chain complexity, technology usage, and ride-hailing usage in trip chains, the study employs structural equation modeling (SEM) techniques that incorporate latent constructs for trip chain complexity and technology use using data from the 2017 National Household Travel Survey. In addition to analyzing the effects on ride-hail, the SEM includes a second outcome variable for transit usage for comparison purposes. The results indicate significant effects of trip chain complexity on the use of transit in trip chains. Technology usage has significant direct effects on the use of ride-hail and transit. Moreover, technology usage indirectly impacts transit through trip chain complexity and the proportion of activity types (i.e., maintenance, discretionary and subsistence activity types) in a trip chain. The modeling framework and parameter estimation results in this study provide a more holistic view of the interrelationships between trip-activity chain complexity, ride-hail usage, and technology usage than is available in the existing literature. The framework and results should provide behavioral insights that have value to transportation modelers, planners, and policymakers in addition to transportation network companies.

Subject Areas: Ridehailing; Trip chain complexity; Technology use; Structural equation modeling

Availability: Ahmed, T. and Hyland, M. (2021). *Trip-Activity Chain Complexity, Technology Use, and Their Impacts on Ride-Hail Usage: A Structural Equation Model Approach*. Transportation Research Board 100th Annual Meeting—A Virtual Event.
https://annualmeeting.mytrb.org/OnlineProgram/Details/15914

11.3. Title: Exploring Partnership Between Transit Agency and Shared Mobility Company: An Incentive Program for App-based Carpooling

Author(s): Shen, Q., Wang, Y., and Gifford, C.

Abstract: How should public transit agencies deliver mobility services in the era of shared mobility? Previous literature recommends that transit agencies actively build partnerships with mobility service companies from the private sector, yet public transit agencies are still in search of a solid empirical basis to help envision the consequences of doing so. This paper presents an effort to fill this gap by studying a recent experiment of shared mobility public–private partnership, the carpool incentive fund program launched by King County Metro in the Seattle region. This program offers monetary incentives for participants who commute using a dynamic app-based carpooling service. Through descriptive analysis and a series of logistic regression models, we find that the monetary incentive to encourage the use of app-based carpooling generates some promising outcomes while having distinctive limitations. In particular, it facilitates the growth of carpooling by making carpooling a competitive commuting option for long-distance commuters. Moreover, our evidence suggests that the newly generated carpooling trips mostly substitute single-occupancy vehicles, thus contributing to a reduction of regional VMT. The empirical results of this research will not only help King County Metro devise its future policies but also highlight an appealing alternative for other transit agencies in designing an integrated urban transportation system in the era of shared mobility.

Subject Areas: Shared mobility; Public–private partnership; App-based carpooling; Incentive fund; Transit agencies

Availability: Shen, Q., Wang, Y., and Gifford, C. (2021). "Exploring Partnership Between Transit Agency and Shared Mobility Company: An Incentive Program for App-based Carpooling." *Transportation*. https://doi.org/10.1007/s11116-020-10140-w

11.4. Title: A Big-data Driven Approach to Analyzing and Modeling Human Mobility Trend Under Non-pharmaceutical Interventions During COVID-19 Pandemic

Author(s): Hu, S., Xiong, C., Yang, M., Younes, H., Luo, W., and Zhang, L.

Abstract: During the unprecedented coronavirus disease 2019 (COVID-19) challenge, non-pharmaceutical interventions became a widely adopted strategy to limit physical movements and interactions to mitigate virus transmissions. For situational awareness and decision-support, quickly available yet accurate big-data analytics about human mobility and social distancing is invaluable to agencies and decision-makers. This paper presents a big-data-driven analytical framework that ingests terabytes of data on a daily basis and quantitatively assesses the human mobility trend during COVID-19. Using mobile device location data of over 150 million monthly active samples in the United States (U.S.), the study successfully measures human mobility with three main metrics at the county level: daily average number of trips per person; daily average person-miles traveled; and daily percentage of residents staying home. A set of generalized additive mixed models is employed to disentangle the policy effect on human mobility from other confounding effects including virus effect, socio-demographic effect, weather effect, industry effect, and spatiotemporal autocorrelation. Results reveal the policy plays a limited, time-decreasing, and region-specific effect on human movement. The stay-at-home orders only contribute to a 3.5%–7.9% decrease in human mobility, while the reopening guidelines lead to a 1.6%–5.2% mobility increase. Results also indicate a reasonable spatial heterogeneity among the U.S. counties, wherein the number of confirmed COVID-19 cases, income levels, industry structure, age and racial distribution play important roles. The data informatics generated by the framework are made available to the public for a timely understanding of mobility trends and policy effects, as well as for time-sensitive decision support to further contain the spread of the virus.

Subject Areas: Human mobility; Non-pharmaceutical interventions; COVID-19; Mobile device location data; Generalized additive mixed model

Availability: Hu, S., Xiong, C., Yang, M., Younes, H., Luo, W., and Zhang, L. (2021). "A Big-data Driven Approach to Analyzing and Modeling Human Mobility Trend Under Non-pharmaceutical Interventions During COVID-19 Pandemic." *Transportation Research Part C: Emerging Technologies*, *124*. https://doi.org/10.1016/j.trc.2020.102955

11.5. Title: The Impact of Uber and Lyft On Vehicle Ownership, Fuel Economy, and Transit Across U.S. Cities

Author(s): Ward, J.W., Michalek, J.J., Samaras, C., Azevedo, I.L., Henao, A., Rames, C., and Wenzel, T.

Abstract: We estimate the effects of transportation network companies (TNCs) Uber and Lyft on vehicle ownership, fleet average fuel economy, and transit use in U.S. urban areas using a set of difference-in-difference propensity score-weighted regression models that exploit staggered market entry across the United States from 2011 to 2017. We find evidence that TNC entry into urban areas causes an average 0.7% increase in vehicle registrations with significant heterogeneity in these effects across urban areas: TNC entry produces larger vehicle ownership increases in urban areas with higher initial ownership (car-dependent cities) and in urban areas with lower population growth (where TNC-induced vehicle adoption outpaces population growth). We also find no statistically significant average effect of TNC entry on fuel economy or transit use but find evidence of heterogeneity in these effects across urban areas, including larger transit ridership reductions after TNC entry in areas with higher income and more childless households.

Subject Areas: Environmental science; Energy policy; Business

Availability: Ward, J.W., Michalek, J.J., Samaras, C., Azevedo, I.L., Henao, A., Rames, C., and Wenzel, T. (2021). "The Impact of Uber and Lyft On Vehicle Ownership, Fuel Economy, and Transit Across U.S. Cities." *iScience*, *24*(1). https://doi.org/10.1016/j.isci.2020.101933

11.6. Title: The Congestion Costs of Uber and Lyft

Author(s): Tarduno, M.

Abstract: I study the impact of transportation network companies (TNCs) on traffic delays using a natural experiment created by the abrupt departure of Uber and Lyft from Austin, TX. Applying difference in differences and regression discontinuity specifications to high-frequency traffic data, I estimate that Uber and Lyft together decreased daytime traffic speeds in Austin by roughly 2.3%. Using Austin-specific measures of the value of travel time, I translate these slowdowns to estimates of citywide congestion costs that range from $33 to $52 million annually. Back of the envelope calculations imply that these costs are similar in magnitude to the consumer surplus provided by TNCs in Austin. Together these results suggest that while TNCs may impose modest travel time externalities, restricting or taxing TNC activity is unlikely to generate large net welfare gains through reduced congestion.

Subject Areas: Transportation network companies; High-frequency traffic data; Congestion

Availability: Tarduno, M. (2021). "The Congestion Costs of Uber and Lyft." *Journal of Urban Economics*, *122*. https://doi.org/10.1016/j.jue.2020.103318

11.7. Title: The Evolution, Usage and Trip Patterns of Taxis & Ridesourcing Services: Evidence From 2001, 2009 & 2017 U.S. National Household Travel Survey

Author(s): Wu, X. and MacKenzie, D.

Abstract: Given the rapid adoption of ridesourcing services (RS), it is critical for transportation planners and policymakers to understand their impacts and keep policies up to date. This study contributes to the literature by using representative samples captured in the 2001, 2009, and 2017 National Household Travel Survey to explore how taxis and ridesourcing (T/R) services have evolved and shaped people's travel behavior pre- and post-disruption at the U.S. national level. It characterizes and visualizes the asymmetries in demand spatially and temporally for T/R trips, showing that ridesourcing has greatly increased T/R trips from flexible and optional activity locations to home, which vary by times of day. It also characterizes tours involving T/R services, showing that while simple optional tours (such as home–recreation–home) represent the largest share of tours involving T/R, the fastest growth has been in simple mandatory tours (such as home–work–home). Tours involving T/R grew from 0.4% of all tours in 2009 to 1% of all tours in 2017, mostly within densely populated and transit-oriented regions. Although less than 1% of T/R trips involved a direct transfer to or from transit, one-third of all tours containing T/R also included transit. However, at the same time, 40% of T/R-containing tours also involved auto trip(s). Overall, this study reveals the complex relationships among their underlying sociodemographic characteristics, RS adoption and usage behavior, and daily tour patterns.

Subject Areas: Ridesourcing; Taxi; Household travel survey; Travel behavior; Tour pattern

Availability: Wu, X. and MacKenzie, D. (2021). "The Evolution, Usage and Trip Patterns of Taxis & Ridesourcing Services: Evidence From 2001, 2009 & 2017 U.S. National Household Travel Survey." *Transportation*. https://doi.org/10.1007/s11116-021-10177-5

11.8. Title: Analysis of Travel Choices and Scenarios for Sharing Rides Final Report

Author(s): Middleton, S., Schroeckenthaler, K., Papayannoulis, V., and Gopalakrishna, D.

Abstract: The purpose of this study is to gain a deeper understanding of the factors influencing traveler decisions about driving or taking a shared ride, including learning about the tradeoffs among desired features of different travel options and trip price. The study seeks to understand whether mode-shifting incentives and disincentives could be applied to encourage more sharing and active mode trips that reduce vehicle miles traveled and congestion. The study analyzed data from a survey conducted by a large transportation network company (TNC) of its users and used analysis that two developers of application tools providing carpooling incentives conducted on their user data to analyze several scenarios of varying cost and time differentials that may influence the likelihood of sharing rides.

Subject Areas: Shared rides; Transportation network company; Carpooling

Availability: Middleton, S., Schroeckenthaler, K., Papayannoulis, V., and Gopalakrishna, D. (2021). *Analysis of Travel Choices and Scenarios for Sharing Rides Final Report.* Report No. FHWA-HOP-21-011, Federal Highway Administration, Washington, DC.
https://ops.fhwa.dot.gov/publications/fhwahop21011/index.htm

11.9. Title: Sentiment Analysis of Popular-music References to Automobiles, 1950s to 2010s

Author(s): Wu, C., Le Vine, S., Bengel, E., Czerwinski, J., and Polak, J.

Abstract: In recent years, there has been a scholarly debate regarding the decrease in automobile-related mobility indicators (car ownership, driving license holding, VMT, etc.). Broadly speaking, two theories have been put forward to explain this trend: (1) economic factors whose impacts are well-understood in principle, but whose occurrence among young adults as a demographic sub-group had been overlooked, and (2) less well-understood shifts in cultural mores, values and sentiment towards the automobile. This second theory is devilishly difficult to study, due primarily to limitations in standard data resources such as the National Household Travel Survey and international peer datasets. In this study, we first compiled a database of lyrics to popular music songs from 1956 to 2015 (defined by inclusion in the annual "top 40") and subsequently identified references to automobiles within this corpus. We then evaluated whether there is support for theory #2 above within popular music by looking at changes from the 1950s to the 2010s. We demonstrate that the frequency of references to automobility tended for many years to increase over time; however, there has more recently been a decline after the late 2000s (decade). In terms of the sentiment of popular music lyrics that reference automobiles, our results are mixed as to whether the references are becoming increasingly positive or negative (machine analysis suggests increasing negativity, while human analysis did not find a significant association), however a consistent observation is that sentiment of automobile references have over time become more positive relative to sentiment of song lyrics overall. We also show that sentiment towards automobile references differs systematically by genre, e.g., automobile references within "Rock" lyrics are in general more negative than similar references to cars in other music genres). The data generated on this project have been archived and made available open access for use by future researchers; details are in the full paper.

Subject Areas: Peak car; Popular music; Sentiment analysis; Natural language processing

Availability: Wu, C., Le Vine, S., Bengel, E., Czerwinski, J., and Polak, J. (2021). "Sentiment Analysis of Popular-music References to Automobiles, 1950s to 2010s." *Transportation*. https://doi.org/10.1007/s11116-021-10189-1

11.10. Title: Plateau Car

Author(s): Metz, D.

Abstract: There is good evidence that the average distance travelled per person by car in many developed economies ceased to grow towards the end of the last century. This phenomenon has been termed “peak car” by analogy with “peak oil,” which refers to the expected peaking and decline in output of this finite resource (Goodwin and Van Dender, 2013). However, for car use, the evidence points to a cessation of growth as the prime effect, with possible long-term decline not yet generally apparent. Accordingly, I propose the term “plateau car” to designate the phenomenon (Metz, 2013a).

Subject Areas: Average distance traveled by car; Peak car; Demand; Demographics; Big cities; Impact of technology

Availability: Metz, D. (2021). “Plateau Car.” *Driving Change: Travel in the Twenty-First Century*. http://drivingchange.org.uk/plateau-car/

11.11. Title: What Does Uber Bring for Consumers?

Author(s): Qiu, J.

Abstract: This paper estimates the consumer surplus that Uber brings for consumers. The estimation uses three datasets: individual-level choice dataset—the National Household Travel Survey (NHTS) data of 2008–2009, origin-destination level dataset—Uber data, and Google data of 2017. Firstly, we use NHTS data to identify consumer's preferences in 2008 under a discrete-choice framework. Assuming unchanged preferences of consumers, we use the coefficients of the discrete-choice model to reveal passengers' demand on different transportation modes in 2017. After revealing the demand curve, this paper calculates the consumer surplus by differencing the consumer surplus in the circumstance where Uber is available with the consumer surplus of the scenario if Uber was not available. We find that Uber brings at least $0.76 gains for each trip. The overall consumer surplus generated by Uber in San Francisco is around $100 million per year.

Subject Areas: Uber; Sharing economy; Discrete choice; Consumer surplus

Availability: Qiu, J. (2021). "What Does Uber Bring for Consumers?" *Data Science and Management*, *2*, pp. 20–27. https://doi.org/10.1016/j.dsm.2021.05.002

11.12. Title: Effects of Built Environment and Weather on Demands for Transportation Network Company Trips

Author(s): Hasnine, M.S., Hawkins, J., and Habib, K.N.

Abstract: This paper investigates the effects of the built environment and weather on the demands for transportation network companies (TNCs) in Toronto. The research is based on a historical dataset of Uber trips from September 2016 to September 2018 in Toronto. A wide range of built environments, socio-demographic, and weather data are generated at the dissemination area-level and fused with the monthly aggregated Uber dataset. To provide insight into the underlying factors that affect TNC demand, a series of aggregate demand models are estimated using log-transformed constant elasticity demand functions, with consideration of the seasonal lag effect. To capture the weather effect, an autoregressive moving average model is estimated for the downtown core of Toronto. The model results show that the influence of lagged ridership and seasonal lag effect have a positive correlation with TNC demand. The trip generation and attraction models reveal that TNC trips increase where when the commuting trip duration is longer than 60 minutes. It is found that the number of apartments in a dissemination area is positively correlated with TNC trip generation, while the number of single-detached houses has a negative correlation. The time-series model indicates that temperature and total daily precipitations are positively correlated with TNC demand. Due to the lack of comprehensive data sources on the Uber and Lyft ridership, the policymakers often struggle to make evidence-based policy recommendations to regulate such disruptive technologies. The series of models presented in this study will help us better understand the potential users of transportation network companies (TNC) and the effects of land use, built environment and weather on transportation network company trips.

