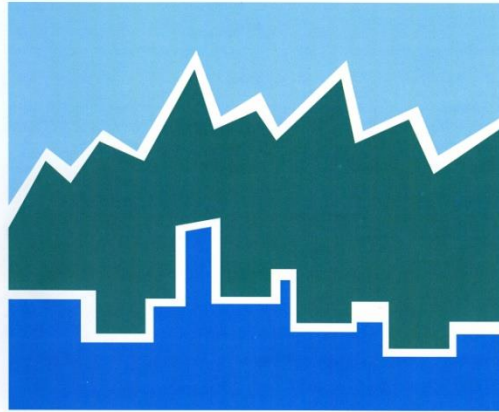# NATIONAL HOUSEHOLD TRAVEL SURVEY

Compendium of Uses

**January 2015 - December 2015**

**Introduction**

This compendium contains various uses and applications of the National Household Travel Survey (NHTS) data used in transportation planning and research from January 2015 to December 2015. Published journal articles and reports that cite the use of NHTS data were selected using the Transportation Research Board (TRB) Annual Meeting Online Portal http://amonline.trb.org/ and Google Alerts, notification emails sent by Google when new search results matched predetermined search terms pertaining to NHTS data. The key word and search engine terms used in both online sources were the **National Household Travel Survey** and **NHTS**.

The research papers were grouped into 11 categories that were created based on the **Subject Areas** and index terms identified in each abstract as well as category titles used in previous NHTS compendium databases. The categories are as follows:

1. Bicycle and Pedestrian Studies
2. Demographic Trends
3. Energy Consumption
4. Environment
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

A one-page description of each paper is provided which includes the **Title, Authors, Abstract, Subject Areas, and Availability.**

Research articles and reports in this document 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 American Journal of Public Health, the International Journal of Behavioral Nutrition and Physical Activity, and the National Center for Transit Research. Several papers were also submitted by researchers and graduate students for presentation and publication to the Transportation Research Board 94$^{st}$ Annual Meeting and can be found in the 2015 TRB Annual Meeting Compendium of Papers.

Please note that this 2015 compendium consists of approximately 379 research papers and articles. This document was updated on an on-going basis with newly published papers that cite NHTS data. For information about adding a research paper to the NHTS compendium, please contact Adella Santos at adella.santos@dot.gov.

Search and documentation support was provided Jasmy Methipara (MacroSys) who also categorized and formatted the paper abstracts.

# Table of Contents

# 1. Bike and Pedestrian Studies

**Investigating next generation's cycling ridership to promote sustainable mobility in different types of cities** *Maria Kamargianni*

**Abstract:** The aim of this paper is to develop a mode to school choice model to quantitatively evaluate the impact of various bicycle services and facilities on adolescents' mode choice behaviour. Stated preference (SP) scenarios specifically designed for this survey were used to elicit preferences for bicycle facilities and infrastructure, such as bike-lanes and bicycle parking places, and also for the availability of safety courses for school goers. The estimated mode choice model, which explicitly considers taste heterogeneity and panel effects, was tested with data collected in different types of cities (urban, rural and insular) of two different countries Greece and Cyprus, enabling comparisons in adolescents' travel behaviour across different geographical areas. The sample consisted of 9554 adolescent who yielded 20,432 SP responses for model estimation. Our results show that the prevalent factors affecting bicycle choice differ across different types of cities. Bad weather conditions affect the most the choice of bicycle in urban areas, while the most significant variable for rural areas is the percentage of cycleway coverage in the route between home and school. The availability of bicycle parking spaces at the schoolyard and the availability of school courses regarding how to walk and cycle with safety, also increased the bicycle utility in all five areas considered. Finally, three policy scenarios were tested to investigate modal split under various cycling policies.

**Subject Area:** Bicycle; Cycle lanes/ways; Cycling to school; Policies; Adolescents; Different types of cities; Sustainable mobility

# Health impact assessment of active transportation: A systematic review

*Natalie Mueller, David Rojas-Rueda, Tom Cole-Hunter, Audrey de Nazelle, Evi Dons, Regine Gerike, Thomas Götschi, Luc Int Panise, Sonja Kahlmeier, Mark Nieuwenhuijsen*

**Abstract:** Objective: Walking and cycling for transportation (i.e. active transportation, AT), provide substantial health benefits from increased physical activity (PA). However, risks of injury from exposure to motorized traffic and their emissions (i.e. air pollution) exist. The objective was to systematically review studies conducting health impact assessment (HIA) of a mode shift to AT on grounds of associated health benefits and risks. Methods: Systematic database searches of MEDLINE, Web of Science and Transportation Research International Documentation were performed by two independent researchers, augmented by bibliographic review, internet searches and expert consultation to identify peer-reviewed studies from inception to December 2014. Results: Thirty studies were included, originating predominantly from Europe, but also the United States, Australia and New Zealand. They compromised of mostly HIA approaches of comparative risk assessment and cost–benefit analysis. Estimated health benefit–risk or benefit–cost ratios of a mode shift to AT ranged between − 2 and 360 (median = 9). Effects of increased PA contributed the most to estimated health benefits, which strongly outweighed detrimental effects of traffic incidents and air pollution exposure on health. Conclusion: Despite different HIA methodologies being applied with distinctive assumptions on key parameters, AT can provide substantial net health benefits, irrespective of geographical context.

**Subject Area:** Active transportation; Air pollution; Health impact assessment; Mode shift; Physical activity; Traffic incident

**Demographic Factors And Workplace To Active Transportation Use In The United States: A Secondary Analysis Of 2009 NHTS Data** *Tyler David Quinn*

**Abstract:** Active transportation is defined by any transportation modality that requires human energy to perform. While the benefits of participating in active transportation are known, and are similar to that of regular exercise, participation rates within the United States are still very low. PURPOSE: To examine the relationships of demographic and workplace factors with active transportation use and active commuting within a United States population-based sample. METHODS: The 2009 National Household Travel Survey data was used to examine 6 demographic factors (age, gender, family income, education level, race, and household geographic location) as well as 5 workplace factors (time to work, distance to work, flextime availability, option to work from home, and work start time). The demographic factors were examined across active transportation use (walking, biking, or either) and active commuting (walking, biking, or either). The workplace factors were examined across active commuters (walking, biking, or either). Unadjusted frequencies, adjusted odds ratios, and adjusted prevalences were found for each factor. RESULTS: Increased odds of active commuting were seen in those with lower age, who were males, with lower income, who lived in an urban area, and who were more highly educated. Increased odds of active transportation use were seen in those who were of lower age, had lower income, were urban dwellers, had higher education, were male bikers, and were female walkers Odds of active commuting were increased with the availability of a flexible schedule, the option to work from home, a shorter time to work, a smaller distance to work, and a work arrival time between 11AM – 4PM. CONCLUSION: Mostly expected demographic factor relationships were found after adjustment for the other demographic factors. All workplace factors were found to be significantly related to active commuting behavior. These relationships should be considered and leveraged in governmental policy decisions, health promotion programming, workplace wellness programming, and workplace policy to possibly increase active transportation use within the United States.