Subject Areas: Transportation network companies (TNCs); Aggregate demand; Trip generation; Trip attraction; Time series model

Availability: Hasnine, M.S., Hawkins, J., and Habib, K.N. (2021). "Effects of Built Environment and Weather on Demands for Transportation Network Company Trips." *Transportation Research Part A: Policy and Practice*, *150*, pp. 171–185. https://www.researchgate.net/profile/Md-Sami-Hasnine/publication/352384492_Effects_of_Built_Environment_and_Weather_on_Demands_for_Transportation_Network_Company_Trips/links/60c7ccd6a6fdcc57ed053b34/Effects-of-Built-Environment-and-Weather-on-Demands-for-Transportation-Network-Company-Trips.pdf

11.13. Title: An Analysis of Carsharing and Battery Electric Vehicles in the United States

Author(s): Feng, Y.

Abstract: According to the California Air Resources Board (CARB, 2020), light-duty vehicles are responsible for 13 percent of statewide NO_x emissions and 28 percent of statewide greenhouse gas emissions. Scientists, policymakers, and car manufacturers have been striving to reduce the air pollution and greenhouse gas emissions from the transportation sector using various measures, ranging from cleaner engines to alternatives to driving to reduce VMT. In this dissertation, I focus on a subset of these measures: carsharing programs and battery electric vehicles (BEVs).

In the first part of this dissertation, I explore the profile of households engaging in carsharing by estimating zero-inflated negative binomial (ZINB) models on data from the 2017 National Household Travel Survey (NHTS). My results show that households who are more likely to carshare are those who participate in other forms of sharing, have more Silent generation members, are less educated (the highest educational achievement is a high school degree), and have fewer vehicles than drivers. Conversely, households with more young adults (18–20 years old), with 2 or more adults and no children, take part in carsharing program less often. Moreover, households who took more part in ridesharing and have fewer vehicles than drivers are less likely to never carshare. Furthermore, households whose annual income between $75,000 and $150,000 are more likely to never carshare.

In the second part of this dissertation, I concentrate on the adoption of BEVs. More specifically, I focus on two questions: 1) what are the characteristics of households who own battery electric vehicles (BEVs) and 2) does the travel behavior of these households differ from the travel of households who have motor vehicles but not BEVs? To answer those questions, I characterize three groups of households based on their vehicle holdings: BEV-only, BEV+ (i.e., households with both one or more BEV and at least one conventional vehicle), and non-BEV households. I analyze data from the 2017 NHTS using mixed methods. Results show that BEV households are more likely to be Asian, well-educated, with a higher income and to live in higher population and employment density areas. Furthermore, BEV-only households are more likely to be composed of one adult (not retired) with fewer Baby Boomers. Yet, BEV+ households are more likely to be larger households with 2 or more adults. Also, BEV+ households are more likely to have more Generation X (37–52 years old in 2017) and Z members (20 years old or younger in 2017). They are also more likely to own their home. My analysis on gender (at the individual level) concluded that BEV owners are more likely to be men. Furthermore, I find that BEV households travel as much as non-BEV households.

Although carsharing and BEVs could substantially decrease the environmental footprint of transportation, they are currently far from mainstream. To promote carsharing programs, their reach could be extended, they could be made more affordable, while increasing the cost of owning and operating private vehicles. Similarly, state and federal governments could continue to provide financial incentives to lower the purchase price difference between conventional and BE vehicles, manufacturers could provide extended warranties on batteries, and the charging infrastructure needs to be developed in order to attract more customers.

The COVID-19 crisis is giving governments around the world an opportunity to invest in clean technologies to jumpstart the economy. It is critical to take advantage of this crisis to reduce air

pollution and greenhouse gas emissions from transportation for the good of current and future generations.

Subject Areas: Battery electric vehicles; Carsharing; Zero-inflated negative binomial models; Socioeconomic and demographic factors

Availability: Feng, Y. (2021). *An Analysis of Carsharing and Battery Electric Vehicles in the United States*. Doctoral Dissertation, University of California, Irvine, CA. https://escholarship.org/uc/item/749441xc

11.14. Title: Measuring Destination-based Segregation Through Mobility Patterns: Application of Transport Card Data

Author(s): Abbasi, S., Ko, J., and Min, J.

Abstract: This study explores the level of segregation experienced by seniors, children/youths, and passengers with disabilities compared to normal-fare passengers at their trip destination when using public transportation. One week's travel records of public transit passengers were extracted from Seoul's transport card data to compute dissimilarity and exposure indices, theoretically equivalent to those developed in segregation research, to capture destination-based segregation through mobility patterns. Additionally, a multigroup entropy index was computed to measure diversity by assessing the social mixture of all passenger flows in a spatial unit. The results revealed that segregation levels experienced by passengers based on their social groups are notably different depending on the time of day and the day of the week. The computed exposure measure illustrates that the potential interaction between the selected social groups and normal-fare passengers is relatively higher during peak hours on weekdays. The results also show that subway stations provide more opportunities for interaction among different social groups. These findings can contribute to a better understanding of social segregation through mobility patterns as well as the effective quantification of the public transport network performance in terms of providing an interaction opportunity for the groups.

Subject Areas: Social interaction space; Segregation; Social groups; Transport card data

Availability: Abbasi, S., Ko, J., and Min, J. (2021). "Measuring Destination-based Segregation Through Mobility Patterns: Application of Transport Card Data." *Journal of Transport Geography*, *92*. https://doi.org/10.1016/j.jtrangeo.2021.103025

11.15. Title: Cohort Analysis of Driving Cessation and Limitation Among Older Adults

Author(s): Schouten, A., Wachs, M., Blumenberg, E.A., and King, H.R.

Abstract: Automobiles are central to participation in economic, social, and cultural activities in the United States. The ability to drive as one ages is fundamental to the quality of life among older adults. Driving rates decline significantly with age. Researchers using cross-sectional data have studied the reasons former drivers have stopped driving, but few have followed individuals over time to examine changes in relationships among driving cessation, socio-demographics, and health conditions. We used longitudinal data from a national sample of 20,000 observations from the University of Michigan Health and Retirement Study (HRS) to examine relationships among demographic variables, health conditions, and driving reduction and driving cessation. Longitudinal data allow analysis of generational differences in behavior, a major advantage over cross-sectional data which only allow comparisons of different people at one point in time. We found, like many other studies, that personal decisions to limit and eventually stop driving vary with sex, age, and health conditions. In addition, unlike most previous studies, we also found that those relationships differ by birth cohort with younger cohorts less likely to stop and limit their driving than their older counterparts. The findings indicate an evolution in the association between driving cessation and its causes.

Subject Areas: Driving cessation; Driving reduction; Older adults; Gender; Cohort effects

Availability: Schouten, A., Wachs, M., Blumenberg, E.A., and King, H.R. (2021). "Cohort Analysis of Driving Cessation and Limitation Among Older Adults." *Transportation*. https://doi.org/10.1007/s11116-021-10196-2

11.16. Title: Accounting and Controlling for Heterogeneity in Behavior and Survey Response: Application in Non-profit Fundraising and Commute Mode Choice

Author(s): Bao, J.

Abstract: This dissertation presents a Compound Poisson Mixture Regression model of the distribution of transaction frequency and monetary value, and apply it to study donations at a private university in the Midwestern United States. The model captures the joint effect of covariates, recognizing that both response variables emanate from one statistical unit – a donor. Moreover, the mixture regression framework provides a rigorous and appealing approach to account for heterogeneity and other features in the data. In particular, the framework captures latent, group-level factors through coefficients that vary across the different population segments.

The data in the study are from donation records for the 17-year period between 2000 and 2016, and an alumni survey conducted in the fall of 2017. The empirical results highlight features of the proposed model, and lead to insights with potential to improve fundraising efforts. Specifically, the results show that the proposed model captures behavioral differences manifested as heterogeneity in either donation amounts, frequencies, or both response variables. Interestingly and in spite of the inclusion of subjective factors assessed through the survey, the results suggest that between-segment differences are not explained by the available data, i.e., the between-segment heterogeneity is unobserved. The results show that covariates, including a number of subjective factors, i.e., connectedness/psychological distance, perceptions of donation impact, and willingness to volunteer, display stratified marginal effects on either transaction amounts, frequencies, or compound effects on both response variables. We discuss how characterization of such effects supports development of targeted fundraising/marketing strategies.

In order to deal with heterogeneous issues arising from the Compound Poisson Mixture Regression model, and to provide a practical way to control rating scale bias in a broader field, we present a method to estimate and control for individuals' rating scale biases appearing in responses to surveys about their experiences, attitudes, feelings and perceptions. The approach is based on the Rasch model and is motivated by the increasing use of survey data in marketing research. Without relying on additional objective information for anchoring purposes, the proposed approach utilizes only survey data itself to provide individual-question level bias correction, with impacts of both individual rating scales and specific questions accounted for. We apply the method to study data from an alumni survey at a private university in the Midwestern United States. Specifically, we use the bias-corrected parameters to estimate the relationships between attitudes and donation behavior. The results show that the bias-corrected survey data significantly improves model accuracy. Moreover, we observe that the marginal effects of survey variables from the bias-corrected model turn out to be different with model with original survey data in certain variables, which indicates that rating scale biases may impact insights related to the effects of alumni attitude. While the (practical) effectiveness of the proposed bias correction method is illustrated, we discuss limitations in the Rasch Model-based method.

To further generalize accounting for heterogeneity in transportation field, this dissertation presents a segmentation analysis of households in the Chicago Metropolitan Area based on reported travel outcomes. The data are from the travel tracker survey conducted between 2007 and 2008 by the

Chicago Metropolitan Agency for Planning. In our analysis, we assume that unobserved, group-level factors play a pivotal role in determining/explaining the heterogeneity observed across the population in terms of mode choice and distance traveled. As a benchmark, we consider a segmentation model relying exclusively on distance traveled by personally-owned vehicle or taxi, an approach used the literature. The results suggest additional information on trips of other modes is useful and validates our joint segmentation approach. Our analysis of the Chicago data suggests that the population consists of 4 segments of households. Aggregate analysis of the travel outcomes in each ZIP code highlights complicated inter-dependencies among travel behavior, residential location, and public transport coverage. Nevertheless, disaggregate analysis (of the correlations in the cluster membership probabilities) suggests that socioeconomic and demographic factors play stronger role in travel outcomes, than do build environment factors. The discussion concludes the actual relationship between urban form and travel behavior is not as simple as it seems in analysis of their statistical relationship, and relevant policies are also supported by our findings.

Subject Areas: Heterogeneity; Compound Poisson Mixture Regression model; Rasch Model-based method; Socioeconomic and demographic factors; Build environment

Availability: Bao, J. (2021). *Accounting and Controlling for Heterogeneity in Behavior and Survey Response: Application in Non-profit Fundraising and Commute Mode Choice*. *Urban Affairs Review*. Doctoral Dissertation, Northwestern University, Evanston, IL. https://www.proquest.com/openview/0faf211781d3ad258dbaebd9f35c7590/1?pq-origsite=gscholar&cbl=18750&diss=y

11.17. Title: Using Deep Learning to Understand Travel Demands in Different Urban Districts

Author(s): Bai, S. and Jiao, J.

Abstract: Travel demand forecast plays an important role in transportation planning. Classic models often predict people's travel behavior based on the physical built environment in a linear fashion. Many scholars have tried to understand built environments' predictive power on people's travel behavior using big-data methods. However, few empirical studies have discussed how the impact might vary across time and space. To fill this research gap, this study used 2019 anonymous smartphone GPS data and built a long short-term memory (LSTM) recurrent neural network (RNN) to predict the daily travel demand to six destinations in Austin, Texas: downtown, the university, the airport, an inner-ring point-of-interest (POI) cluster, a suburban POI cluster, and an urban-fringe POI cluster. By comparing the prediction results, we found that: the model underestimated the traffic surge for the university in the fall semester and overestimated the demand for downtown on non-working days; the prediction accuracy for POI clusters was negatively related to their adjacency to downtown; and different POI clusters had cases of under- or overestimation on different occasions. This study reveals that the impact of destination attributes on people's travel demand can vary across time and space because of their heterogeneous nature. Future research on travel behavior and built environment modeling should incorporate the temporal inconsistency to achieve better prediction accuracy.

Subject Areas: Travel demand forecast; Long short-term memory; Recurrent neural network; Destination attributes; Temporal inconsistency

Availability: Bai, S. and Jiao, J. (2021). "Using Deep Learning to Understand Travel Demands in Different Urban Districts." *Transportation Research Record: Journal of the Transportation Research Board*. https://doi.org/10.1177%2F0361198121994582

11.18. Title: Generational Differences in Automobility: Comparing America's Millennials and Gen Xers Using Gradient Boosting Decision Trees

Author(s): Wang, K. and Wang, X.

Abstract: Whether the Millennials are less auto-centric than the previous generations has been widely discussed in the literature. Most existing studies use regression models and assume that all factors are linear-additive in contributing to the young adults' driving behaviors. This study relaxes this assumption by applying a non-parametric statistical learning method, namely the gradient boosting decision trees (GBDT). Using U.S. nationwide travel surveys for 2001 and 2017, this study examines the non-linear dose-response effects of lifecycle, socio-demographic and residential factors on daily driving distances of Millennial and Gen-X young adults. Holding all other factors constant, Millennial young adults had shorter predicted daily driving distances than their Gen-X counterparts. Besides, residential and economic factors explain around 50% of young adults' daily driving distances, while the collective contributions for life course events and demographics are about 33%. This study also identifies the density ranges for formulating effective land use policies aiming at reducing automobile travel demand.

Subject Areas: Millennials; Life course events; Gradient boosting decision trees (GBDT); Driving distance; VMT; Machine learning

Availability: Wang, K. and Wang, X. (2021). "Generational Differences in Automobility: Comparing America's Millennials and Gen Xers Using Gradient Boosting Decision Trees." *Cities*, *114*. https://doi.org/10.1016/j.cities.2021.103204

11.19. Title: Commuting in America: Brief 21.2 Vehicle Availability Patterns and Trends

Author(s): Blumenberg, E., Paul, J., and Pierce, G.

Abstract: Access to an automobile in the United States is an important determinant of household mobility, as well as the economic, educational, and myriad other benefits which mobility confers. Previous analyses of national trends in vehicle availability through 2010 show a decline in zero-vehicle households across diverse populations and continued growth in the number of vehicles per household but a slowdown in growth of available vehicles relative to driving-age adults.

Recent trends related to transportation, the demographic composition of population, technology, and residential location highlight the importance of revisiting and updating these analyses. In this report, we extend and deepen the analyses to assess vehicle availability patterns and trends across the United States through 2017, with a focus on zero-vehicle households. The analysis draws on three different data sources comprised of multiple associated datasets—the Public Use Microdata Samples of the U.S. Census and the American Community Survey (ACS), and the National Household Travel Survey (NHTS).

Subject Areas: Vehicle access; Household mobility; Demographic composition; Technology; Residential location; Zero-vehicle households

Availability: Blumenberg, E., Paul, J., and Pierce, G. (2021). *Commuting in America: Brief 21.2 Vehicle Availability Patterns and Trends*. UCLA Luskin School of Public Affairs, Los Angeles, CA. https://traveltrends.transportation.org/wp-content/uploads/sites/62/2021/04/CA02-5.pdf

11.20. Title: Ride-Hailing and Taxi Versus Walking: Long Term Forecasts and Implications from Large-Scale Behavioral Data

Author(s): Khattak, Z.H., Miller, J.S., and Ohlms, P.

Abstract: Introduction: Although ride-hailing and taxi trips can potentially reduce single-occupant vehicle trips and auto ownership, they can also replace pedestrian trips. Because physical activity is associated with improved health outcomes, the extent to which ride-hailing and taxi travel captures walking's mode share is of interest to policymakers.

Methods: Based on large-scale behavioral data from the 2017 U.S. National Household Travel Survey, this paper reports on the development of a full Bayesian logistic regression model for determining the mode split between (1) ride-hailing and taxi and (2) walk while accounting for unobserved heterogeneity. The results from the stand-alone model inform two longer term travel forecasting scenarios: (a) higher risk of walk trips converting to ride-hailing and taxi, specifically in the future with high prevalence of automated vehicles; (b) higher probability of such trips remaining as walking.