**Subject Area:** active transportation; demographic factors

## Active Transportation by Transit-Dependent and Choice Riders and Potential Displacement of Leisure Physical Activity *Rodríguez, Joel*

**Abstract:** Public transit users are expected to have higher levels of active transportation (AT, walking and bicycling) because they often need to walk to and from transit. Surveys in Baltimore and Seattle (n = 1,622) revealed that transit users performed more AT than nonusers, especially when dependent on transit. Health benefits and impacts of their limited travel options are discussed. Choice transit riders, who use transit and have a car, and dependent transit riders, who are limited to transit use, are compared for differences in AT and leisure physical activity time (LPA). Less LPA is explored as a consequence of the additional AT.

**Subject Area:** automobile availability; lack of time; leisure; neighborhood; time use; walkability; walking

**Walkability Study for School Accessibility: Case Study of the San Juan, Puerto Rico Elementary Schools** *Rodríguez, Joel*

**Abstract:** Geographic Information Systems (GIS) mapping applications have proven to be an integral part in school site planning. However, most school site planning does not take walkability into account. This study describes a method to measure how walking access to schools was affected by the closure of elementary schools in the San Juan County. Recent studies in students walking to school in the US have found that there has been a major decrease overall (National Household Travel Society 2013). Using population density and dasymetric mapping, the number of students in each parcel in the San Juan School County was estimated. A walkability service area was derived from a network dataset using the functional classification of roadways from the Federal Highway Administration (FHWA). Accessibility was calculated ¼ miles away from the school using the service areas before and after school closure. It was determined that after school closure pedestrian accessibility and total distance walked to school did not change significantly. Network analysis represents a direct approach that assesses accessibility and physical barriers of the urban environment. Combining the walkability service area and the population per parcel, student accessibility was calculated. The use of this methodology will allow a better assessment for the school site planning and can be used to develop initiatives that will promote walking to and from school.

**Subject Area:** walkability; GIS; school site planning

**Understanding Spatiotemporal Patterns of Biking Behavior by Analyzing Massive Bike Sharing Data in Chicago** *Xiaolu Zhou*

**Abstract:** The growing number of bike sharing systems (BSS) in many cities largely facilitates biking for transportation and recreation. Most recent bike sharing systems produce time and location specific data, which enables the study of travel behavior and mobility of each individual. However, despite a rapid growth of interest, studies on massive bike sharing data and the underneath travel pattern are still limited. Few studies have explored and visualized spatiotemporal patterns of bike sharing behavior using flow clustering, nor examined the station functional profiles based on over-demand patterns. This study investigated the spatiotemporal biking pattern in Chicago by analyzing massive BSS data from July to December in 2013 and 2014. The BSS in Chicago gained more popularity. About 15.9% more people subscribed to this service. Specifically, we constructed bike flow similarity graph and used fastgreedy algorithm to detect spatial communities of biking flows. By using the proposed methods, we discovered unique travel patterns on weekdays and weekends as well as different travel trends for customers and subscribers from the noisy massive amount data. In addition, we also examined the temporal demands for bikes and docks using hierarchical clustering method. Results demonstrated the modeled over-demand patterns in Chicago. This study contributes to offer better knowledge of biking flow patterns, which was difficult to obtain using traditional methods. Given the trend of increasing popularity of the BSS and data openness in different cities, methods used in this study can extend to examine the biking patterns and BSS functionality in different cities.

**Subject Area:** bike share, land use, recreation, behavior, transportation infrastructure, neighborhoods

# Bicycle-pedestrian grants awarded in the Rutland Region *Mountain Times*

**Abstract:** On Sept. 24, the Vermont Agency of Transportation (VTrans) announced awards through the Bicycle and Pedestrian Program to five Rutland County towns for infrastructure projects to facilitate bicycle and foot travel.

**Subject Area:** bicycle injury; fatality

## Using Webcams and Crowds to Study Active Transportation *J. Aaron Hipp, Alicia Manteiga, Amanda Burgess, Abby Stylaniou, and Robert Pless*

**Abstract:** Active transportation opportunities and infrastructure are an important component of a community's design, livability, and health. Features of the built environment influence active transportation, but objective study of the effects of built environment improvements on active transportation is challenging. Outdoor temperature is known to be a common barrier to active transportation, yet there is limited information examining the interaction between temperature, built environment improvements, and active transportation. In this case study, 20,529 publicly available webcam images from two intersections in Washington, D.C., were used to examine the impact of an improved crosswalk on active transportation. A crowdsource, Amazon Mechanical Turk, analyzed image data. Temperature data was collected from the National Oceanic and Atmospheric Administration. Summary analyses demonstrated slight, bi-directional differences in the number of images with pedestrians and bicycles captured before and after the enhancement of the crosswalks. Chi-square analyses revealed these changes were not significant. In general, pedestrian presence increased in images captured during moderate temperatures compared to images captured during hot or cold temperatures. Chi-square analyses of one intersection indicated the crosswalk improvement may have encouraged walking in more uncomfortable outdoor temperatures. The methods employed provide an objective, cost-effective alternative to traditional means of examining the effects of built environment changes on active transportation. The use of webcams to collect active transportation data has applications for community policymakers, planners, and health professionals. Future research should work to validate this method in a variety of settings as well as across different built environment and community policy initiatives.

**Subject Area:** bicycle injury; fatality

## As More Adults Pedal, Their Biking Injuries And Deaths Spike, Too *NPR*

**Abstract:** More adults across the country are strapping on helmets and hopping on bikes to get to work. That's good news for people's hearts and waistlines, but it also means more visits to the emergency room.

Hospital admissions because of bike injuries more than doubled between 1998 and 2013, doctors reported Tuesday in JAMA, the journal of the American Medical Association. And the rise was the biggest with bikers ages 45 and over.

**Subject Area:** bicycle injury; fatality

**Availability:** NPR Morning Edition September 3, 2015. "As more adults pedal, their biking injuries and deaths spike, too" http://www.npr.org/sections/health-shots/2015/09/02/436662737/as-more-adults-pedal-their-biking-injuries-and-deaths-are-spiking-too

**Share the road**  *Rutland Herald Opinion/Commentary*

**Abstract:** The deaths of three bikers in Vermont this year in collisions with drivers has raised the profile of biker safety.  While biking is not necessarily a year-round commuting option in Vermont, due to the cold and snow, the demand and the growth in users means we need to adjust how we plan for our transportation future.

**Subject Area:** bicycle injury; fatality

**Availability:** Rutland Herald September 28, 2015. "Share the Road"
http://www.rutlandherald.com/article/20150928/OPINION04/709289991

# Cycling 101 Needn't Be Collision Course *The New York Times*

**Abstract:** Cycling as recreation, sport and transport has exploded in recent years, with continued growth likely as more locales install bike lanes and bike-share programs. But as you might expect, with that growth has come an increase in bike-related injuries.