Results: The results revealed that some of the important characteristics that increase the likelihood of a traveler using the ride-hailing and taxi mode versus walking include having a longer trip, using a smartphone to access the internet, having an interest in technologies, having a medical condition, and living in a metropolitan area with rail access. Further, the results from the first scenario suggest that an overall increase of up to 2.9 percent in the ride-hailing and taxi mode share may be expected. The second scenario shows that between 68 percent and 76 percent of ride-hailing and taxi trips could be diverted to walking if supportive pedestrian infrastructure was provided in the case study locations. The planning process can be adapted to consider not only congestion, crash, and emissions impacts of such shifts but also the effects of a loss of physical activity.

Conclusions: The study findings show how the ride-hailing and taxi mode competes with walking. Further, the findings enable planners to update their regional travel forecasting models; policymakers can thus encourage active travel by prioritizing pedestrian infrastructure investments that may divert ride-hailing and taxi trips to walking. However, equity should be a key consideration to ensure that addressing the competition between these two modal choices does not hinder the provision of pedestrian facilities in communities that depend on walking.

Subject Areas: Ride-hailing; Taxi; Walking; Shared mobility; Health impacts; Bayesian modeling; Mobility applications

Availability: Khattak, Z.H., Miller, J.S., and Ohlms, P. (2021). "Ride-Hailing and Taxi Versus Walking: Long Term Forecasts and Implications from Large-Scale Behavioral Data." *Journal of Transport & Health*, *22*. https://doi.org/10.1016/j.jth.2021.101121

11.21. Title: Modal Shifts in California from 2012-2017: Investigating Changes in Biking, Walking, and Transit from the 2012 CHTS and 2017 NHTS

Author(s): Pike, S. and Handy, S.

Abstract: This study evaluates changes in travel mode shares in California over the period from 2012, when the California Household Travel Survey (CHTS) was most recently completed, to 2017, the most recent implementation of the National Household Travel Survey (NHTS). Initial review of the data suggests decreases in biking and walking over this time period. This study explores the factors contributing to this change—namely, are these apparent changes the artifact of methodological differences between the analysis of the two surveys, or do they reflect real changes in the travel behavior of Californians? We also explore external factors, or changes over time that may contribute to mode share changes, such as demographic shifts or system-wide shocks such as the Great Recession. There are many differences in the preparation of the data used in the analysis across the two surveys; for example, the variables included in weighting are not the same for the CHTS and the NHTS. These differences are not found to have an impact on the outcomes of interest; however, they do suggest the need for more coordination among the NHTS and the CHTS to better enable comparative studies.

Subject Areas: Travel mode shares; Changes in walking and biking; California mode shares; National Household Travel Survey; California Household Travel Survey; Survey methods

Availability: Pike, S. and Handy, S. (2021). *Modal Shifts in California from 2012-2017: Investigating Changes in Biking, Walking, and Transit from the 2012 CHTS and 2017 NHTS*. University of California, Davis, CA. https://doi.org/10.7922/G290222K

11.22. Title: Citizen-Centric Smart Cities: Planning for Travel Behavior in a Technology Empowered Future

Author(s): Shamshiripour, A.

Abstract: A multitude of confounding factors contribute to the success of smart cities (Caragliu et al., 2011; Giffinger et al., 2010; Lee et al., 2013). Many of these factors are centered around the citizens and their interactions with its various technological elements. The concept of "citizen-centric smart cities" is proposed in the literature to better comply with this (Allam and Newman, 2018; Lee and Lee, 2014; Yonezawa et al., 2015; Zakzak, 2019). Acknowledging the role of the technology-centric approaches in the past in leading our cities toward ecosystems that favor drivers over pedestrians (Allam and Newman, 2018; Ewing et al., 2018; Shelton et al., 2015; Southworth, 2005), the research presented in this dissertation aims at providing insights into the success of future citizen-centric smart cities.

Extracting the influence of sociopsychological contributors, such as lifestyles, habits, and higher level orientations, is a dominant note of the present research throughout its four main study chapters, as discussed briefly in the following. First (chapter 3), the dynamics of travelers' modality styles were analyzed while accounting for the existence of mobility-on-demand (MoD) services in the market. The dynamics of modality styles is an important aspect that has remained understudied to this point. This study contributes to the existing literature by breaking down the modality style dynamics into (1) the baseline preferences and (2) the longer term (i.e., a 30-day time window) intermodal substitution behavior.

Second (chapter 4), the influence of lifestyles on productive travels using public transportation was analyzed to obtain insights into how a future autonomous transit system can account for the expectations and needs of its users with respect to the efficiency of the activities performed while riding—i.e., cited in the literature as "travel-based multitasking" (Singleton, 2018). How well a transportation mode could facilitate this desire of the travelers is cited in the literature as its "multitaskability" and plays an indisputable role in attracting potential users (Mokhtarian, 2019; Mokhtarian and Salomon, 1997; Pawlak et al., 2016). As such, the results of this research could be used to inform future developments of the transit system toward providing more attractive services.

Third (chapters 5 and 6), the impacts of the COVID-19 pandemic on the dynamics of activity-travel behavior in the future is analyzed based on a comprehensive travel survey conducted in the Chicago metropolitan area. The pandemic forced many to reexamine their habits, and thereby, caused considerable changes in the current travel patterns. Therefore, the last two research chapters of this dissertation are dedicated to understanding the "stickiness" of the heightened levels of shifting toward teleactivities (i.e., online shopping and working from home, etc.) as well as private modes of travel in the post-pandemic future.

Subject Areas: Smart city; Sociopsychological contributors; Modality styles; Public transportation; Activity-travel behavior; Teleactivities

Availability: Shamshiripour, A. (2021). *Citizen-Centric Smart Cities: Planning for Travel Behavior in a Technology Empowered Future*. Doctoral Dissertation, University of Illinois at Chicago,

Chicago, IL. https://www.proquest.com/openview/2c8080a9de5b81bd40222e9c09169137/1?pq-origsite=gscholar&cbl=18750&diss=y

11.23. Title: Using Survey Data to Understand Ridesourcing in Tennessee: Who, Where, When, and Why?

Author(s): Crossland, C.K.

Abstract: With companies like Uber and Lyft leading the way, ride-sourcing has grown and continues to grow in popularity in the United States since its introduction just more than 10 years ago. While research on this new transportation mode has largely focused on national-level trends and studies of large metropolitan areas, little has been written about its impacts in smaller and mid-sized cities and States. This paper aims to understand the socioeconomic characteristics and travel behavior trends of those using ride-sourcing in less studied regions, using Tennessee as a case study. This thesis has three parts: a literature review of past research; a comparison of the demographics of ride-sourcing users at the national, Census division, and State levels based on the 2017 National Household Travel Survey (NHTS); and a comparison of different user groups within the State of Tennessee using survey data collected in three metropolitan regions in Tennessee (Knoxville, Nashville, and Memphis). The results of the NHTS data analysis reveal some key differences in national/large city characteristics as compared to those found in the State-level analysis, including the importance of gender and race. The subsequent survey data analysis revealed four distinct market segments: those who use ride-sourcing in their own city, those who use ride-sourcing only when traveling, those who use ride-sourcing only with friends or family, and those who do not use ride-sourcing. By understanding the differences between user locations and user types, better policies and regulations can be created to more efficiently and effectively harness the potential of this growing transportation mode.

Subject Areas: Ride-sourcing; Socioeconomic characteristics; Travel behavior

Availability: Crossland, C.K. (2021). *Using Survey Data to Understand Ridesourcing in Tennessee: Who, Where, When, and Why?* Master's Thesis, The University of Tennessee, Knoxville, TN. https://trace.tennessee.edu/utk_gradthes/6177

11.24. Title: Changes in When and Where People Are Spending Time in Response to COVID-19

Author(s): Reinicke, N., Borlaug, B., and Moniot, M.

Abstract: The COVID-19 pandemic has resulted in a significant change in driving behavior as people respond to the new environment. However, existing methods for analyzing driver behavior, such as travel surveys and travel demand models, are not suited for incorporating abrupt environmental disruptions. To address this, we analyze a set of high-resolution trip data and introduce two new metrics for quantifying driving behavioral shifts as a function of time, allowing us to compare the time periods before and after the pandemic began. We apply these metrics to the Denver, CO, metropolitan statistical area (MSA) to demonstrate the utility of the metrics. Then, we present a case study for comparing two distinct MSAs—Louisville, KY; and Des Moines, IA–which exhibit significant differences in the makeup of their labor markets. The results indicate that although the regions of study exhibit certain unique driving behavioral shifts, emerging trends can be seen when comparing between seemingly distinct regions. For instance, travelers in all three MSAs are generally shown to have spent more time at residential locations and less time in workplaces in the time period after the pandemic started. In addition, workplaces that may be incompatible with remote working, such as hospitals and certain retail locations, generally retained much of their pre-pandemic travel activity.

Subject Areas: Driving behavior; Behavioral shifts; Emerging trends; Metropolitan statistical area

Availability: Reinicke, N., Borlaug, B., and Moniot, M. (2021). *Changes in When and Where People Are Spending Time in Response to COVID-19*. National Renewable Energy Laboratory, Golden, CO. https://www.nrel.gov/docs/fy21osti/78473.pdf

11.25. Title: Have the Gender Differences in Commuting Been Shrinking or Persistent? Evidence from Two-Earner Households in the U.S.

Author(s): Kwon, K. and Akar, G.

Abstract: This study explores gender differences in commute behavior with a focus on two-earner households using data from the 2001, 2009, and 2017 U.S. National Household Travel Surveys (NHTS). To understand whether gender differences are shrinking or persistent in terms of commute distances, we first analyze these differences by assessing descriptive statistics and *t* test across multiple population subcategories and trip purposes. We then employ seemingly unrelated regression (SUR) models on the pooled data in order to analyze the determinants of the household total commute distance and share of women's commute distance. Our study reveals: (1) the gender gap in commute distances has narrowed over the years; however, the magnitude of change is small; (2) women continue to have shorter commute distances; and (3) commute mode, presence of children, and occupation-related characteristics affect gender gaps in commuting.

Subject Areas: Commute behavior; Gender difference; Two-earner households; Seemingly unrelated regression; National Household Travel Survey

Availability: Kwon, K. and Akar, G. (2021). "Have the Gender Differences in Commuting Been Shrinking or Persistent? Evidence from Two-Earner Households in the U.S." *International Journal of Sustainable Transportation*. https://doi.org/10.1080/15568318.2021.1971345

11.26. Title: Exploring the Influence of Built Environment on Uber Demand

Author(s): Sabouri, S., Park, K., Smith, A., Tian, G., and Ewing, R.

Abstract: Ride-sourcing services have made significant changes to the transportation system, essentially creating a new mode of transport, arguably with its own relative utility compared to the other standard modes. As ride-sourcing services have become more popular each year and their markets have grown, so have the publications related to the emergence of these services. One question that has not been addressed yet is how the built environment—the so-called D variables (i.e., density, diversity, design, distance to transit, and destination accessibility)—affect demand for ride-sourcing services. By having unique access to Uber trip data in 24 diverse U.S. regions, we provide a robust data-driven understanding of how ride-sourcing demand is affected by the built environment, after controlling for socioeconomic factors. Our results show that Uber demand is positively correlated with total population and employment, activity density, land use mix or entropy, and transit stop density of a Census block group. In contrast, Uber demand is negatively correlated with intersection density and destination accessibility (both by auto and transit) variables. This result might be attributed to the relative advantages of other modes—driving, taking transit, walking, or biking—in areas with denser street networks and better regional job access. The findings of this paper have important implications for policy, planning, and travel demand modeling, where decision makers seek solutions to shape the built environment in order to reduce automobile dependence and promote walking, biking, and transit use.

Subject Areas: Ride-sourcing services; Transportation network companies; Uber; Built environment; Trip distribution; Multilevel modeling

Availability: Sabouri, S., Park, K., Smith, A., Tian, G., and Ewing, R. (2020). "Exploring the Influence of Built Environment on Uber Demand." *Transportation Research Part D: Transport and Environment*, *81*. https://doi.org/10.1016/j.trd.2020.102296

11.27. Title: Work from Home Outlasts COVID -19

Author(s): Ramachandran, S.

Abstract: Based on wealthy novel overview information on nearly 5,000 working age grownups, we report that 35.2 percent of the workforce worked totally from domestic in May 2020, up from 8.2 percent in February 2020. Profoundly taught, high-income, and White people were much more likely to move to farther work and to preserve business taking after the infection outbreak. Using accessible gauges of the potential number of home-based specialists proposes that an expansive lion's share (71.7 percent) of U.S. laborers that seem work from domestic, effectively did so in May. We offer a few prove demonstrating that separated from the potential for home-based work, industry trade conditions and labor request moreover mattered for employment outcomes taking after the infection flareup.

The flareup of COVID-19 around the globe constrained businesses to enhance and alter the way they conduct their work. Workplaces have gotten to be less vital, and work from domestic has all of a sudden become mandatory. This sudden requirement for work from domestic is driving the advanced change of the workforce and the advancement of the work environment at an exceptional speed. Mass selection of telecommuting has gotten to be a crucial trade alter since the flareup of the infection. This paper looks at this uncommon effect of coronavirus widespread on sudden request for work from domestic and the ensuing thrust for the advanced change of the workforce.

Subject Areas: COVID-19; Working from home; Telecommuting; Social distancing; Employment

Availability: Ramachandran, S. (2021). *Work from Home Outlasts COVID -19*. Industrial People Management; Volume-IV, pp. 168–183. Vaniyambadi, Tirupattur District, Tamil Nadu, India. https://www.researchgate.net/profile/Pratik-Chatterjee-2/publication/354688214_Industrial_People_Management_Volume-IV/links/61471c7a519a1a381f6c7f90/Industrial-People-Management-Volume-IV.pdf#page=175

11.28. Title: Adoption of Delivery Services in Light of the COVID Pandemic: Who and How Long?

Author(s): Wang, X., Kim, W., Holguín-Veras, J., and Schmid, J.

Abstract: A significant growth in demand for online shopping in light of the coronavirus disease (COVID) crisis has received attention from transportation practitioners, policymakers, and researchers. However, an important question arises in this increase in online shopping and resulting deliveries: How long will this last? Very little is known whether this popularity would last a long time. To address this question, the authors conducted a survey of 915 individuals residing in the United States and classified them into the four distinctive consumer types (i.e., the prior adopter, temporary adopter, and permanent new adopter, and non-adopter) depending on their usage of delivery services before, during, and after (expected) the COVID crisis. This research aims to gain behavioral insight by exploring the differences between the four consumer types and investigating factors affecting the initial adoption and continuance intention of using delivery services. The descriptive analysis revealed that there are clear differences not only between the four types of consumers but also between the four product types (i.e., grocery, food, home goods, and other packages) considered in the survey. The models found that factors affecting the initial adoption and continuance intention are different from the previous studies conducted before the COVID pandemic. Implications for planning and policymaking are also discussed.

Subject Areas: Continuance intention; COVID; Delivery; Pandemic; Technology adoption

Availability: Wang, X., Kim, W., Holguín-Veras, J., and Schmid, J. (2021). "Adoption of Delivery Services in Light of the COVID Pandemic: Who and How Long?" *Transportation Research Part A: Policy and Practice*, *154*, pp. 270–286. https://doi.org/10.1016/j.tra.2021.10.012

11.29. Title: Intersectional Transportation Trends in LA County

Author(s): Brozen, M., Rios, N., Cardenas, I., Ekman, A.Y., and Bressette, B.