**Subject Area:** cycling

# Do characteristics of walkable environments support bicycling? Toward a definition of bicycle-supported development *Christopher D. Muhs & Kelly J. Clifton*

**Abstract:** Does walkability equate with bikeability? Through a comprehensive review of studies of the built environment and bicycling, including mode choice, route choice, safety, and urban design literature, this paper addresses this question. Previous work has raised the issue that the two modes are functionally different, despite them often being combined into a nonmotorized category, and has highlighted research challenges. Existing studies of bikeability have largely focused on infrastructure. This paper contributes to the literature on bicycling and the built environment by providing a thorough review of past research with a focus on the relationships between land use, urban form, and bicycling. Highly walkable and highly bikeable environments are quite different, and there is little consistency in the built-environment attributes associated with cycling across studies. We postulate that this inconsistency is due in part to a disconnect between theory and methods of measuring the environment for cycling along with data limitations, including sample sizes and our understanding being based mainly on cross-sectional data. Many research opportunities are present for land-use planning policies now that planning for cycling is a top priority for cities and regions across the world.

**Subject Area:** bikeability

## Changing Perceptions Of Cycling In The African American Community To Encourage Participation In A Sport That Promotes Health In Adults *Adriana Torcat, Talia McCray, and Teri Durden*

**Abstract:** This study introduces two interventions designed to influence perceptions of cycling among African Americans. Results from the 2001 National Household Transportation Survey reveal that African Americans cycle at two-thirds the rate of White and Hispanic Americans (Pucher and Renne, 2003). Moreover, African Americans are less likely to possess alternative transportation modes like a bicycle (Royal and Miller-Steiger, 2008). Researchers suggest that cycling disparities are linked to negative perceptions among inexperienced cyclists and non-cyclists –including African Americans (McCray et al, 2010). An important consideration in analyzing why African Americans generally do not cycle is that of perception. The purpose of this study is to address negative perceptions of cycling that inhibit bicycle use, including a lack of experience, knowledge, and safety. Few studies exist that explore race or ethnic-specific reasons for low levels of physical activity and this information is needed to increase physical activity among minority groups (Rogers, et al. 2007). By examining perceptions of cycling among African Americans, this study builds on existing literature and fills a significant void in addressing the lack of bicycle ridership in the African-American community.

**Subject Area:** Cycling, African American, Intervention, Safety-Training, Analysis of Means, AOM, Exploratory Factor Analysis, EFA

**Happy Wanderer: Biking, beers highlights of Coastal Rail Trail** *Ginny Prior*

**Abstract:** n/a

**Subject Area:** bicycle, leisure

**Routledge Handbook of Transportation. Chapter 9 Pedestrian Transportation."** *Christopher Monsere, Nick Foster, Todd Borkowitz, Sirisha Kothuri, Matthew Downey and Robert Bertini*

**Abstract:** In many locations, streets have been designed and operated primarily for use by motor vehicles. In many urban areas, however, it is becoming more common for streets to be viewed as significant public places. Bicycling, walking and other human-powered forms of travel- commonly referred to as active transportation are gaining increased design attention for their associated economic, environmental and health benefits. New designs are being applied that modify streets to better meet the mobility needs of all users, and to be safer, more sustainable, resilient, multimodal and economically beneficial. Active transportation facilities that focus on moving people have a key role to play in this transformation. This Chapter provides an overview of the design assumptions and considerations for pedestrian facilities. Following a brief review of safety trends and discussion of general design philosophy, the chapter presents design inputs (dimensions and performance and an overview of typical facilities for pedestrians. The design review includes operations, primarily at signalized intersections. The chapter primarily references US-based design standards and documents.

**Subject Area:** pedestrian facility design

**Spatial variation in local road pedestrian and bicycle crashes."** *Musinguzi, Abram, and Deo Chimba*

**Abstract:** Pedestrians and bicyclists use different roadways varied along socioeconomic and demographic factors which make them vulnerable to crashes. This paper conducts cluster analysis in GIS to verify the spatial variation of pedestrian and bicycle crashes with respect to socioeconomic and demographics in Tennessee. By understanding which factors are particularly significant to these groups, planning, design and safety improvements can be identified to address these non-motorized trip safety concerns

**Subject Area:** bicycle and pedestrian crash; safety concerns

# Active Transportation Surveillance — United States, 1999–2012 , MPH;

*Geoffrey P. Whitfield, PhD; Prabasaj Paul, PhD & Arthur Wendel, MD*

**Abstract:** Five surveillance systems assess one or more components of active transportation. The American Community Survey and the National Household Travel Survey (NHTS) both assess the mode of transportation to work in the past week. From these systems, the proportion of respondents who reported walking or bicycling to work can be calculated. NHTS and the American Time Use Survey include 1-day assessments of trips or activities. With that information, the proportion of respondents who report any walking or bicycling for transportation can be calculated. The National Health and Nutrition Examination Survey and the National Health Interview Survey both assess recent (i.e., in the past week or past month) habitual physical activity behaviors, including those performed during active travel. From these systems, the proportion of respondents who report any recent habitual active transportation can be calculated.

**Subject Area:** physical activity; active transportation

# Exploring thresholds of built environment characteristics for walkable communities: Empirical evidence from the Seoul Metropolitan area *Hyn-Joo Eom & Gi-Hyoug Cho*

**Abstract:** Numerous studies have shown that dense, well-connected, and diverse environments are key features that promote walking. Accepting these finding as true, we hypothesized that decreasing marginal effects may occur in the associations between the built environments and walking. The purpose of this study was as follows: (1) to empirically test whether a non-linear relationship between the two exists, and (2) to identify the threshold of the built environment characteristics that promote walking. Using the 2012 Seoul Metropolitan Household Travel Survey, this study analyzed 411,899 individuals' travel behaviors and their neighborhood environments. We calculated the population and street densities, and the Herfindahl–Hirschman Indexes (HHI) of 1107 administrative units located within the study area.

The results of multilevel logit and linear models showed that these built environment characteristics had a non-linear relationship with the occurrence and duration of walking. The positive association with taking walking trips and negative association with taking private vehicle trips were greatly reduced where gross density reaches beyond 9132–16,101 persons/km2. The positive influence of land-use mixture and street connectivity also showed that the marginal number and duration of walking indicated a sharp decline at a certain intensity of those characteristics.

The findings of the study imply that thresholds of density, street connectivity, and land-use mixture levels that promote walking may exist within the existing context of the study area. We hope that the findings of our study provide useful guidelines for those attempting to developing walkable communities by modifying the characteristics of the built environment.