Abstract: The costs and benefits of the transportation system are distributed unequally, leading to people receiving less access to opportunities. This report sought to understand how this issue plays out within Los Angeles County by analyzing trends in transportation patterns across race/ethnicity, income, gender, age, ability, and geography. This report used data from the 2017 National Household Travel Survey California Add-On and 2013–2017 collision data from the UC Berkeley Transportation Injury Mapping System to report the number of trips and miles per day, transportation mode and purpose, and collision incidents for women and youth of color, Black people, people with disabilities, lower income older adults, people living in families in poverty, and households living in priority population areas. We find similarities in the number of unlinked trips taken per day, but there are unique and diverging patterns in terms of average trip distances and duration. Women of color, Black people, and people living in priority population areas tended to have longer average trip distances. Meanwhile, youth of color, people with disabilities, lower income older adults, and people living in families in poverty had shorter average trip distances. All of these groups, except for women of color, traveled at slower average travel speeds than people overall in Los Angeles County, likely due to reliance on transit and walking. We also find significant differences in collision risks, especially by race and mode. Black people being overrepresented in collisions by every travel mode and walking in particular, and disparities extend to Black and Latino/a pedestrians. Overall, these trends highlight the need to make significant investments in transportation to ensure that the access benefits derived from the transportation system can fairly benefit everyone in LA County. The recommendations derived from this analysis are intended to help address transportation inequities in Los Angeles County and move toward a more equitable and justice-oriented future.

Subject Areas: Travel behavior; Collisions; Transportation equity; Identity; Inequality; Sociodemographic

Availability: Brozen, M., Rios, N., Cardenas, I., Ekman, A.Y., and Bressette, B. (2021). *Intersectional Transportation Trends in LA County*. Research Report, University of California, Los Angeles, CA. https://www.metrans.org/assets/research/psr-19-60_brozen_final-report_jw.pdf

11.30. Title: The Evolution, Usage and Trip Patterns of Taxis & Ridesourcing Services: Evidence from 2001, 2009 & 2017 US National Household Travel Survey

Author(s): Wu, X. and MacKenzie, D.

Abstract: Given the rapid adoption of ride-sourcing services (RS), it is critical for transportation planners and policymakers to understand their impacts and keep policies up to date. This study contributes to the literature by using representative samples captured in the 2001, 2009, and 2017 National Household Travel Surveys to explore how taxis and ride-sourcing (T/R) services have evolved and shaped people's travel behavior pre- and post-disruption at the U.S. national level. It characterizes and visualizes the asymmetries in demand spatially and temporally for T/R trips, showing that ride-sourcing has greatly increased T/R trips from flexible and optional activity locations to home, which vary by times of day. It also characterizes tours involving T/R services, showing that while simple optional tours (such as home–recreation–home) represent the largest share of tours involving T/R, the fastest growth has been in simple mandatory tours (such as home–work–home). Tours involving T/R grew from 0.4 percent of all tours in 2009 to 1 percent of all tours in 2017, mostly within densely populated and transit-oriented regions. Although less than 1 percent of T/R trips involved a direct transfer to or from transit, one-third of all tours containing T/R also included transit. However, at the same time, 40 percent of T/R-containing tours also involved auto trip(s). Overall, this study reveals the complex relationships among their underlying sociodemographic characteristics, RS adoption and usage behavior, and daily tour patterns.

Subject Areas: Ride-sourcing; Taxi; Household travel survey; Travel behavior; Tour pattern

Availability: Wu, X. and MacKenzie, D. (2021). "The Evolution, Usage and Trip Patterns of Taxis & Ridesourcing Services: Evidence from 2001, 2009 & 2017 US National Household Travel Survey." *Transportation.* https://doi.org/10.1007/s11116-021-10177-5

11.31. Title: Impacts of Transportation Network Companies on Vehicle Miles Traveled, Greenhouse Gas Emissions, and Travel Behavior Analysis from the Washington D.C., Los Angeles, and San Francisco Markets

Author(s): Martin, E., Shaheen, S., and Stocker, A.

Abstract: Transportation network companies (TNCs), such as Lyft, Uber, and their global counterparts, have expanded around the world over the past decade and have changed the way that people travel around cities and regions. The individual mobility benefits provided by TNCs have been clear. Passengers can summon a vehicle quickly via smartphone from almost anywhere to take them almost anywhere, with advance communication on estimated wait time, travel time, and cost. TNCs may also provide users with added mobility benefits, especially for those living in areas where public transit service is infrequent or non-existent. However, the growing popularity of TNCs has forced important questions about their impacts on the overall transportation network. Although past research has focused on many different aspects of TNC impacts, including their effects on travel behavior, modal shift, congestion, and other topics, there are still many important questions. This report advances the understanding of TNC effects on vehicle miles traveled (VMT), greenhouse gas (GHG) emissions, and personal vehicle ownership. The research also explores key questions regarding the impact of pooled TNC services, Lyft Shared rides and UberPool, and further investigates how TNCs alter the use of other transportation modes, including public transit.

Subject Areas: Ride-sourcing; Taxi; Household travel survey; Travel behavior; Tour pattern

Availability: Martin, E., Shaheen, S., and Stocker, A. (2021). *Impacts of Transportation Network Companies on Vehicle Miles Traveled, Greenhouse Gas Emissions, and Travel Behavior Analysis from the Washington D.C., Los Angeles, and San Francisco Markets*. Report, Transportation Sustainability Research Center, University of California, Berkeley, CA. https://tsrc.berkeley.edu/publications/impacts-transportation-network-companies-vehicle-miles-traveled-greenhouse-gas-0

11.32. Title: Impacts of Built Environment on Travel Behaviors of Generation Z: A Longitudinal Perspective

Author(s): Chen, X., Li, T., and Yuan, Q.

Abstract: Having grown up in an "always-on" technological environment, Generation Z differ significantly in attitudes and lifestyles compared to previous generations. However, their travel behaviors have not been widely discussed and adequately understood. Using data from the latest three National Household Travel Surveys in the United States, we in this paper identify the uniqueness of Gen Z in travel behaviors and preferences, and use the zero-inflated Poisson model to test the impacts of key factors on the mode choices. Results from the longitudinal analysis indicated that Gen Z are not always more environmentally friendly than same-age people in the past decades, while Gen Z have a stronger tendency to travel in a green way in response to changes in built environment than their counterparts decades ago. These findings demonstrate that Gen Z, who have been greatly affected by technological advances and social media, may show unprecedented potential to support sustainable transportation.

Subject Areas: Travel behaviors; Mode choice; Generation Z; Built environment; National Household Travel Survey

Availability: Chen, X., Li, T., and Yuan, Q. (2021). "Impacts of Built Environment on Travel Behaviors of Generation Z: A Longitudinal Perspective." *Transportation*. https://doi.org/10.1007/s11116-021-10249-6

11.33. Title: Do Travel Surveys Show That Californians Walked and Biked Less in 2017 Than in 2012?

Author(s): Pike, S. and Handy, S.

Abstract: The California Department of Transportation set a goal of doubling walking and transit use and tripling bicycling in the State between 2010 and 2020. However, the most recent comprehensive travel surveys—the 2012 California Household Travel Survey (CHTS) and the California results from the 2017 National Household Travel Survey (NHTS)—suggest that the State is moving in the wrong direction. These surveys seemed to show that a smaller share of trips were made by walking or biking in 2017 than in 2012, while private vehicle mode share increased. It is unclear whether the decline represents real changes stemming from various demographic or other factors or is instead related to methodological differences between the two surveys. Researchers at the University of California, Davis used the publicly available 2012 CHTS and 2017 NHTS California add-on data to examine the impact of methodological differences on the changes in mode shares over this 5-year period and conducted a preliminary investigation into the role of demographic and other factors in these changes. This policy brief summarizes the findings from that research and provides policy implications.

Subject Areas: Travel behaviors; Biking and walking trips; Mode share change; Policy implications

Availability: Pike, S. and Handy, S. (2021). *Do Travel Surveys Show That Californians Walked and Biked Less in 2017 Than in 2012?* Policy Brief, National Center for Sustainable Transportation, University of California, Davis, CA. https://ncst.ucdavis.edu/research-product/do-travel-surveys-show-californians-walked-and-biked-less-2017-2012

11.34. Title: Generational Travel Patterns in the United States: New Insights from Eight National Travel Surveys

Author(s): Zhang, M. and Li, Y.

Abstract: Millennials' automobility preferences and choices have attracted widespread attention from academia, policymakers, and business industries. Existing studies, however, have reported mixed findings on whether millennials differ from their predecessor generations, leading to contradictory conclusions drawn for transportation planning and policy recommendations. This study utilized eight U.S. national travel surveys to construct a panel data that covers a continuous range of ages for persons 5 years and older for baby boomers, Generation X, and millennials. With this unique dataset, the study performed analyses on the trend of daily vehicle miles traveled (VMT) by an average person from each generation and its subgroups. The study found that baby boomers, Generation X, and millennials shared a three-phased trending pattern of VMT over the life course but exhibited varying levels of daily VMT in different life stages. During adulthood, millennials have kept their daily VMT consistently lower than that of Generation X by about 3 VMT, or 8 percent, whereas the younger group of baby boomers outdrove the older millennials at age 28 and after by about 3.5 VMT, or 9 percent, daily. When each generation is considered over its life course, peak-level daily VMT tends to occur at earlier ages for each successive generation. From the multilevel modeling of daily VMT, the study identified generation-related group effects and estimated VMT elasticities with respect to person age, driving licensure, vehicle ownership, household size, and gasoline price-adjusted income. The study's findings on the direction and size of VMT influences associated with the five planning or policy variables did not support the speculation that millennials would match or surpass baby boomers and Generation X in their future daily VMT trajectory. Public policies should be designed to nurture the shifting trend of reduced automobility from the older to the younger generations.

Subject Areas: Baby boomers; Generation X; millennials; Vehicle miles traveled (VMT); Nationwide Personal Transportation Survey (NPTS); National Household Travel Survey (NHTS)

Availability: Zhang, M. and Li, Y. (2021). "Generational Travel Patterns in the United States: New Insights from Eight National Travel Surveys." *Transportation Research Part A: Policy and Practice*, *156*, pp. 1–13. https://doi.org/10.1016/j.tra.2021.12.002

11.35. Title: "Would It Be Weird to Live Here Without a Car?": Using Reddit to Understand Car-Free Lifestyle Decisions

Author(s): Iacobucci, E.

Abstract: Car use is associated with negative social, economic, and environmental externalities. Encouraging people to adopt a car-free lifestyle is one way to address these harms, since car ownership is a major predictor of driving. Nevertheless, few people in the United States voluntarily live without a car. In this dissertation, I seek (1) to understand why people decide to live car-free, and (2) to investigate the potential that more people could adopt car-free lifestyles. I use threads scraped from Reddit, an online social media platform, to address these issues, employing content analysis to examine data from seven U.S. cities in which Reddit commenters discuss car ownership decisions.

I find that the car-free are multimodal, employ contingency plans, rely on ride-hailing and car-sharing services to fill mobility gaps, and readily get used to car-free living. Among car owners, I find that while some need cars, others keep them for convenience. Costs are a primary motivator in ownership decisions, especially parking costs. Awareness of these costs motivates shedding of cars, while lowered costs, e.g., via free parking, encourage ownership. Accessible neighborhoods facilitate car-free life, with commenters describing walking and using transit to access common destinations. Changes in car ownership are catalyzed in two ways: (1) key life events (e.g., moving) cause changes in travel needs or available choices, or (2) people reevaluate their available options and make new choices, unspurred by a key event.

I conclude that there are groups, like those who keep cars for convenience, or those whose needs could be met by alternative modes, that display high potential to become car-free. Changes in cost structure and policy may be leveraged to bring these changes about.

Subject Areas: Car-free lifestyle; Reddit; Content analysis; Car ownership decisions

Availability: Iacobucci, E. (2021). *"Would It Be Weird to Live Here Without a Car?": Using Reddit to Understand Car-Free Lifestyle Decisions*. Doctoral Dissertation, Rutgers, The State University of New Jersey, New Brunswick, NJ. https://rucore.libraries.rutgers.edu/rutgers-lib/66787/PDF/1/play/

Chapter 12. Emerging Travel Modes

12.1 Title: Multi-objective Framework for Optimum Configuration of Human-Driven and Shared or Privately Owned Autonomous Vehicles

Author(s): Singh, H., Ghamami, M., Nouri, H., and Gates, T.

Abstract: Private autonomous vehicles (PAVs) and shared autonomous vehicles (SAVs) are known to improve safety, mobility, roadway capacity, and driver productivity and reduce parking costs (due to better utilization of space and self-parking to less expensive spots). However, the increased vehicle miles traveled (VMT) might increase overall emission production, system travel time, and operating costs. Also, the purchase price of autonomous vehicles (AVs) is expected to be higher than that of human-driven (conventional) vehicles. A multi-objective mathematical model is proposed to minimize the purchase and operating costs, time spent, and emission production. The proposed model captures the tradeoff between the benefits of increased mobility, reduction in the value of travel of time (VOTT), efficient driving pattern, and the negative impacts of increased VMT and ownership cost due to the adoption of AVs. The proposed framework assists with the development of simplified adoption models that can be used by the policymakers and/or investors. SAVs would be the optimal solution if the replacement rate or CO_2 costs are significantly low or CO costs are sufficiently high. SAVs can also be the optimal solution if the travel time is used efficiently or the purchase price is below certain relative threshold while minimizing system cost. Considering the private mobility system, PAVs can be the optimal solution only if the on-board amenities are improved, lifetime mileage is increased, and AV technology is installed in luxurious cars and is being adopted by people with high VOTT.

Subject Areas: Autonomous vehicles; Emission production; Human-driven vehicles; Mobility; Private autonomous vehicles; Shared autonomous vehicles; Vehicle miles traveled; Value of travel of time

Availability: Singh, H., Ghamami, M., Nouri, H., and Gates, T. (2021). “Multi-objective Framework for Optimum Configuration of Human-Driven and Shared or Privately Owned Autonomous Vehicles.” *International Journal of Sustainable Transportation*.
https://doi.org/10.1080/15568318.2021.1887415

12.2 Title: Marketing Mobility as a Service: Insights from the National Household Travel Survey

Author(s): Crossland, C. and Brakewood, C.

Abstract: The introduction of the Mobility as a Service (MaaS) concept in recent years has led to trials of MaaS around the world. This concept provides bundles of transportation services which people can purchase instead of individual modes. In many areas of the United States, shared transportation modes are operated and purchased separately. The 2017 National Household Travel Survey provided responses on five shared transportation modes: bikeshare, carshare, online delivery services, rideshare, and public transit. The goal of this paper is to evaluate potential shared transportation bundles that could be marketed for MaaS in the United States. Every two, three, four, and five shared transportation bundle combinations were created to find which transportation bundles would be best suited for the models. For each transportation bundle, three binary logit models were run: one for those who live in urban areas, one for those who live in rural areas, and one nationwide. In total, 36 models were estimated, and 12 models were selected for this paper. While most of the models had similar trends, such as each bundle being used by those with fewer vehicles, there were key differences between urban and rural areas for each bundle, including gender and income level. By understanding who uses which modes of transportation, MaaS plans can be marketed toward the groups most likely to use them.

Subject Areas: Mobility as a service; Ridesharing; Delivery; Public transit; Bikeshare; Carshare

Availability: Crossland, C. and Brakewood, C. (2021). *Marketing Mobility as a Service: Insights from the National Household Travel Survey.* Transportation Research Board 100th Annual Meeting—A Virtual Event. https://annualmeeting.mytrb.org/OnlineProgram/Details/15655

12.3 Title: Back to the Future: Opinions of Autonomous Cars Over Time

Author(s): Bejerano, G., Robinette, P., Yanco, H.A., and Phillips, E.

Abstract: The aim of this research was to investigate whether preferences of U.S. adults regarding autonomous vehicles have changed in the past decade. We believe this to be indicative of the effect of cultural shifts over time in preferences regarding robots, similar to the effect of cultural and national differences on preferences regarding robots. By replicating a 2009 survey regarding autonomous vehicle parking, we found that participants ranked four out of six parking and transportation options significantly differently now particularly for an autonomous vehicle with no override, a taxi, driving a standard vehicle, and being next to a vehicle driven by another person. Additionally, we found partial support that participants who were more informed about autonomous vehicle technology showed an increase in preferences for autonomous vehicles.