**Subject Area:** Built environment; Walking; Threshold

## Bicyclist Deaths Associated with Motor Vehicle Traffic — United States, 1975–2012

*Jason Vargo, PhD; Benjamin G. Gerhardstein, MPH; Geoffrey P. Whitfield, PhD; & Arthur Wendel, MD*

**Abstract:** Physical activity, including bicycling, is linked with multiple health benefits (1). However, although bicycles account for only about 1% of trips across all modes of transportation, on a per trip basis, bicyclists die on U.S. roads at a rate double that of vehicle occupants (2). In 2009, an estimated 392 billion trips (across all modes) were taken in the United States, including 4.1 billion bicycle trips, and 33,808 deaths occurred on U.S roadways (across all modes), including 630 bicyclist deaths (3–5). This report examines mortality trends among cyclists using national collision data from the Fatality Analysis Reporting System (FARS) for the period 1975–2012. Annual rates for cyclist mortality decreased 44%, from 0.41 to 0.23 deaths per 100,000 during this period, with the steepest decline among children aged <15 years. In recent years, reductions in cyclist deaths have slowed. However, age-specific cyclist mortality rates for adults aged 35–74 years have increased since 1975. Multifaceted approaches to bicyclist safety have been shown to be effective in increasing bicycling while decreasing traffic injuries and fatalities (1). With U.S. adults choosing to walk and cycle more, implementation of these approaches might help counter recent increases in adult cyclist deaths.

# Non-Motorized Travel: Analysis of the 2009 NHTS California Travel Survey Add-On Data Estimating Total Miles Walked and Biked by Census Tract in California *Susan Handy & Deborah Salon*

**Abstract:** Walking and bicycling as modes of transportation – traditionally called non-motorized transportation or more recently labeled active travel – offer many benefits from a health standpoint, in addition to economic, environmental, and equity benefits. Yet they represent a small share of all travel in the U.S., which is less than 10% of all trips as of 2008. Although many factors explain this situation, significantly higher levels of walking and bicycling in other developed countries, including Denmark (26%), Germany (32%) and the Netherlands (47%), as well as higher levels of bicycling within some communities in the U.S., suggest that policy changes could bring a significant increase in the use of nonmotorized modes. Understanding patterns of non-motorized travel and the factors that influence them, both the quality of the environment and the characteristics of individuals, is critical for designing effective policies to promote non-motorized travel. The objective of this project was to improve our understanding of non-motorized travel in California and the factors that influence that travel.
To achieve this objective, the research team analyzed data from the National Household Travel Survey (NHTS), focusing on the Calif. Addon data. Descriptive results showed who is walking and bicycling, how much, and for what purposes. Modeling results identified key factors associated with walking and bicycling, including environmental characteristics and individual characteristics. The results helped practitioners in their efforts to develop effective policies to increase non-motorized travel. The project produced four detailed research reports and an executive summary describing results and their relevance for policy makers.

**Subject Area:** Walking, bicycling, travel survey, non-motorized

## Residential Density and Walk Access to Urban Rail *Zoe Roller and Sherman Lewis*

**Abstract:** Data from BART, Google maps, and block group census show that riders walking to BART stations from home on average walk a little over half a mile to a station. There is no correlation between residential density and walk access in the sixteen high-walk access stations studied, but when certain downtown stations were removed, there is a strong correlation. The reason seems to be that downtown stations with low walk to transit resulted from people not needing to take BART to work; many are close enough to walk. Planners typically use half-mile for planning transit orientation. However, since roughly 84 percent of walk access is up to 0.89 miles, planners should consider longer walks, along with other design and economic incentive to shift travel mode.

**Subject Area:** Agent-based model; Utilitarian walking; Travel costs; Spatial segregation; Socioeconomic disparities; Behavior feedback

**Availability:** TBD

**Plans for pavement or for people? The politics of bike lanes on the 'Paseo Boricua' in Chicago, Illinois** *Amy Lubitow, Bryan Zinschlag , &bNathan Rochester*

**Abstract:** Over the course of the past two decades, bicycling has become increasingly popular in the USA. Although the rate of bike trips made in the USA has more than tripled since 1977, it is relatively low compared with many European cities (Pucher et al., 2011a). In urban areas throughout the USA, bicycling is increasingly being touted as an environmentally friendly way to enhance transit choice as public transportation budgets are slashed and automobile infrastructures remain congested. Discourse around the proliferation of bicycling infrastructure development in American cities often obscures complex aspects of community-level choice regarding transit, including the placement and implementation of bike lanes.

This paper seeks to explore the dynamic ways that community members and city planners make sense of bike infrastructure development in Chicago, Illinois. Qualitative interviews and participant observation were employed to clarify the community context of bike lane development in a gentrifying area of the city. We find that community engagement is a critical component of promoting the acceptance and use of bike infrastructure and discuss the role of a community bike shop in facilitating community engagement around bicycling in the neighbourhood of Humboldt Park, home to the second largest Puerto Rican community in the USA.

**Subject Area:** bicycling infrastructure, Chicago, city bureaucracy, community,  grassroots organization,  race,  transport

## The Walking Renaissance: A Longitudinal Analysis of Walking Travel in the Greater Los Angeles Area, USA

*Kenneth Joh , Sandip Chakrabarti, Marlon G. Boarnet and Ayoung Woo*

**Abstract:** Promoting walking travel is considered important for reducing automobile use and improving public health. Recent U.S. transportation policy has incentivized investments in alternative, more sustainable transportation modes such as walking, bicycling and transit in auto-oriented cities such as Los Angeles. Although many past studies have analyzed changes in walking travel across the U.S., there is little clarity on the drivers of change. We address this gap by conducting a longitudinal analysis of walking travel in the greater Los Angeles area from 2001 to 2009. We use travel diary and household data from regional and national surveys to analyze changes in walking trip shares and rates across our study area. Results show that walking has significantly increased across most of Los Angeles, and that increases in walking trips generally correspond with increases in population, employment, and transit service densities. Estimates from fixed-effects regression analysis generally suggest a positive association between population density and walking, and that higher increases in transit stop density are correlated with increased walking trips to and from transit stops. These findings illustrate how regional planning efforts to pursue a coordinated land use-transit planning strategy can help promote walking in auto-oriented or vehicle adopting cities.

**Factors that Influences Pedestrian Intention to Cross a Road While using Mobile Phone** *Hanan, Suhaila Abdul, Noor Fadhilah Said, Aida Amelia Mohd Kamel, and Siti Azwin Farhana Che Amil.*

**Abstract:** Road accident has been identified as a cause of injury and death around the world including Malaysia. Among those who were killed and injured are pedestrian. There were few studies investigated the cause of the accident that involved the pedestrian in the other country. However, in Malaysia, as far as road safety and pedestrian is concerned, the research still at an early stage. The theory of planned behavior (TPB) has been utilized widely in all research areas including road safety and pedestrian. Thus, this theory was used to understand the psychosocial factors that influence pedestrian intentional behavior. In particular, this paper examined the extent to which the TPB influenced pedestrian intention to cross a road while using mobile phone. This research utilized quantitative approach, that is a survey (n = 107). The result indicated that subjective norm (SN) and perceived behavioral control (PBC) significantly influenced intention to cross a road when using mobile phone. Thus, based on the result, it was suggested that the safety awareness campaign and education should focus on SN and PBC e.g., Pedestrian Awareness Day.