Subject Areas: Autonomous vehicles; Preferences regarding robots

Availability: Bejerano, G., Robinette, P., Yanco, H.A., and Phillips, E. (2021). "Back to the Future: Opinions of Autonomous Cars Over Time." *HRI '21 Companion: Companion of the 2021 ACM/IEEE International Conference on Human-Robot Interaction*, pp. 157–161. https://doi.org/10.1145/3434074.3447150

12.4 Title: Performance Evaluation of Station-Based Autonomous On-Demand Car-Sharing Systems

Author(s): Javanshour, F., Dia, H., Duncan, G., Abduljabbar, R., and Liyanage, S.

Abstract: Autonomous Mobility-on-Demand (AMoD) systems hold potential promise for addressing urban mobility challenges. Their key principle is to utilize fleets of shared self-driving vehicles to respond to customer demand on flexible routes in real-time. This research investigates station-based AMoD car-sharing systems and uses scenario analyses to identify plausible future paths for their deployment. A traffic simulation model which implements real-time rebalancing of idle vehicles is developed to evaluate their performance under uncertain travel demands. Unlike other literature which assumed homogeneous demand and resulted in low increases in vehicle kilometers travelled (VKT), this study relied on realistic heterogeneous demand and showed a significant increase in VKT. A case study for Melbourne demonstrated the impacts and showed that while AMoD can meet the demand for travel using only 16% of the current vehicle fleet, they would produce 77% increase in VKT. This would significantly increase congestion in any real-world scenario and goes against the hype of AMoD being the answer to congestion problems.

Subject Areas: Vehicle dynamics; Urban areas; Roads; Public transportation; Optimization; Heuristic algorithms; Autonomous vehicles; Agent-based modelling; Disruptive mobility

Availability: Javanshour, F., Dia, H., Duncan, G., Abduljabbar, R., and Liyanage, S. (2021). "Performance Evaluation of Station-Based Autonomous On-Demand Car-Sharing Systems." *IEEE Transactions on Intelligent Transportation Systems*, pp. 1–12.
https://doi.org/10.1109/TITS.2021.3071869

12.5 Title: Emissions Impact of Connected and Automated Vehicle Deployment in California

Author(s): Circella, G., Jaller, M., Sun, R., Qian, X., and Alemi, F.

Abstract: This study helps understand how the anticipated emergence of autonomous vehicles will affect various aspects of society and transportation, including travel demand, vehicle miles traveled, energy consumption, and emissions of greenhouse gases and other pollutants. The study begins with a literature review on connected and automated vehicle (CAV) technology for light-duty vehicles, the factors likely to affect CAV adoption, expected impacts of CAVs, and approaches to modeling these impacts. The study then uses a set of modifications in the California Statewide Travel Demand Model (CSTDM) to simulate the following scenarios for the deployment of passenger light-duty CAVs in California by 2050: (0) Baseline (no automation); (1) Private CAV; (2) Private CAV + Pricing; (3) Private CAV + Zero emission vehicles (ZEV); (4) Shared CAV; (5) Shared CAV + Pricing; (6) Shared CAV + ZEV. The modified CSTDM is used to forecast travel demand and mode share for each scenario, and this output is used in combination with the emission factors from the EMission FACtor model (EMFAC) and Vision model to calculate energy consumption and criteria pollutant emissions. The modeling results indicate that the mode shares of public transit and in-state air travel will likely sharply decrease, while total vehicle miles traveled and emissions will likely increase, due to the relative convenience of CAVs. The study also reveals limitations in models like the CSTDM that primarily use sociodemographic factors and job/residence location as inputs for the simulation of activity participation and tour patterns, without accounting for some of the disruptive effects of CAVs. The study results also show that total vehicle miles traveled and vehicle hours traveled could be substantially impacted by a modification in future auto travel costs. This means that the eventual implementation of pricing strategies and congestion pricing policies, together with policies that support the deployment of shared and electric CAVs, could help curb tailpipe pollutant emissions in future scenarios, though they may not be able to completely offset the increases in travel demand and road congestion that might result from CAV deployment. Such policies should be considered to counteract and mitigate some of the undesirable impacts of CAVs on society and on the environment.

Subject Areas: Connected and automated vehicles; Travel demand; Vehicle miles traveled; Emission impacts; Mode share; Future scenarios; California Statewide Travel Demand Model

Availability: Circella, G., Jaller, M., Sun, R., Qian, X., and Alemi, F. (2021). *Emissions Impact of Connected and Automated Vehicle Deployment in California*. University of California, Davis, CA. https://escholarship.org/uc/item/0qf4k22c

12.6 Title: Future Regional Air Mobility Analysis Using Conventional, Electric, and Autonomous Vehicles

Author(s): Roy, S., Maheshwari, A., Crossley, W.A., and DeLaurentis, D.A.

Abstract: Recent activities in electric propulsion and autonomy provide opportunity to improve both regional and urban air mobility. The inclusion of electric propulsion and the promise of autonomy to simplify flight operations could provide benefits that lead to wider use of small aircraft for regional transportation. The effort here presents a computational analysis framework to evaluate three different modes of transportation (airline, automobile, and air taxi); the air taxi service options consider different conventional takeoff and landing aircraft options powered by either conventional fuels or electricity with various levels of autonomy to assess potential advantages. The framework is developed in two variants: a specific trip model and a generic trip model. The specific trip approach leverages Google Maps and Rome2Rio application programming interfaces for driving and flight information, respectively, whereas the generic approach uses curve-fit/approximate models derived from the specific trip model for rapid calculations of trip time and cost for various system-level market studies. Potential market sensitivity study reveals that the inclusion of distributed propulsion, autonomy, ride-sharing, and aircraft production rate all impact the market attractiveness of the on-demand air taxi operations. Of these, an increased level of autonomy and the ability to facilitate ride-sharing are the two most important factors that affect the market attractiveness of regional air mobility.

Subject Areas: Urban air mobility; Conventional takeoff and landing; Application programming interface; Electric propulsion; Aircraft production; Flight operation; Electricity; Acquisition costs; Air transportation system; Autonomous systems

Availability: Roy, S., Maheshwari, A., Crossley, W.A., and DeLaurentis, D.A. (2021). "Future Regional Air Mobility Analysis Using Conventional, Electric, and Autonomous Vehicles." *Journal of Air Transportation*. https://doi.org/10.2514/1.D0235

12.7 Title: Do E-scooters Fill Mobility Gaps and Promote Equity Before and During COVID-19? A Spatiotemporal Analysis Using Open Big Data

Author(s): Yan, X., Yang, W., Zhang, X., Xu, Y., Bejleri, I., and Zhao, X.

Abstract: The growing popularity of e-scooters and their rapid expansion across urban streets has attracted widespread attention. A major policy question is whether e-scooters substitute existing mobility options or fill the service gaps left by them. This study addresses this question by analyzing the spatiotemporal patterns of e-scooter service availability and use in Washington DC, focusing on their spatial relationships with public transit and bikesharing. Results from an analysis of three open big datasets suggest that e-scooters have both competing and complementary effects on transit and bikesharing services. The supply of e-scooters significantly overlaps with the service areas of transit and bikesharing, and we classify a majority of e-scooter trips as substitutes to transit and bikesharing uses. A travel time-based analysis further reveals that when choosing e-scooters over transit, travelers pay a price premium and save some travel time. The price premium is greater during the COVID-19 pandemic, but the associated travel-time savings are smaller. This implies that public health considerations rather than time-cost tradeoffs are the main driver for many to choose e-scooters over transit during COVID-19. In addition, we find that e-scooters complement bikesharing and transit by providing services to underserved neighborhoods. A sizeable proportion (about 10 percent) of e-scooter trips are taken to connect with the rail services. Future research may combine the big-data-based analysis presented here with traditional methods to further shed light on the interactions between e-scooter services, bikesharing, and public transit.

Subject Areas: Micromobility; E-scooter; Public transit; Bikesharing; Big data; COVID-19

Availability: Yan, X., Yang, W., Zhang, X., Xu, Y., Bejleri, I., and Zhao, X. (2021). *Do E-scooters Fill Mobility Gaps and Promote Equity Before and During COVID-19? A Spatiotemporal Analysis Using Open Big Data*. arXiv preprint, arXiv:2103.09060 [cs.CY]. https://arxiv.org/abs/2103.09060

12.8 Title: Survey on e-Powered Micro Personal Mobility Vehicles: Exploring Current Issues towards Future Developments

Author(s): Boglietti, S., Barabino, B., and Maternini, G.

Abstract: Nowadays, the diffusion of electric-powered micro-personal mobility vehicles (e-PMVs) worldwide—i.e., e-bikes, e-scooters, and self-balancing vehicles—has disrupted the urban transport sector. Furthermore, this topic has captured many scholars and practitioners' interest due to multiple issues related to their use. Over the past five years, there has been strong growth in the publication of e-PMV studies. This paper reviews the existing literature by identifying several issues on the impact that e-PMVs produce from different perspectives. More precisely, by using the PRIMA's methodological approach and well-known scientific repositories (i.e., Scopus, Web of Science, and Google Scholar), 90 studies between 2014 and 2020 were retrieved and analyzed. An overview and classification into endogenous issues (e.g., impact on transport and urban planning) and exogenous issues (e.g., impact on safety and the environment) are provided. While several issues are deeply investigated, the findings suggest that some others need many improvements. Therefore, the status quo of these studies is being assessed to support possible future developments.

Subject Areas: Micromobility; Electric scooter; Personal mobility vehicle; Personal transporter; Segway; Micromobility problems

Availability: Boglietti, S., Barabino, B., and Maternini, G. (2021). "Survey on e-Powered Micro Personal Mobility Vehicles: Exploring Current Issues towards Future Developments." *Sustainability*, *13*(7). https://doi.org/10.3390/su13073692

12.9 Title: User Characteristics of Shared-Mobility: A Comparative Analysis of Car-Sharing and Ride-Hailing Services

Author(s): Hyun, K., Naz, F., Cronley, C., and Leat, S.

Abstract: Over the past 20 years, shared-mobility services have become important transportation options, as they provide on-demand, door-to-door mobility without requiring vehicle ownership. Although low-income communities may benefit especially from the services due to their lower vehicle ownership and high dependency on public transit, scant research has been conducted exploring how frequently these individuals utilize the shared-mobility programmes. This study develops a mathematical model based on Zero Inflated Negative Binomial Regression to understand the effects of individuals' sociodemographic characteristics, financial status, and travel behaviours on car-sharing and ride-hailing usage. The model outcomes indicate that the individuals experiencing financial burden are more likely to use car-sharing services while those with a higher income tend to use ride-hailing. Ride-hailing tends to serve those who have lower miles driven or those who use public transit. Results show that car-sharing and ride-hailing could provide create synergetic impacts to attract more riders to the shared-mobility services.

Subject Areas: Car-sharing; Ride-hailing; Zero inflated negative binomial regression; National Household Travel Survey

Availability: Hyun, K., Naz, F., Cronley, C., and Leat, S. (2021). "User Characteristics of Shared-Mobility: A Comparative Analysis of Car-Sharing and Ride-Hailing Services." *Transportation Planning and Technology*. https://doi.org/10.1080/03081060.2021.1919351

12.10 Title: Commuter Demand Estimation and Feasibility Assessment for Urban Air Mobility in Northern California

Author(s): Rimjha, M., Hotle, S., Trani, A., and Hinze, N.

Abstract: This study aims to estimate passenger demand for Urban Air Mobility (UAM) and analyze the feasibility of operating the system in Northern California. UAM is a concept mode of transportation that is designed to bypass ground congestion for time-sensitive, price-inelastic travelers using autonomous, electric aircraft with Vertical Takeoff and Landing (VTOL) capabilities. This study focuses specifically on commuting trips, which are frequent and considered relatively more time-sensitive than other types of personal trips. The UAM mode's feasibility is studied using sensitivity analysis of UAM demand to cost per passenger mile and the number of vertiports placed in the region. This study also explores the spatial distribution of UAM demand in Northern California, which further helps in identifying the major commuter trip-attraction and trip-production zones for the UAM mode in the region. The results indicate that sufficient UAM demand for commuting trips can only be reached at optimistically low UAM offered fares. These fare levels could be challenging to obtain given the high real estate cost in Northern California's urban regions. Moreover, the reliability of the UAM mode must be comparable to the automobile mode; otherwise, it loses significant demand with increasing delays. The results also show that the commuting flows with promising UAM demand in Northern California are heavily one-directional, with San Francisco Financial District being a major attraction. Other types of trips should also be considered along with commuting trips to generate an economically viable system and reduce deadheading.

Subject Areas: On-demand mobility; Urban air mobility; Vertical takeoff and landing; Travel demand

Availability: Rimjha, M., Hotle, S., Trani, A., and Hinze, N. (2021). "Commuter Demand Estimation and Feasibility Assessment for Urban Air Mobility in Northern California." *Transportation Research Part A: Policy and Practice*, *148*, pp. 506–524. https://doi.org/10.1016/j.tra.2021.03.020

12.11 Title: Multimodal Transportation with Ridesharing of Personal Vehicles

Author(s): Patel, R.K., Etminani-Ghasrodashti, R., Kermanshachi, S., Rosenberger, J.M., and Weinreich, D.

Abstract: This study explores how people with disabilities perceive and accept autonomous vehicles (AVs) as a technology to improve their mobility. A focus group discussion was conducted to explore individuals' preferences towards integrating level 4 AVs into the existing microtransit service in Arlington, Texas. Participants demonstrated a positive perception towards the integration of AVs into the current microtransit infrastructure. The results suggest that accessibility to a well-designed built environment is vital in adopting AVs by people with disabilities. Moreover, AVs' accessibility to healthcare facilities is one of the main concerns identified by focus groups of persons with disabilities. In particular, participants with visual impairment were hopeful that future AV services could improve their mobility through advanced apps, booking systems, and vehicle equipment. This study offers several implications for designing AV service in line with the needs of persons with disabilities while combining with the current microtransit service.

Subject Areas: People with disabilities; Autonomous vehicles; Mobility; Microtransit; Built environment

Availability: Patel, R.K., Etminani-Ghasrodashti, R., Kermanshachi, S., Rosenberger, J.M., and Weinreich, D. (2021). "Exploring Preferences towards Integrating the Autonomous Vehicles with the Current Microtransit Services: A Disability Focus Group Study." *International Conference on Transportation and Development 2021 (Virtual Conference)*.
https://doi.org/10.1061/9780784483534.031

12.12 Title: Bridging the Income and Digital Divide with Shared Automated Electric Vehicles

Author(s): Lazarus, J., Bauer, G., Greenblatt, J., and Shaheen, S.

Abstract: Shared mobility services, including carsharing, bikesharing, scooter sharing, and transportation network company (TNC) services (also called ridesouring and ridehailing), offer flexible, on-demand alternatives to personal auto use that can also supplement public transit and active modes of transportation. While early adoption of shared mobility services has primarily been led by younger individuals with higher levels of income and education (Shaheen et al., 2017), recent evidence suggests that lower-income people of color (POC) without access to personal vehicles are among the heaviest users of TNC services (Lazarus, et al., 2020, Brown, 2018). Lower-income POC are using TNCs for essential trip purposes, including commuting and accessing healthcare, groceries, and public transportation (Lazarus, et al., 2020). It is widely anticipated that vehicle automation and electrification may further enhance the affordability of shared on-demand services as well as reduce the negative environmental and safety impacts of road transportation in general (Greenblatt and Shaheen, 2015).

Pooling, in which multiple passengers traveling along similar paths are matched and transported in the same vehicle, has been projected to reduce the congestion and emissions impacts of shared automated vehicle (SAV) fleets (Viegas et al., 2016; WEF and BCG, 2018; Greenblatt and Shaheen, 2015; Greenblatt and Saxena, 2015). Yet prior to the COVID-19 pandemic, which spurred the suspension of many existing pooled on-demand ride services, the rate of pooled ride requests among users of the TNC services Lyft and Uber was relatively low, resulting in negligible impacts to overall vehicle occupancies (CARB, 2019; Schaller, 2018; Shaheen and Cohen, 2019). In 2018, only about 30 percent of TNC users surveyed across four metropolitan regions in California considered requesting a pooled ride more than half the time they used TNCs (Lazarus et al., 2021). Ultimately, the ability to fully leverage the potential societal benefits offered by the three revolutions in urban transportation (electrification, automation, and sharing) relies heavily on the ubiquity of individuals willing to pool rides as well as an equitable distribution of the benefits that innovative mobility offers.