## Modeling Factors Influencing Commuter Cycling Routes: A Study of GPS Cycling Records in Auburn, Alabama *Michale Alexander Moore*

**Abstract:** Road accident has been identified as a cause of injury and death around the world including Malaysia. Among those who were killed and injured are pedestrian. There were few studies investigated the cause of the accident that involved the pedestrian in the other country. However, in Malaysia, as far as road safety and pedestrian is concerned, the research still at an early stage. The theory of planned behavior (TPB) has been utilized widely in all research areas including road safety and pedestrian. Thus, this theory was used to understand the psychosocial factors that influence pedestrian intentional behavior. In particular, this paper examined the extent to which the TPB influenced pedestrian intention to cross a road while using mobile phone. This research utilized quantitative approach, that is a survey (n = 107). The result indicated that subjective norm (SN) and perceived behavioral control (PBC) significantly influenced intention to cross a road when using mobile phone. Thus, based on the result, it was suggested that the safety awareness campaign and education should focus on SN and PBC e.g., Pedestrian Awareness Day.

**Subject Area:** cycling routes, GPS, Malaysia, TPB, safety, pedestrian

## Prevalence of Dog Walking and Sociodemographic Characteristics of Dog Walkers in the U. S.: An Update from 2001 *Richards, Elizabeth A*

**Abstract:** Objectives: To describe and estimate the prevalence of dog walking using a nationwide sample. Methods: 2009 National Household Travel Survey data (N = 5100) were analyzed for: duration of dog walks, number of dog walks/day, total dog walking minutes/day. Results: In a one-day period, 67% of dog walkers took at least one walk ≥10 minutes, 20% walked a dog for at least 30 minutes, and 28% took more than one dog walk. Older participants and participants with children were more likely to accumulate ≥ 30 minutes of dog walking in a one-day period. Conclusions: A majority of dog walks occurred in bouts ≥ 10 minutes, suggesting dog walking is a legitimate form of health-enhancing physical activity which contributes to meeting physical activity guidelines.

**Subject Area:** Pets; Physical Activity; Walking

# Distracted walking: Examining the extent to pedestrian safety problems
*Mwakalonge, Judith, Saidi Siuhi, and Jamario White*

**Abstract:** Pedestrians, much like drivers, have always been engaged in multi-tasking like using hand-held devices, listening to music, snacking, or reading while walking. The effects are similar to those experienced by distracted drivers. However, distracted walking has not received similar policies and effective interventions as distracted driving to improve pedestrian safety. This study reviewed the state-of-practice on policies, campaigns, available data, identified research needs, and opportunities pertaining to distracted walking. A comprehensive review of literature revealed that some of the agencies/organizations disseminate useful information about certain distracting activities that pedestrians should avoid while walking to improve their safety. Various walking safety rules/tips have been given, such as not wearing headphones or talking on a cell phone while crossing a street, keeping the volume down, hanging up the phone while walking, being aware of traffic, and avoiding distractions like walking with texting. The majority of the past observational-based and experimental-based studies reviewed in this study on distracted walking is in agreement that there is a positive correlation between distraction and unsafe walking behavior. However, limitations of the existing crash data suggest that distracted walking may not be a severe threat to the public health. Current pedestrian crash data provide insufficient information for researchers to examine the extent to which distracted walking causes and/or contributes to actual pedestrian safety problems.

## PeopleForBikes: Much of what we thought we knew about women and bikes was wrong *Brian -staff*

**Abstract:** PeopleForBikes says new analysis of its research into American bicycling shows that many assumptions about women and bikes are wrong. The study of women and bicycling used data from PFP's participation study, released earlier this year. Regarding women and cycling, the study showed that 45 million American women rode a bike outsides at least once last year, compared to 59 million men. The gender gap was considerably smaller than that shown by other studies; for example, the 2009 National Household Travel Survey found that just 24 percent of bicycle trips were made by women.

**Subject Area:** bicycle, women

**Availability:** [www.bicycleretailer.com](www.bicycleretailer.com)  *PeopleForBikes: Much of what we thought we knew about women and bikes was wrong* Brian –staff; May 28, 2015
http://www.bicycleretailer.com/studies-reports/2015/05/28/peopleforbikes-much-what-we-thought-we-knew-about-women-and-bikes-was

# Energy Flux and its Role in Obesity and Metabolic Disease *Gregory Hand and Steven N. Blair*

**Abstract:** In order to reverse the global obesity pandemic, there is a need for an enhanced understanding of the energy dynamics that underlie the problem. To maintain a stable body weight, energy intake must, over time, match or equal energy expenditure, a concept known as energy balance. Obesity results from a positive state of energy balance (i.e. when energy intake exceeds energy expenditure). However, recent research suggests that strategies to combat obesity should focus on energy flux (the amount of calories going through a system), rather than energy balance alone. In other words, it is easier to maintain weight loss at higher levels of physical activity. Recent findings suggest that a high energy flux, maintained by increasing energy expenditure, can improve an individual's metabolic profile without changing weight. Further understanding of this concept may help in the design of interventions to achieve and maintain a healthy weight.

**Subject Area:** Energy balance, energy flux, obesity, metabolic disease

**Analysing bicycle-sharing system user destination choice preferences: Chicago's Divvy system** *Ahmadreza Faghih-Imania & Naveen Eluru*

**Abstract:** In recent years, there has been increasing attention on bicycle-sharing systems (BSS) as a viable and sustainable mode of transportation for short trips. However, due to the relatively recent adoption of BSS, there is very little research exploring how people consider these systems within existing transportation options. Given recent BSS growth around the world, there is substantial interest in identifying contributing factors that encourage individuals to use these systems. The current study contributes to this growing literature by examining BSS behavior at the trip level to analyze bicyclists' destination preferences. Specifically, we study the decision process involved in identifying destination locations after picking up a bicycle at a BSS station, using a random utility maximization approach in the form of a multinomial logit model (MNL). The quantitative frameworks developed have been estimated using 2013 data from the Chicago's Divvy system. In our modeling effort, we distinguish between BSS users with annual membership and short-term customers with daily passes. The developed model should allow bicycle-sharing system operators to plan services more effectively by examining the impact of travel distance, land use, built environment, and access to public transportation infrastructure on users' destination preferences. Using the estimated model, we generated utility profiles as a function of distance and various other attributes, allowing us to represent visually the trade-offs that individuals make in the decision process. To illustrate further the applicability of the proposed framework for planning purposes, destination station-choice probability prediction is undertaken.

**Subject Area:** Bicycle sharing systems; Divvy Chicago; Destination choice; Location choice; Multinomial logit model; Bicycle infrastructure

**Albert Lea shows how walking and other healthy habits can rejuvenate a rural community** *Jay Walljasper*

**Abstract:** Albert Lea, MN is working to prove that healthy lifestyles like walking and good nutrition are not just big city things.