This research investigates strategies to improve the mobility of low-income travelers by incentivizing the use of electric SAVs (SAEVs) and public transit. We employ two agent-based simulation engines, an activity-based travel demand model of the San Francisco Bay Area, and vehicle movement data from the San Francisco Bay Area and the Los Angeles Basin to model emergent travel behavior of commute trips in response to subsidies for TNCs and public transit. Sensitivity analysis was conducted to assess the impacts of different subsidy scenarios on mode choices, TNC pooling and match rates, vehicle occupancies, vehicle miles traveled (VMT), and TNC revenues. The scenarios varied in the determination of which travel modes and income levels were eligible to receive a subsidy of $1.25, $2.50, or $5.00 per ride. Four different mode-specific subsidies were investigated, including subsidies for 1) all TNC rides, 2) pooled TNC rides only, 3) all public transit rides, and 4) TNC rides to/from public transit only. Each of the four mode specific subsidies were applied in scenarios which subsidized travelers of all income levels, as well as scenarios that only subsidized low-income travelers (earning less than $50,000 annual household income). Simulations estimating wait times for TNC trips in both the San Francisco Bay Area and Los Angeles regions also revealed that wait times are distributed approximately equally across low- and high-income trip requests.

Subject Areas: Transportation network services; Low income; Affordability; Pooled ride; Shared automated vehicle; Activity-based travel demand model

Availability: Lazarus, J., Bauer, G., Greenblatt, J., and Shaheen, S. (2021). *Bridging the Income and Digital Divide with Shared Automated Electric Vehicles*. University of California, Berkeley, CA and Emerging Futures, Berkeley, CA. https://escholarship.org/uc/item/5f1359rd

12.13 Title: An Incentive Based Dynamic Ride-Sharing System for Smart Cities

Author(s): Bakibillah, A.S.M., Paw, Y.F., Kamal, M.A.S., Susilawati, S., and Tan, C.P.

Abstract: Connected and automated vehicle (CAV) technology, along with advanced traffic control systems, cannot ensure congestion-free traffic when the number of vehicles exceeds the road capacity. To address this problem, in this paper, we propose a dynamic ride-sharing system based on incentives (for both passengers and drivers) that incorporates travelers of similar routes and time schedules on short notice. The objective is to reduce the number of private vehicles on urban roads by utilizing the available seats properly. We develop a mobile-cloud architecture-based system that enables real-time ride-sharing. The effectiveness of the proposed system is evaluated through microscopic traffic simulation using Simulation of Urban Mobility (SUMO) considering the traffic flow behavior of a real smart city. Moreover, we develop a lab-scale experimental prototype in the form of Internet of Things (IoT) network. The simulation results show that the proposed system reduces fuel consumption, CO_2 and CO emissions, and average waiting time of vehicles significantly, while increasing the vehicle's average speed. Remarkably, it is found that only 2–10% ride-sharing can improve the overall traffic performance.

Subject Areas: Dynamic ride-sharing; Incentive; Traffic congestion; Smart city

Availability: Bakibillah, A.S.M., Paw, Y.F., Kamal, M.A.S., Susilawati, S., and Tan, C.P. (2021). "An Incentive Based Dynamic Ride-Sharing System for Smart Cities." *Smart Cities*, *4*(2), pp. 532–547. https://doi.org/10.3390/smartcities4020028

12.14 Title: Strategic Evacuation for Hurricanes and Regional Events with and without Autonomous Vehicles

Author(s): Lee, J. and Kockelman, K.M.

Abstract: A scheduling algorithm is developed for optimal planning of large-scale, complex evacuations to minimize total delay plus travel time across residents. The algorithm is applied to the eight-county Houston-Galveston region and land use setting under the 2017 Hurricane Harvey scenario with multiple destinations. Autonomous vehicle (AV) use under central guidance is also tested, to demonstrate the evacuation time benefits of AVs. Higher share of AVs delivers more efficient evacuation performance, thanks to greater reliability on evacuation order compliance, lower headways, and higher road capacity. Furthermore, 100% AV use delivers lower overall evacuation costs and network clearance times and less uncertainty in travel times (via lower standard deviation in). Based on evaluations of different evacuation schedules, a 50% compressed evacuation time span resulted in longer travel times and network congestion. A 50% longer evacuation time span reduced residents' total travel time and network congestion, but increased the evacuation cost. As expected, evacuation efficiency falls when evacuees do not comply with evacuation schedules. Large shares of AVs will not be possible in the near future, so methods to enhance evacuees' compliance behavior (e.g., enforced and prioritized evacuation orders) should be considered until a meaningful level of AV technical maturity and penetration rate is available. This paper demonstrates the benefits of scheduled departure times, AV use, and evacuation order compliance, which help balance conflicting objectives during emergencies.

Subject Areas: Scheduling algorithm; Evacuation; Autonomous vehicle

Availability: Lee, J. and Kockelman, K.M. (2021). "Strategic Evacuation for Hurricanes and Regional Events with and without Autonomous Vehicles." *Transportation Research Record: Journal of the Transportation Research Board*. https://doi.org/10.1177%2F03611981211007482

12.15 Title: Case Studies in Secure Contracting and Communication in Transportation Systems

Author(s): Lewis, A.N.

Abstract: Advancements in information and communication technologies have led to the proliferation of intelligent transportation systems (ITS). These systems leverage emerging technologies to address the challenges of traditional transportation systems. As the number of connected devices continues to increase, smart cities and communities are reliant on ITS as a part of their ecosystems. ITS are efficient and sustainable mobility systems that leverage emerging technologies to securely interact with other transportation systems and entities. This dissertation explores three case studies in privacy preserving contracting and communication among vehicles in transportation systems. The first case involves paratransit systems where we explore paratransit agency adoption of complementary ride-hailing services through secure contracting. The second case involves vehicular ad-hoc networks in which we analyze the communication and data exchange between vehicles in the network. In the last case, we introduce smart infrastructure in the analysis of ITS and traffic in smart city environments by modeling the shift in traffic behaviors through the use of dynamic traffic lights. The major contributions of this dissertation are in the analysis of the communication, security, and sustainability in the three case studies.

Subject Areas: Intelligent transportation systems; Privacy; Paratransit systems; Vehicular ad-hoc networks; Smart infrastructure; Dynamic traffic lights; Security; Sustainability

Availability: Lewis, A.N. (2021). *Case Studies in Secure Contracting and Communication in Transportation Systems*. Doctoral Dissertation, University of California, Irvine, CA. https://escholarship.org/content/qt26c366rk/qt26c366rk_noSplash_cdb6a4373b485ebf9a96ddfcac6ad63f.pdf

12.16 Title: Navigating School Zones: 5 Challenges for Deploying Automated Vehicles Near Schools

Author(s): Clamann, M. and Pullen-Seufert, N.

Abstract: The variability of conditions among school zones combined with a high density of traffic during peak times operating near pedestrians and bicyclists whose safety is paramount represents a complex operational design domain for automated driving systems (ADS). These characteristics represent safety challenges that should be addressed through technology, design, and regulatory approaches before ADS are deployed. However, these issues have not been comprehensively addressed to date, and to reach the full safety potential of ADS, their design will need to account for the complexity and uncertainty in and around school zones. The goal of this work was to address this gap and characterize the safety challenges to pedestrians that will need to be addressed before ADS can be deployed near schools. Building on an existing research framework, and interviews with school transportation experts, attributes of school transportation infrastructure were cross referenced against safety issues faced by pedestrians and automated vehicles to identify current challenges related to transportation within school zones. The themes that emerged from the results of the analysis consolidated around five challenge areas for schools and automated driving systems including levels of automation, operational design domain of schools, young students, school transportation stakeholders, and test strategies. Addressing these challenges areas now would lay a foundation to prepare for future ADS deployments and addressing some current challenges to pedestrian safety.

Subject Areas: Multiple discrete-grouped choice models; Multiple discrete outcomes; Linear outside good utility; Grouped consumption; Unobserved budgets; Utility theory; Time use; Consumer theory

Availability: Clamann, M. and Pullen-Seufert, N. (2021). *Navigating School Zones: 5 Challenges for Deploying Automated Vehicles Near Schools*. The National Academies of Sciences, Engineering, and Medicine, Washington, DC. https://trid.trb.org/view/1759783

12.17 Title: Travel in the Digital Age: Vehicle Ownership and Technology-Facilitated Accessibility

Author(s): Blumenberg, E., Paul, J., and Pierce, G.

Abstract: Despite their negative externalities, cars provide many benefits. Chief among these is the ability to travel to destinations within a reasonable time budget. Consequently, in the U.S. most households—even low-income households—own and use automobiles. But technological innovations may be altering this dynamic. New technology-facilitated services and activities may reduce the advantages of private vehicle ownership, potentially allowing households to live car-free or downsize their household vehicle fleets. In this study we use data from the 2017 U.S. National Household Travel Survey to investigate the relationship between these innovations and vehicle ownership. We find a positive relationship between the use of ridehail and carshare services and the likelihood of being a zero-vehicle household. The data also show a positive relationship between online shopping and working from home and the likelihood of having fewer household vehicles than adults. Combined, the findings suggest that new technology-facilitated activities may allow some households to eliminate or reduce their dependence on privately-owned vehicles. For other households, new technology-facilitated services may not directly affect their decisions about automobile ownership, but rather increase their access to opportunities while easing the financial burden of vehicle ownership. Agencies and organizations should explore opportunities to better connect households—particularly households with travel and financial constraints—to technology-facilitated services and activities that enable improved access.

Subject Areas: Online shopping; Automobile ownership; Ridehail; Carshare; Work from home

Availability: Blumenberg, E., Paul, J., and Pierce, G. (2021). "Travel in the Digital Age: Vehicle Ownership and Technology-Facilitated Accessibility." *Transport Policy*, *103*. https://doi.org/10.1016/j.tranpol.2021.01.014

12.18 Title: Best Frennemies? A Characterization of TNC And Transit Users Based on the 2017 NHTS

Author(s): Khatun, F. and Saphores, J.

Abstract: The emergence of on-demand ride services like Uber and Lyft has created new travel options but also new competition for taxis and transit. In spite of their popularity, relatively little is known about the characteristics of Uber and Lyft users because TNCs consider those data to be proprietary, which is unfortunate because this information would help understand recent trends in transit ridership. To characterize and contrast households who use public transportation (PT) and transportation network company (TNC) services, we analyze data from the 2017 National Household Travel Survey using a Cross nested logit (CNL) model at the household level to account for intra household travel dependencies. We segment NHTS households who have access to both TNCs and transit into four mutually exclusive categories based on the modes they used in the 30 days prior to their 2017 NHTS survey day: (1) households who took transit but not TNCs, (2) households who took TNCs but not transit, (3) those who took both; and (4) those who took neither. We found that households with Millennials and post-Millennials, those with a higher income, more education, no children, and fewer vehicles than driving license holders are more prone to using either TNCs (either with or without transit). Conversely, increasing the number of household members who are Baby Boomers or older, who have a lower income, a lower educational attainment, or more children, who own their home, or who have adult members with a medical condition are less likely to use TNCs.

Subject Areas: Transportation network companies; Cross nested logit model; Transit ridership

Availability: Khatun, F. and Saphores, J. (2021). *Best Frennemies? A Characterization of TNC And Transit Users Based on the 2017 NHTS*. Transportation Research Board 100th Annual Meeting—A Virtual Event, Washington, DC. https://annualmeeting.mytrb.org/OnlineProgram/Details/15685

12.19 Title: Impact of Autonomous Vehicle Technology on Long Distance Travel Behavior

Author(s): Maleki, M., Chan, Y., and Arani, M.

Abstract: Although rapid progress in-vehicle automated technology has sped up the possibility of using fully automated technology for public use, little research has been done on the possible influences of autonomous vehicles (AVs) technology on long-distance travel. This technology has the potential to have a significant effect on intercity trips. This study analyzed a travel survey to anticipate the impact of this technology on long-distance trips. We have divided trips into two different categories, including trips for pleasure and trips for business. Different hypotheses based on the authors' knowledge and assisted by existing literature have been defined for each type of trip. By using the Pearson method, these hypotheses have been tested and the positive or negative responses from respondents have been evaluated. The findings show that using AVs for pleasure trips can increase the number of travelers and stimulate people to choose longer distances for their trips. In addition, people enjoy more and will be interested to travel more frequently. For business trips, AV technology can reduce travel costs and job-related stress. Unlike pleasure trips for which people are not interested in traveling at night, business travelers prefer to travel at night.

Subject Areas: Long-distance trips; Autonomous vehicles; Travel behavior; Hypothesis; Pearson method

Availability: Maleki, M., Chan, Y., and Arani, M. (2021). *Impact of Autonomous Vehicle Technology on Long Distance Travel Behavior*. arXiv preprint, arXiv:2101.06097 [cs.CY]. https://arxiv.org/abs/2101.06097

12.20 Title: Spatial Variation in Shared Ride-hail Trip Demand and Factors Contributing to Sharing: Lessons From Chicago

Author(s): Dean, M.D. and Kockelman, K.M.

Abstract: As ride-hailing becomes more common in cities, public agencies increasingly seek transportation network company (TNC) service data to understand (and potentially regulate) demand and service response. Despite the increase in ride-hailing or TNC demand and subsequent research into its determinants, there remains little research on shared TNC trips and the spatial distribution of trip demand across demographic and land use variables. Using Chicago as a case study, shared TNC trip data from 2019 were used to estimate the count and ratio of shared ride services based on built environment, demographic, location, time of day, and trip details. Findings reveal that trip length, day of week designation, density of pedestrian and multi-modal infrastructure, and underlying socioeconomic characteristics of the origin zones influence the proportion and count of shared ride-hail trips. Of concern is that those using transit or active modes may be taking more ride-hailing trips, but these Chicago-region results indicate that the provision of pedestrian infrastructure and remoteness to transit stops result in fewer shared trips.

Subject Areas: Pooling; Shared ride-hailing; Spatial econometrics; Built environment

Availability: Dean, M.D. and Kockelman, K.M. (2021). "Spatial Variation in Shared Ride-hail Trip Demand and Factors Contributing to Sharing: Lessons From Chicago." *Journal of Transport Geography*, *91*. https://doi.org/10.1016/j.jtrangeo.2020.102944

12.21 Title: Does Ridesourcing Impact Driving Decisions: A Survey Weighted Regression Analysis

Author(s): Zou, Z. and Cirillo, C.

Abstract: The initial public offerings (IPOs) of Uber and Lyft in 2019 marked a milestone for the decade-old ridesourcing. As we start to embrace ridesourcing in our daily life, we also rearrange our daily travel amongst different modes of transportation. As the fundamental decisions in travel behavior, car ownership and car travel should be re-examined in the advent of shared mobility. In this paper, we applied a vehicle choice model that factors in ridesourcing frequency to understand the decisions about (1) how many cars an individual would declare as the primary driver of and (2) the annual vehicle miles traveled (VMT) for all cars he or she drive. We used a subsample of the latest 2017 National Household Travel Survey (NHTS) data that focus on the Capital region (Washington, DC–Maryland–Virginia) as our study area. We applied a weighted regression analysis following the NHTS survey design and derived population-representative results on both decisions. In addition, we calculated the driving cost for each household vehicle based on the latest fuel economy data and incorporated driving cost into the car travel model. The results suggest that ridesourcing is associated with a smaller chance of an individual being the primary driver of a car. However, the elasticity indicates that ridesourcing usage has a small impact on the number of primarily driven cars. Furthermore, ridesourcing has no significant impact on the annual VMT, either. Driving cost, on the other hand, still plays the key role in determining driving distances.