**Subject Area:** walking, small town

**Availability:** [www.Minnpost.com](www.Minnpost.com) *Albert Lea shows how walking and other healthy habits can rejuvenate a rural community* May 22, 2015 Jay Walljasper
https://www.minnpost.com/health/2015/05/albert-lea-shows-how-walking-and-other-healthy-habits-can-rejuvenate-rural-community

# What is Causing the Worldwide Rise in Body Weight? *Robin P Shook, Steven N Blair, John Duperly, Gregory A Hand, Sandra M Matsudo, & Joanne L Slavin*

**Abstract:** The worldwide rise in body weight has reached epidemic proportions and this has serious public health consequences. Despite the universal recognition of this problem, its causes are still debated: some attribute it to excess caloric intake; others blame a lack of physical activity (PA); some implicate specific changes to micro- and macro-nutrients. During the past century, government health agencies have developed guidance on healthy eating. These, along with advances in agriculture and food manufacturing, have largely eliminated nutrient deficiencies and helped reduce the consumption of fat. Over the past 60 years, however, technological advances and shifts in the types of occupations prominent in industrialized as well as developing countries have resulted in well-documented decreases in energy expenditure. Energy intake must be balanced with energy expenditure in order to prevent weight gain, and there is increasing evidence that this balance must be at a relatively high level of energy flux. A program that was started in São Paulo in 1996 known as 'Agita' has sought to motivate populations to engage in small amounts of physical exercise daily to tackle growing obesity levels. This multi-agency initiative is one example of how to successfully increase exercise within a community and scale both within (e.g. all states in Brazil) and across many nations. Reducing caloric intake in whole populations is challenging especially at relatively low levels of energy expenditure, and evidence suggests that there is a critical energy flux threshold for regulating intake to achieve energy balance. Increasing PA, however, may be more achievable than reducing intake. Activity raises caloric expenditure and can offset excess intake. The implementation of programs to achieve greater PA is therefore vital if the worldwide rise in body weight is to be halted, while we also need to implement programs to help people eat smarter.

## Utilitarian and Recreational Walking Differ in Their Associations with the Built Environment *Bumjoon Kang, Anne V. Moudon, Philip M. Hurvitz, & Brian E. Saelens*

**Abstract:** n/a

**Subject Area:** walking classification, built environment

# Biker Diet: Fuel your body properly to get the most benefit from your bicycle
*Lynn Griffith*

**Abstract:** Survey of Pedestrian and Bicyclist Attitudes and Behaviors reported that 18 percent of the population over the age of 16 rode their bicycle at least once during the summer.  A 2009 National Household Travel Survey reported that 11.9 percent of all trips taken in the U.S. are done by walking or bicycling, an increase of 9.5 percent since 2001.  The previous survey also reported that 33 percent of those who ride their bikes ride for recreational purposes, 28 percent for exercise, and 17 percent for errands.

**Subject Area:** bicycle

## From Minneapolis, Evidence That the Census Undercounts Walking and Biking
*Angie Schmitt*

**Abstract:** The U.S. Census is the most widely cited source of data about how Americans get around. It's updated regularly and it covers the whole country, but it comes up short in a number of ways. The Census only asks about commute trips, and commuting only accounts for about 16 percent of total household travel [PDF]. What happens when you measure the other 84 percent? Researchers at the University of Minnesota set out to design a better way to track how people move around the Twin Cities region, and one key finding is that walking and biking appear to be growing a lot faster than the Census indicates.

**Subject Area:** Census, Biking, UMN Survey

**Our View: Consider your bike as a transportation option** *Editorial Board*
*Rockford Register Star*

**Abstract:** May is national Bike Month

**Subject Area:** Bicycle to work

**Availability:** Editorial Board Rockford Register Star, *Our View: Consider your bike as a transportation option RRstar.com*, May 14, 2015.
http://www.rrstar.com/article/20150514/OPINION/150519645

# City of Turlock promotes bike to work week *Elizabeth Arakelian*

**Abstract:** It is Bike to Work Week and that means there is no better time to enjoy the spring weather than getting on your bike and peddling to work. Cycling has been on the rise in recent years as the number of trips made by bicycles in the United States has more than doubled from 1.7 billion in 2001 to 4 billion in 2009 according to the National Household Travel Survey. The League of American Bicyclists ranked California as the eighth most bicycle friendly state in the country in their 2015 listing.

**Subject Area:** Bicycle to work

## The National Physical Activity Plan: A Call to Action From the American Heart Association A Science Advisory From the American Heart Association

*William E. Kraus, MD, FAHA, Chair; Vera Bittner, MD, MSPH; Lawrence Appel, MD, MPH, FAHA; Steven N. Blair, PED, FAHA; Timothy Church, MD, MPH, PhD; Jean-Pierre Després, PhD, FAHA; Barry A. Franklin, PhD, FAHA; Todd D. Miller, MD, FAHA; Russell R. Pate, PhD; Ruth E. Taylor-Piliae, PhD, RN, FAHA; Dorothea K. Vafiadis, MS, FAHA; Laurie Whitsel, PhD*

**Abstract:** The health benefits of regular physical activity and the relation between physical inactivity and chronic disease morbidity and mortality are well established. Also clear is the fact that efforts to increase physical activity at the population level will require collective action by government, nongovernment, for-profit, and nonprofit entities working together at the local, state, and national levels. The US National Physical Activity Plan (NPAP), developed by the National Physical Activity Plan Alliance, of which the American Heart Association (AHA) is a member, is designed to facilitate this collective action, to help organizations from all sectors of society work together to increase physical activity in all segments of the American population. The purposes of this advisory are to summarize the data that describe the health benefits of regular physical activity and the public health burden of low levels of physical activity, to describe the NPAP and the role it will play in increasing population levels of physical activity, and to encourage readers of Circulation to join the AHA's efforts to promote its implementation.

**Subject Area:** physical activity

# Walking distance, route choice, and activities while walking: A record of following pedestrians from transit stations in the San Francisco Bay area
*Hyungkyoo Kim*

**Abstract:** With the goal of making more walkable urban environments, studies on pedestrian behavior heavily rely on surveys or are increasingly using global positioning system tracking as the main vehicle of collecting data. Alternatively, this study adopts following pedestrians, a direct observation method, to examine pedestrians' walking distance, route choice, and activities while walking from transit stations. Following 139 pedestrians from Glen Park and Rockridge BART stations in the San Francisco Bay Area to their final destinations on weekday afternoons suggests three major findings. Pedestrians walked 548 m on average and up to 1100 m, exceeding 1/4 mile (400 m), a rule-of-thumb distance frequently implemented in practice. Seventy-five per cent of the pedestrians walked along the main streets and twenty-nine per cent chose to walk longer routes. Seventy-four per cent of them engaged in various activities while walking, including shopping, window shopping, conversing with others and using street furniture. This study provides not only quantitative findings that are consistent with those from similar studies, but also descriptive information about pedestrian behavior, which they rarely do.