Subject Areas: Ridesourcing; Car ownership; VMT; Driving cost; NHTS; Survey weights

Availability: Zou, Z. and Cirillo, C. (2021). "Does Ridesourcing Impact Driving Decisions: A Survey Weighted Regression Analysis." *Transportation Research Part A: Policy and Practice*, *146*, pp. 1–12. https://doi.org/10.1016/j.tra.2021.02.006

12.22 Title: What Type of Infrastructures Do E-Scooter Riders Prefer? A Route Choice Model

Author(s): Zhang, W., Buehler, R., Broaddus, A., and Sweeney, T.

Abstract: e-scooter is an innovative travel mode that meets the demand of many travelers. A lack of understanding of user routing preferences makes it difficult for policymakers to adapt existing infrastructures to accommodate these emerging travel demands. This study develops an e-scooter route choice model to reveal riders' preferences for different types of transportation infrastructures, using revealed preferences data. The data were collected using Global Positioning System units installed on e-scooters operating on Virginia Tech's campus. We applied the Recursive Logit route choice model to 2000 randomly sampled e-scooter trajectories. The model results suggest e-scooter riders are willing to travel longer distances to ride in bikeways (59% longer), multi-use paths (29%), tertiary roads (15%), and one-way roads (21%). e-scooter users also prefer shorter and simpler routes. Finally, slope is not a determinant for e-scooter route choice, likely because e-scooters are powered by electricity.

Subject Areas: E-scooter; Route choice; Recursive logit; Revealed preference

Availability: Zhang, W., Buehler, R., Broaddus, A., and Sweeney, T. (2021). "What Type of Infrastructures Do E-Scooter Riders Prefer? A Route Choice Model." *Transportation Research Part D: Transport and Environment*, *94*. https://doi.org/10.1016/j.trd.2021.102761

12.23 Title: Changes in Travel Behavior, Attitudes, and Preferences among E-Scooter Riders and Nonriders: First Look at Results from Pre and Post E-Scooter System Launch Surveys at Virginia Tech

Author(s): Buehler, R., Broaddus, A., Sweeney, T., Zhang, W., White, E., and Mollenhauer, M.

Abstract: Shared micromobility such as electric scooters (e-scooters) has the potential to enhance the sustainability of urban transport by displacing car trips, providing more mobility options, and improving access to public transit. Most published studies on e-scooter ridership focus on cities and only capture data at one point in time. This study reports results from two cross-sectional surveys deployed before (n = 462) and after (n = 428) the launch of a fleet of shared e-scooters on Virginia Tech's campus in Blacksburg, VA. This allowed for a pre–post comparison of attitudes and preferences of e-scooter riders and nonusers. E-scooter ridership on campus followed patterns identified in other studies, with a greater share of younger riders, in particular undergraduate students. Stated intention to ride before system launch was greater than actual ridership. The drop-off between prelaunch intention to ride and actual riding was strongest for older age groups, women, and university staff. As in city surveys, the main reasons for riding e-scooters on campus were travel speed and fun of riding. About 30% indicated using e-scooters to ride to parking lots or to access public transport service, indicating their potential as a connector to other modes of transport. Perceptions about convenience, cost, safety, parking, rider behavior, and usefulness of the e-scooter systems were more positive among nonriders after system launch, indicating that pilot projects may improve public perceptions of e-scooters. Building more bike lanes or separate spaces for e-scooters could help move e-scooter riders off sidewalks—a desire expressed by both pedestrians and e-scooter users.

Subject Areas: Shared micromobility; Sustainability; Attitudes and preferences; E-scooter ridership

Availability: Buehler, R., Broaddus, A., Sweeney, T., Zhang, W., White, E., and Mollenhauer, M. (2021). "Changes in Travel Behavior, Attitudes, and Preferences among E-Scooter Riders and Nonriders: First Look at Results from Pre and Post E-Scooter System Launch Surveys at Virginia Tech." *Transportation Research Record: Journal of the Transportation Research Board*. https://doi.org/10.1177%2F03611981211002213

12.24 Title: Examining Municipal Guidelines for Users of Shared E-Scooters in the United States

Author(s): Ma, Q., Yang, H., Ma, Y., Yang, D., Hu, X., and Xie, K.

Abstract: The emergence of shared electric scooters (E-Scooters) has drawn the significant attention of local governments in many urban areas. Despite the fast growth in the number of trips, current guidelines for using E-Scooters have consistently experienced lags in development. Existing guidelines, in some cities, are rather vague and vary drastically across different areas. This paper aims to analyze current municipal requirements for the use of E-Scooters in the U.S., and to discuss more gaps for improvement. Specifically, E-Scooter user guidelines of 156 cities were explored. A multifaceted analysis was conducted to characterize the distinct features of E-Scooter user guidelines. A total of sixteen key attributes were identified and two categorizing procedures were implemented in the analysis. The comparative results show the completeness of information and similarities between cities. We conclude that municipalities should introduce more actionable guidelines driven by quantitative performance metrics.

Subject Areas: Electric scooters; Micro-mobility; User guidelines; Municipal policy; Sidewalk; Shared mobility

Availability: Ma, Q., Yang, H., Ma, Y., Yang, D., Hu, X., and Xie, K. (2021). "Examining Municipal Guidelines for Users of Shared E-Scooters in the United States." *Transportation Research Part D: Transport and Environment*, *92*. https://doi.org/10.1016/j.trd.2021.102710

12.25 Title: Urban Air Mobility: Factors Affecting Vertiport Capacity

Author(s): Rimjha, M. and Trani, A.

Abstract: This study aims at analyzing critical factors impacting vertiport capacity in urban areas. Urban Air Mobility (UAM) or Advanced Air Mobility (AAM) is a concept transportation mode being designed for intracity transport of passengers and cargo utilizing autonomous electric vehicles capable of Vertical Take-Off and Landing (VTOL) from dense and congested areas. The vertiports are expected to be placed on rooftops in Central Business Districts (CBD), limiting vertiports' size and suggesting high infrastructure costs. Therefore, vertiport capacity analysis is critical for an efficient UAM network as operations could be tailored for maximum efficiency. This analysis uses the vertiport designs developed for a previous study using current guidelines for heliports by Federal Aviation Administration (FAA). The minimum area of all designs was estimated for single and dual taxi-lanes configurations. From a preliminary geospatial analysis of San Francisco CBD, the rooftops' sizes are less likely to accommodate vertiports with more than three landing pads, even with tailored modifications. Therefore, this capacity analysis only considers vertiports with 1, 2, and 3 landing pads. A Discrete Event Simulation (DES) model is developed in MATLAB to simulate UAM operations and determine vertiport capacity. A high-demand vertiport in San Francisco Financial District is selected to understand the impact of unidirectional flows on a vertiport's passenger serving capacity. The analysis focuses on the utilization of various elements of vertiport, as they comprise the overall efficiency of the vertiport operations. Moreover, vertiport capacity sensitivity against elements such as the charging rate, service times at landing pads, and parking stalls are included in the findings.

Subject Areas: Schedules; Sensitivity; Navigation; Surveillance; Urban areas; Transportation; Federal Aviation Administration

Availability: Rimjha, M. and Trani, A. (2021). "Urban Air Mobility: Factors Affecting Vertiport Capacity." *2021 Integrated Communications Navigation and Surveillance Conference (ICNS)*, pp. 1–14. https://doi.org/10.1109/ICNS52807.2021.9441631

12.26 Title: Competition Among Traditional Modes, A Fully Autonomous Auto, and A Piloted Air Taxi for Commuting Trips in the U.S.

Author(s): Garrowmon, L.A., Roy, S., and Newman, J.P.

Abstract: This paper examines competition among a conventional auto, transit, a fully autonomous ground vehicle (AV), and a piloted air taxi for commute trips. A stated choice experiment with eight trade-off questions based on 1,405 individuals from five U.S. cities was conducted. Multinomial logit, nested logit, and panel mixed logit with random taste parameters models were used to predict mode choice. As part of the stated choice experiment, we examined the willingness of individuals to travel with strangers and found that individuals are more willing to travel with strangers in an air taxi than an AV. We also found that older individuals are more willing to travel with strangers than younger individuals in an AV. Values of time (VOTs) were estimated for each mode and revealed heterogeneity across respondents, with a non-trivial percentage having high VOTs. Conversely, 16.3 percent of respondents were not interested in the air taxi option and never chose this option. Our results highlight the need for those forecasting demand for an air taxi service to incorporate the percentage of the population that will likely never consider using an air taxi, as well as a distribution of VOT for those who will consider using this mode.

Subject Areas: Air taxi; Urban air mobility; Autonomous ground vehicles; Mode choice; Value of time; Air traveler behavior

Availability: Garrow, L.A., Roy, S., and Newman, J.P. (2020). *Competition Among Traditional Modes, A Fully Autonomous Auto, and A Piloted Air Taxi for Commuting Trips in the U.S.* Georgia Institute of Technology, Atlanta, GA. http://garrowlab.ce.gatech.edu/sites/default/files/20201015%20TR-C%20MNL%20Survey%202%20Combined.pdf

12.27 Title: The Flying Car: A Solution for Green Transportation

Author(s): Draghici, A., Ivascu, L., Mocan, A., and Robescu, D.

Abstract: Facing urban agglomeration, many local governments worldwide became active deploying green urban transport policies (GUTP). By doing so, their central objective is to curb CO_2 emissions and manage the latent tension between accessibility, mobility, and quality of life. In this paper, we briefly analyze the urban Europe state based on the available data from the report of 2019. Then there will be presented an inventory of the flying car existing models as innovative solutions developed based on electric cars to green the cities' transportation.

Subject Areas: Green transportation; Innovation; Urban transport policy; Airmobile; Flying car

Availability: Draghici, A., Ivascu, L., Mocan, A., and Robescu, D. (2021). "The Flying Car: A Solution for Green Transportation." *Advances in Smart Vehicular Technology, Transportation, Communication and Applications. Smart Innovation, Systems and Technologies*, *226*, pp. 145–158. https://doi.org/10.1007/978-981-16-1209-1_14

12.28 Title: Potential Crash Rate Benchmarks for Automated Vehicles

Author(s): Goodall, N.J.

Abstract: Most automobile manufacturers and several technology companies are testing automated vehicles (AVs) on public roads. While automation of the driving task is expected to reduce crashes, there is no consensus as to how safe an AV must be before it can be deployed. An AV should be at least as safe as the average driver, but national crash rates include drunk and distracted driving, meaning that an AV that crashes at the average rate is somewhere between drunk and sober. In this paper, safety benchmarks for AVs are explored from three perspectives. First, crash rates from naturalistic driving studies are used to determine the crash risk of the model (i.e., sober, rested, attentive, cautious) driver. Second, stated preference surveys in the literature are reviewed to estimate the AV risk acceptable to the public. Third, crash, injury, and fatality rates from other transportation modes are compared as baseline safety levels. A range of potential safety targets is presented as a guide for policymakers, regulators, and AV developers to assist in evaluating the safety of automated driving technologies for public use.

Subject Areas: Transportation network company; Shared mobility; Shared economy; Trip generation; Travel behavior; National Household Travel Survey (NHTS)

Availability: Goodall, N.J. (2021). "Potential Crash Rate Benchmarks for Automated Vehicles." *Transportation Research Record*, *2675*(10), pp. 31–40.
https://doi.org/10.1177%2F03611981211009878

12.29 Title: Evaluating Impact of Operational Limits by Estimating Potential UAM Trips in an Urban Area

Author(s): Maheshwari, A., Sells, B.E., Harrington, S., DeLaurentis, D., and Crossley, W.

Abstract: To realize the vision of large-scale urban air mobility (UAM) operations, it is important to understand and quantify the impact of various operational limits and their interdependence with potential new technologies. This paper builds upon the prior computational framework development to perform such analysis for two candidate metropolitan areas: Chicago and Dallas. As part of the larger study, various operational limits, including high operating cost, aerodrome throughput capacity, weather, surface congestion, etc., are analyzed. In this work, daily commute trips are generated for each metropolitan area (~6 million for Chicago and ~5 million for Dallas), along with the income information to estimate the number of UAM-preferred trips for various network sizes. A number of metro-level sensitivity studies for specific aerodrome infrastructure, operating cost scenarios, and ride-sharing are reported. A summary of key findings from various concurrent studies is also provided to assist the UAM community in realizing this new mode of transportation.

Subject Areas: Urban air mobility; Operational costs; Metro-level sensitivity; Aerodrome infrastructure; Seaplane base; Aircraft on ground; Instrument flight rules; Airspace; Helipad; Sensitivity analysis

Availability: Maheshwari, A., Sells, B.E., Harrington, S., DeLaurentis, D., and Crossley, W. (2021). *Evaluating Impact of Operational Limits by Estimating Potential UAM Trips in an Urban Area*. Session: Operational Aspects of On-demand Mobility and Transformational Flight I, American Institute of Aeronautics and Astronautics Aviation 2021. https://doi.org/10.2514/6.2021-3174

12.30 Title: Weather Impact Assessment for Urban Aerial Trips in Metropolitan Areas

Author(s): Chao, H., Maheshwari, A., DeLaurentis, D., and Crossley, W.

Abstract: Weather conditions in metropolitan areas influence urban aerial mobility (UAM) operations, passenger ride comfort, and the potential UAM market sizes. The success of UAM operations depends on reliable services under different urban weather conditions. However, the correlation between commuter travel patterns and daily weather patterns creates various impact levels. Hence, this study builds a UAM weather impact assessment module based on urban traveling traffic patterns and climatic conditions. The weather module can quantify the weather impact level, identify the most critical weather conditions, and help experts identify potential technology solutions. By taking the Chicago and Dallas regions as examples, the results show that the Chicago region is not preferable for UAM services (53 percent chance of unimpacted trips) in the winter than in the Dallas region (67 percent chance of unimpacted trips). The most severe weather phenomena are low temperature, snow, and low visibility in Chicago, whereas the "wind 15–20 knots" is the most common bad weather condition in both areas. Some existing technologies might mitigate the weather impacts; however, a more detailed analysis relies on the technical details of UAM vehicle designs.

Subject Areas: Urban air mobility; Weather impact; Weather conditions; Greedy algorithm; Ground based augmentation system; Local area augmentation system; Instrument landing system

Availability: Chao, H., Maheshwari, A., DeLaurentis, D., and Crossley, W. (2021). *Weather Impact Assessment for Urban Aerial Trips in Metropolitan Areas*. Session: Operational Aspects of On-demand Mobility and Transformational Flight II, American Institute of Aeronautics and Astronautics Aviation 2021. https://doi.org/10.2514/6.2021-3176

12.31 Title: Novel Hierarchical Markov Decision Process Framework to Enable Ridesharing in On-Demand Air Service Operations

Author(s): Maheshwari, A. and DeLaurentis, D.

Abstract: The convergence of various technological and operational solutions has reinstated the interest in on-demand air service as a viable mode of transportation. Industry, academia, and Government organizations are collaborating as part of NASA's Advanced Aerial Mobility National Campaign to create technology solutions suited for large-scale implementation of this new mode of transportation. Our prior studies suggest vehicle operating cost per passenger are one of the most important factors affecting the attractiveness of such service. In this paper, we propose a novel hierarchical Markov decision process framework that can bridge the gap between state-of-the-art reinforcement learning development and complex aviation scheduling problems. We specifically focus on enabling ride-sharing in ODAS operations, as that can help significantly offset the cost of ODAS operations per passenger. We demonstrate the functioning of the two layers through simple example problems and a case study for a hypothetical ODAS service, located in the Chicago metropolitan area.

Subject Areas: Urban air mobility; On-demand air service; Markov decision process; Reinforcement learning development; Chicago; Markov decision process; Charter flight

Availability: Maheshwari, A. and DeLaurentis, D. (2021). *Novel Hierarchical Markov Decision Process Framework to Enable Ridesharing in On-Demand Air Service Operations*. Session: Operational Aspects of On-demand Mobility and Transformational Flight I, American Institute of Aeronautics and Astronautics Aviation 2021. https://doi.org/10.2514/6.2021-3173

12.32 Title: Individual and Location-Based Characteristics Associated with Autonomous Vehicle Adoption in the Chicago Metropolitan Area: Implications for Public Health

Author(s): Losada-Rojas, L.L. and Gkritza, K.