**Transportation for the Twenty-First Century Designing Healthy Communities and Active Lifestyles with Safe Routes to School** *Deb Hubsmith and Margaux Mennesson*

**Abstract:** A study released in spring 2013 by the US PIRG Education Fund shows that after decades of steady growth, US driving rates have slowed and even stalled and that, in the long term, Americans are unlikely to return to driving as much as they did before. The groundbreaking report finds that millennials (the generation of people born between 1983 and 2000) drove 23 percent fewer miles on average in 2009 than they did in 2001—a greater decline in driving than any other age group. Millennials are also more likely than previous generations to want to live in urban and walkable neighborhoods and are more open to nondriving forms of transportation than older Americans. As millennials grow older and start having families, how will communities evolve to serve the needs of those who value dense, urban neighborhoods and walkable/bikeable centers with less reliance on driving?
When safety is paramount to parents, how will cities and towns ensure that children can safely walk and bicycle to and from school and around the community? Safe Routes to School programs will play an integral role in the way cities and towns serve these families now and in the coming decades.

**Subject Area:** Safe Routes to School; millennials

**Walking beyond the Socioeconomic Status in an Objectively and Perceptually Walkable Pedestrian Environment** *Zeynep Toker*

**Abstract:** An extensive body of literature suggests that physical environment, physical activity, and socioeconomic status (SES) are intrinsically linked to each other and to weight related health problems. In this study, the role of objective and perceived pedestrian environment characteristics (microscale measures) was explored in relation to people's recreational walking patterns in two neighborhoods with opposite SES. A total of 441 street segments were assessed and a total of 133 questionnaires were conducted. The findings suggest that recreational walking can take place beyond a neighborhood's suggested SES when objective and especially perceived microscale characteristics (pedestrian environment) are favorable.

**Modeling spatial segregation and travel cost influences on utilitarian walking: Towards policy intervention** *Yong Yang, Amy H. Auchincloss Daniel A. Rodriguez, Daniel G. Brown, Rick Riolo, & Ana V. Diez-Roux*

**Abstract:** We develop an agent-based model of utilitarian walking and use the model to explore spatial and socio-economic factors affecting adult utilitarian walking and how travel costs as well as various educational interventions aimed at changing attitudes can alter the prevalence of walking and income differentials in walking. The model is validated against US national data. We contrast realistic and extreme parameter values in our model and test effects of changing these parameters across various segregation and pricing scenarios while allowing for interactions between travel choice and place and for behavioral feedbacks. Results suggest that in addition to income differences in the perceived cost of time, the concentration of mixed land use (differential density of residences and businesses) are important determinants of income differences in walking (high income walk less), whereas safety from crime and income segregation on their own do not have large influences on income differences in walking. We also show the difficulty in altering walking behaviors for higher income groups who are insensitive to price and how adding to the cost of driving could increase the income differential in walking particularly in the context of segregation by income and land use. We show that strategies to decrease positive attitudes towards driving can interact synergistically with shifting cost structures to favor walking in increasing the percent of walking trips. Agent-based models, with their ability to capture dynamic processes and incorporate empirical data, are powerful tools to explore the influence on health behavior from multiple factors and test policy interventions.

**Subject Area:** Agent-based model; Utilitarian walking; Travel costs; Spatial segregation; Socioeconomic disparities; Behavior feedback

# Charge your smartphone while you ride on this eco-friendly bamboo bicycle!
*Heather Suhr*

**Abstract:** n/a

**Subject Area:** bamboo bicycle; electricity generation

**Availability:** Suhr, Heather; The Raw Food World, Lifestyle, News, Science & Tech; 26, Jan. 2015
http://news.therawfoodworld.com/charge-smartphone-ride-eco-friendly-bamboo-bicycle/

# Where does Bicycling for Health Happen? Analysing Volunteered Geographic Information through Place and Plexus *Greg P. Griffin & Junfeng Jiao*

**Abstract:** Research on the role of bicycling for health through physical activity has been limited by the lack of information on where bicyclists ride. New big data sources available through smartphone-based applications provide a rich source to provide bicycle volume data more comparable to the scale of information available for automotive and public transit modes. In the case of smartphone apps for fitness tracking, results of this data can be used similar to the growing application of global positioning systems for automotive travel surveying. The authors evaluate data from Travis County, Texas for the purpose of determining where bicyclists ride, primarily for fitness purposes. Ride trip volumes are evaluated with residential and employment density, land use diversity, bicycle facilities and terrain to characterize places chosen for bicycling for health. Though limited to bicycle rides and routes voluntarily logged using the smartphone app, this method provides promise for applications in multi-modal transportation planning and health impact assessment studies.

**Subject Area:** bicycling, health, crowdsourcing, VGI, GIS, built environment

**Public awareness of and support for infrastructure changes designed to increase walking and biking in Los Angeles County** *Lauren N. Gase, Noel C. Barragan, Paul A. Simon, Richard J. Jackson, & Tony Kuo*

**Abstract:** Objective: Policies to promote active transportation are emerging as a best practice to increase physical activity, yet relatively little is known about public opinion on utilizing transportation funds for such investments. This study sought to assess public awareness of and support for investments in walking and biking infrastructure in Los Angeles County.
Method: In the fall of 2013, the Los Angeles County Department of Public Health conducted a telephone survey with a random sample of registered voters in the region. The survey asked respondents to report on the presence and importance of walking and biking infrastructure in their community, travel behaviors and preferences, and demographics.
Results: One thousand and five interviews were completed (response rate 20%, cooperation rate 54%). The majority of participants reported walking, biking, and bus/rail transportation investments as being important. In addition, participants reported a high level of support for redirecting transportation funds to active transportation investment — the population average was 3.28 (between 'strongly' and 'somewhat' support) on a 4 point Likert scale.
Conclusion: Voters see active transportation infrastructure as being very important and support redirecting funding to improve the infrastructure. These findings can inform policy-decisions and planning efforts in the jurisdiction.

**Subject Area:** Walking; Bicycling; Active transportation

**Association between neighborhood walkability and GPS-measured walking, bicycling and vehicle time in adolescents** *Jordan A. Carlson, Brian E. Saelens, Jacqueline Kerr, Jasper Schipperijn, Terry L. Conway, Lawrence D. Frank, Jim E. Chapman, Karen Glanz, Kelli L. Cain, & James F. Sallis*

**Abstract:** Objectives:  To investigate relations of walking, bicycling and vehicle time to neighborhood walkability and total physical activity in youth.
Methods: Participants (N=690) were from 380 census block groups of high/low walkability and income in two US regions. Home neighborhood residential density, intersection density, retail density, entertainment density and walkability were derived using GIS. Minutes/day of walking, bicycling and vehicle time were derived from processing algorithms applied to GPS. Accelerometers estimated total daily moderate-to-vigorous physical activity (MVPA). Models were adjusted for nesting of days (N=2987) within participants within block groups.
Results: Walking occurred on 33%, active travel on 43%, and vehicle time on 91% of the days observed. Intersection density and neighborhood walkability were positively related to walking and bicycling and negatively related to vehicle time. Residential density was positively related to walking.
Conclusions: Increasing walking in youth could be effective in increasing total physical activity. Built environment findings suggest potential for increasing walking in youth through improving neighborhood walkability.