Abstract: Introduction: Autonomous vehicles (AVs) could have profound effects on mobility, safety, and the build environment. In specific, AVs are expected to provide more mobility choices to the elderly and underserved areas, reduce traffic congestion and transportation costs, among others. The changes in built environment could result in a reduction in active travel and physical activity, which might lead to increases in non-communicable diseases (NCDs) and pose risks to public health.

Methodology: Using a combination of available secondary data and the responses of an online survey from adults' residents of the Chicago metropolitan statistical area, this study aims to enhance the understanding of the individual and location-based characteristics that might influence the levels of adoption of AVs. A market segmentation analysis was first conducted to classify respondents into five distinct AV adoption levels and identify common characteristics. Built environment and health-related characteristics, that surround the ZIP Codes where different levels of adopters reside, were also examined using an ordered probit model in order to understand the influence that AV adoption would have on the factors related to active travel.

Results: The ordered probit estimation results suggest that the level of adoption is associated with a combination of individual and location-based characteristics, some of which are related to active travel behavior. It was found that respondents in the high adopter categories are generally lacking opportunities for active travel and show high levels of NCD in the ZIP Codes where they reside.

Conclusions: AV implementation based only on the propensity to adoption might result in adverse health outcomes. Our results can inform planning strategies and health interventions so as to avoid a massive shift from active travel modes to AVs and mitigate any other adverse impacts on public health that this technology might bring.

Subject Areas: AV adoption; Active travel; Built environment; Public health; Online survey; Health outcomes

Availability: Losada-Rojas, L.L. and Gkritza, K. (2021). "Individual and Location-Based Characteristics Associated with Autonomous Vehicle Adoption in the Chicago Metropolitan Area: Implications for Public Health." *Journal of Transport & Health*, *22*. https://doi.org/10.1016/j.jth.2021.101232

12.33 Title: Universal Access to Autonomous Vehicle: Universal Access Principles/Guidelines/Examples to Robot Taxis

Author(s): Lee, S.

Abstract: According to the rapid progression of self-driving technologies, self-driving taxis are expected to be commercialized and narrow the social and economic isolation of people with disabilities by offering a new means of personal transportation. However, there is a lack of research on increasing informational and physical accessibility. Especially since there is no research or design project considering the unique journey and environment that the new transportation brings. So that self-driving taxis can widely be used as transportation for people with disabilities. This paper presents eight universal access principles (four principles each in two layers: digital and physical) and detailed examples describing the principles. The eight principles build on (1) existing literature studies mainly based on the prominent universal design principles from North Carolina State University and (2) robot-taxi journey analysis of users with three types of disabilities (wheelchair users, blindness, and limblessness). Moreover, I have repeatedly verified and co-designed examples of the eight principles through interviews with people with disabilities. This thesis facilitates discussion of how much universal accessibility of self-driving cars is necessary and essential and leads to more research and design.

Subject Areas: Design; Self-driving taxis; Universal access principles; People with disabilities

Availability: Lee, S. (2021). *Universal Access to Autonomous Vehicle: Universal Access Principles/Guidelines/Examples to Robot Taxis*. Master's Thesis, University of Washington, Seattle, WA. https://digital.lib.washington.edu/researchworks/handle/1773/47293

12.34 Title: Shared Autonomous Vehicles: User Expectations and Opportunities for Design

Author(s): Lee, M.

Abstract: With radical technological developments, we will soon experience self-driving mobility services of the future. Early autonomous vehicles were only able to recognize and handle some driving situations, but the continuous development of technology eliminated this boundary. Recent studies expect fully autonomous vehicles to be introduced as shared autonomous vehicles (SAVs), a shared-fleet service model. In addition, many researchers expect that using SAVs, which are a form of shared automation vehicles, will create socioeconomic benefits, such as preventing urban sprawl, improving safety, reducing emissions, and creating more free time. However, a recent study has shown that most current SAV models focus on optimizing systemwide operations rather than on the user side. The research related to this issue has expressed concern that technologies such as SAV could fail without considering user-side experience. As a result, research and development on the user side of SAV, which provides many socioeconomic benefits, is needed.

Therefore, this study aims to identify design opportunities that provide the best user experience in SAVs. In addition, suggested design opportunities aim to contribute to future SAV design by identifying design elements that encourage and support future users' in-vehicle activities. To find out user experience and needs in SAVs, I considered in-vehicle activities due to automation as an important user factor and considered mood as a way to support design approaches based on user needs. In this regard, considering that SAVs are likely to be operated in metropolitan areas, three major trip types of SAVs were selected through literature review: commute, business, and leisure. Then, experience prototyping and self-report measure design methods were applied to explore specific user experiences for selected trip types. Finally, based on the results of the first study, a designer workshop was conducted to find user-side design opportunities that encouraged future use of SAVs.

As a result, this study provides data on specific user experiences, such as in-vehicle activity, desired mood, and users' needs of future passengers, while at the same time providing four design opportunities to provide the best possible experience for SAV users. Furthermore, a visual example of applying four design opportunities to three main trip types through user data is also provided.

Subject Areas: Shared autonomous vehicle; User-side experience; Trip types; Experience prototyping; Self-report measure design

Availability: Lee, M. (2021). *Shared Autonomous Vehicles: User Expectations and Opportunities for Design*. Master's Thesis, Ulsan National Institute of Science and Technology, Ulsan, South Korea. https://scholarworks.unist.ac.kr/handle/201301/53773

12.35 Title: The Impacts of Vehicle Automation on Transport-Disadvantaged People

Author(s): Wu, X., Cao, J., and Douma, F.

Abstract: As an emerging technology, vehicle automation will have profound impacts on various aspects of society. Although recent studies have examined the impacts of the proliferation of vehicles with high/full-level automation, few have emphasized the implications for social equity. To better understand how autonomous vehicles (AVs) may influence equity, this study explores the potential influence of AVs on eight groups of transportation-disadvantaged people. Specifically, we synthesize prominent travel behaviors of the identified groups and explore possible impacts of AVs on these groups. We found that AVs tend to bring more benefits than harm to some people but may have mixed effects on others. Based on the findings, we provide policy recommendations for future policy decision making, which will likely play an essential role in maximizing AVs' benefits and mitigating their challenges.

Subject Areas: Autonomous vehicle; Driverless vehicle; Connected and automated vehicles; Equity; Transport disadvantage; Environmental justice

Availability: Wu, X., Cao, J., and Douma, F. (2021). "The Impacts of Vehicle Automation on Transport-Disadvantaged People." *Transportation Research Interdisciplinary Perspectives*, *11*. https://doi.org/10.1016/j.trip.2021.100447

12.36 Title: Supervision of a Self-Driving Vehicle Unmasks Latent Sleepiness Relative to Manually Controlled Driving

Author(s): Flynn-Evans, E.E. et al.

Abstract: Human error has been implicated as a causal factor in a large proportion of road accidents. Automated driving systems purport to mitigate this risk, but self-driving systems that allow a driver to entirely disengage from the driving task also require the driver to monitor the environment and take control when necessary. Given that sleep loss impairs monitoring performance and there is a high prevalence of sleep deficiency in modern society, we hypothesized that supervising a self-driving vehicle would unmask latent sleepiness compared to manually controlled driving among individuals following their typical sleep schedules. We found that participants felt sleepier, had more involuntary transitions to sleep, had slower reaction times and more attentional failures, and showed substantial modifications in brain synchronization during and following an autonomous drive compared to a manually controlled drive. Our findings suggest that the introduction of partial self-driving capabilities in vehicles has the potential to paradoxically increase accident risk.

Subject Areas: Self-Driving vehicle; Automated driving systems; Latent sleepiness; Accident risk

Availability: Flynn-Evans, E.E. et al. (2021). "Supervision of a Self-Driving Vehicle Unmasks Latent Sleepiness Relative to Manually Controlled Driving." *Scientific Reports*, *11*. https://doi.org/10.1038/s41598-021-92914-5

12.37 Title: Public Acceptance of Electric Roadways: The Case of Los Angeles, California

Author(s): Konstantinou, T., Gkartzonikas, C., and Gkritza, K.

Abstract: Dynamic charging has the potential to overcome the barriers to electric vehicle (EV) adoption by converting road segments into powered lanes (electric roadways, or ERs). This paper focuses on examining public acceptance by determining the factors that affect the short-term and long-term intention to purchase an EV and drive on ERs; identifying the clusters of the technology acceptance; and assessing the value of travel time savings (VTTS) for driving on ERs, in general and for different clusters. A survey was conducted in Los Angeles, CA, and distributed online, gathering 600 responses. The results showed that respondents' innovativeness, lifestyle, and environmental consciousness significantly affect the intention to drive on ERs in the short and long run. Public acceptance, in general, seems to be related to charging patterns, safety of commute route, and safety concerns for ERs, among other factors, and depends on the implementation time of the technology. Higher VTTS were found for electrified lanes exclusive for EVs on interstate and arterial roads. People who were classified as positive toward ERs had higher VTTS for ERs followed by those who were neutral and those who were concerned about ERs. This paper can help policymakers and transport operators devise strategies to accelerate EV adoption by appropriately implementing the ER technology.

Subject Areas: Electric vehicles; Electric roadways; Public acceptance; Intention to use; Value of travel time savings

Availability: Konstantinou, T., Gkartzonikas, C., and Gkritza, K. (2021). "Public Acceptance of Electric Roadways: The Case of Los Angeles, California." *International Journal of Sustainable Transportation*. https://doi.org/10.1080/15568318.2021.1983675

12.38 Title: Travel Time Impacts of Using Shared Automated Vehicles Along a Fixed-Route Transit Corridor

Author(s): Huang, Y. and Kockelman, K.M.

Abstract: Shared automated vehicles (SAVs) offering a fixed-route transit may compete well against privately operated vehicles. This paper analyzes the system costs of all travelers along a 6.4-kilometer (4-mile) corridor under different penetration rates for 10-seat SAVs. The work prices out walking, waiting, riding, and driving times for all travelers in the corridor, along with vehicle ownership, parking, and operating costs. Results show that such self-driving minibuses or SAVs lower total costs per passenger-kilometer traveled when SAV mode split exceeds 20 percent, even though walking and waiting are valued at relatively high cost. Such vehicles dramatically free up pavement (and parking) space and perform even better when parking costs at drivers' destinations are high.

Subject Areas: Transit corridor; Total system cost; Public transportation; Shared automated vehicles

Availability: Huang, Y. and Kockelman, K.M. (2021). "Travel Time Impacts of Using Shared Automated Vehicles Along a Fixed-Route Transit Corridor." *Transport Findings*. https://doi.org/10.32866/001c.29147

12.39 Title: From Forecasting to Scenario Planning: The Case of Autonomous Vehicles

Author(s): Bauranov, A.

Abstract: Efforts to forecast travel demand have led to the development of complex models which attempt to replicate human daily actions, choices, and movements. However, a growing body of literature suggests that the complexity of these models and their limited consideration of uncertainty have adversely affected their usefulness in the planning process. This dissertation argues that transportation planning should shift to methods that facilitate understanding and communication of uncertainty instead of relying on seemingly deterministic predictions of complex models. Two modeling paradigms—activity-based and scenario-based models—are analyzed to show how they handle uncertainty in the case of assessing the travel impacts of autonomous vehicles.

Three metropolitan areas, Seattle, San Francisco, and the Detroit region, are used as case studies to estimate the impacts of autonomous vehicles on total travel and accessibility. The results of the activity-based modeling indicate that the effects of autonomous vehicles are different in different regions, primarily due to the differences in income, density, and access to public transit. While vehicle miles increase in all three regions—17 percent in Seattle, 22 percent in the bay area, and 11 percent in Detroit—accessibility is highly dependent on the local context. The scenario-based model is not able to produce the results with this level of granularity. However, due to many unknowns associated with emerging technology, the scenario-based model proved to be better suited to incorporate various aspects of autonomous vehicles.

Beyond the estimates of travel impact, the results show that more informed planning can be achieved by moving away from deterministic forecasting and especially away from the urge to improve forecasting accuracy by building bigger models. Every piece of additional data and every additional parameter has an uncertainty cost that is compounded with the previous uncertainty costs. Instead, the modelers should aim to create more useful models by increasing the transparency of the modeling process and by reducing its complexity.

Subject Areas: Autonomous vehicle; Travel demand forecasting; Transportation planning; Scenario planning; Deterministic forecasting; Urban planning

Availability: Bauranov, A. (2021). *From Forecasting to Scenario Planning: The Case of Autonomous Vehicles*. Doctoral Dissertation, Harvard University, Cambridge, MA. https://dash.harvard.edu/handle/1/37370255?show=full

12.40 Title: Cooperation for Scalable Supervision of Autonomy in Mixed Traffic

Author(s): Hickert, C., Li, S., and Wu, C.

Abstract: Improvements in autonomy offer the potential for positive outcomes in a number of domains, yet guaranteeing their safe deployment is difficult. This work investigates how humans can intelligently supervise agents to achieve some level of safety even when performance guarantees are elusive. The motivating research question is: In safety-critical settings, can we avoid the need to have one human supervise one machine at all times? The paper formalizes this "scaling supervision" problem and investigates its application to the safety-critical context of autonomous vehicles (AVs) merging into traffic. It proposes a conservative, reachability-based method to reduce the burden on the AVs' human supervisors, which allows for the establishment of high-confidence upper bounds on the supervision requirements in this setting. Order statistics and traffic simulations with deep reinforcement learning show analytically and numerically that teaming of AVs enables supervision time sublinear in AV adoption. A key takeaway is that, despite present imperfections of AVs, supervision becomes more tractable as AVs are deployed en masse. While this work focuses on AVs, the scalable supervision framework is relevant to a broader array of autonomous control challenges.

Subject Areas: Scalable supervision; Intelligent transportation systems; Human factors and human-in-the-loop; Autonomous agents

Availability: Hickert, C., Li, S., and Wu, C. (2021). *Cooperation for Scalable Supervision of Autonomy in Mixed Traffic*. arXiv preprint, arXiv:2112.07569 [cs.LG].
https://arxiv.org/abs/2112.07569v1

12.41 Title: Market Diffusion of Autonomous Electric Vehicles and Charging Infrastructure

Author(s): Shah, S.

Abstract: The transportation sector is the largest contributor to greenhouse gas emissions in the United States, and autonomous electric vehicles (AEVs) can help to mitigate this problem. AEVs can also make travel more convenient and efficient. There are three important contributions in this research. First, this research estimates the diffusion of AEVs and forecasts the AEV market penetration in the United States and Texas by using Bass diffusion (BD) and generalized Bass diffusion (GBD) models. BD and GBD models are calibrated using historical sales data from similar products. Two external variables, charging station and tax, are incorporated in the GBD model. A sensitivity analysis assesses the impact of the variables on AEV adoption. The model results provide important insights for policymakers to prepare for AEV future. Second, potential increase in travel with AEV for the non-driving, elderly, and people with travel-restrictive medical conditions is estimated using NHTS 2017 data. Travelers' groups are created assuming each person within the above three groups will increase their miles traveled to a certain threshold. Study results indicate, for all three new travelers' groups, there will be an increase in travelers as well as in vehicle miles traveled in the United States. Third, the need for charging infrastructure based on future market penetration of AEVs in Texas has been estimated. Study assumed market size as 80 percent of Texan households and Bass parameters calibrated for the United States are valid for Texas. Under these assumptions, Texas's future AEVs market diffusion was forecasted, and using this market size, future charging infrastructure need for Texas was simulated using EVI-Pro Lite.

Subject Areas: Autonomous electric vehicles; Bass diffusion models; Charging station; Tax

Availability: Shah, S. (2021). *Market Diffusion of Autonomous Electric Vehicles and Charging Infrastructure*. Doctoral Dissertation, The University of Texas at San Antonio, San Antonio, TX. https://www.proquest.com/openview/44935265cd1bb45677541c15ff06cbc7/1?pq-origsite=gscholar&cbl=18750&diss=y