**Subject Area:** Density; Land use; Mode share; Physical activity; Transportation

# 2. Demographic Trends

**The Effects of Demographic Change on Selected Transportation Services and Demand** *Murdock SH, Cline ME, Zey M, Perez D,& Jeanty PW.*

**Abstract:** Change in demographic characteristics, absent improvement in socioeconomic resources of minority households, are likely to affect the magnitude of change as well as the demand for various types of transportation. In this chapter the effects of population growth and change in the demographic characteristics of the population on change in vehicle ownership, drivers, and transportation mode choice on the work commute are analyzed. In addition, it explores the impacts of growth in the number of drivers and change in the age structure of the driving population on change in the number of vehicular crashes. Using U.S. Census Bureau projections to 2060 and other data, changes in transportation use and related factors are projected. Total population growth will be the major factor increasing the size of the driving population even as racial/ethnic changes and population aging work to attenuate that growth and lead to lower mileage driven per driver. These same changes will lead to an overall decrease in crash rates even as a larger number of elderly become victims of traffic fatalities. In addition, racial/ethnic changes are projected to lead to a larger proportion of the population using public transportation and carpooling and increases in the percentage of households without vehicles.

**Subject Area:** minority; travel behavior; transportation use

**Availability:** Murdock, Steve H., et al. "The Effects of Demographic Change on Selected Transportation Services and Demand." Population Change in the United States. Springer Netherlands, 2015. 133-152. http://link.springer.com/chapter/10.1007/978-94-017-7288-4_7

# The same mode again? An exploration of mode choice variability in Great Britain using the National Travel Survey *Eva Heinen, & Kiron Chatterjee*

**Abstract:** The main focus of travel behaviour research has been explaining differences in behaviour between individuals (interpersonal variability) with less emphasis given to the variability of behaviour within individuals (intrapersonal variability). The subject of this paper is the variability of transport modes used by individuals in their weekly travel. Our review shows that previous studies have not allowed the full use of different modes in weekly travel to be taken into account, have used categorical variables as simple indicators of modal variability and have only considered a limited set of explanatory indicators in seeking to explain modal variability. In our analysis we use National Travel Survey data for Great Britain. We analyse modal variability with continuous measures of modal variability (Herfindahl–Hirschman Index, the difference in mode share between the primary and secondary mode, the total number of modes used). Taking inspiration from Hägerstrand (1970), we conceive that modal variability is determined by different types of spatial mobility constraints and find that reduced modal variability is predicted for having mobility difficulties, being aged over 60, being non-white, working full-time, living in smaller settlement, lower household income, having regular access to a car, having no public transport pass/season ticket and not owning a bicycle. The findings can support a change in perspective in transport policy from encouraging people to replace the use of one mode with another to encouraging people to make a change to their relative use of different transport modes.

**Subject Area:** Intrapersonal variability; Mode choice; Multimodality; Modal variability; Mobility constraints

## Beyond Traffic *USDOT*

**Abstract:** Beyond Traffic is an invitation to the American public—including the users, developers, owners, and operators of the transportation network and the policy officials who shape it—to have a frank conversation about the shape, size, and condition of that system and how it will meet the needs and goals of our nation for decades to come. The Blue Paper includes a discussion about the transportation needs of those in poverty and references the NHTS News Brief on Transportation Mobility and Poverty.

**Subject Area:** poverty and transportation

**Availability:** USDOT Blue Paper; Beyond Traffic 2045 Trends and Choices Feb. 2. 2015
http://www.dot.gov/sites/dot.gov/files/docs/Draft_Beyond_Traffic_Framework.pdf

# Commuting Time and Household Responsibilities: Evidence Using Propensity Score Matching *J. Ignacio Gimenez-Nadal & Jose Alberto Molina*

**Abstract:** The growth in women's participation in the labor force has attracted attention to the gender differences in commuting behavior, and to their implications. This study analyses the relationship between individual commuting behavior and household responsibilities, with a focus on gender differences in that relationship. Using the Dutch Time Use Surveys for the years 2000 and 2005, we analyze the relationship between commuting time, and the time devoted to home production and childcare. To deal with reverse causality, we use Propenstity Score Matching techniques to obtain imputed data for individuals. After reverse causality is taken into account, we find that the effect of home production on commuting time for women is more than double the effect for men, while childcare time has an effect on women's commuting time behavior only. Our results explain why prior studies have found that women have shorter commutes than men, shedding light on the Household Responsibility Hypothesis (HRH).

**Subject Area:** commuting, home production, childcare, propensity score matching, Multinational Time Use Study

# Cohort Effects and Their Influence on Car Ownership *Michael Iacono & David Levinson*

**Abstract:** Recent trends in the United States suggest a movement toward saturation of vehicle ownership. This paper examines this trend through an analysis of car ownership in the Minneapolis-St. Paul, Minnesota (USA) metropolitan region. Data from pooled cross-sectional household surveys are used to calibrate a model of car ownership that includes birth cohort effects to capture unobserved variations in preference toward car ownership across generations. Declines in household size and worker status have significant impacts in limiting the growth of car ownership, but they are also coupled by an apparent softening of preferences toward ownership among young adults.

# 3. Energy Consumption

**Probabilistic estimation of plug-in electric vehicles charging load profile** *Nima H. Tehrani, & Peng Wang*

**Abstract:** Plug-in electric vehicles (PEVs) are widely considered as a sustainable mode of transport by countries worldwide due to high efficiency and low or zero carbon emissions. However, PEVs will add significant additional load to the existing power distribution system and it will be a challenge to meet the new demand. In this study, probabilistic modelling has been presented to estimate the system-wide PEV charging load within domestic grids. U.S. national household travel survey data set has been utilized to quantitatively determine the mobility behaviour of PEVs.

Uncertain nature of the problem in modelling and data preparation should be taken into account. Due to the existence of complex interdependencies between the system inputs, the problem definition leads to a multivariate uncertainty analysis problem. The modelling procedure is decomposed into two basic components: the modelling of the marginal distributions; and that of the stochastic dependence structure. In addition, Copula theory is presented for the multivariate modelling of dependent random variable. The results indicate that the PEVs can contribute to increase the load demand at certain hours, although the charging demand is very limited most of the time. Moreover, the probabilistic distribution of aggregated PEV charging demand is compared with that obtained by the Monte Carlo simulation. The numerical results have shown the effectiveness of the proposed methodology.

**Subject Area**: Load profile; Charging demand; PEV; Electric vehicle; Probabilistic modelling; Monte Carlo simulation

# Market-based Demand Response via Residential Plug-in Electric Vehicles in Smart Grids *Farshad Rassaei, Wee-Seng Soh, & Kee-Chaing Chua*

**Abstract:** Flexibility in power demand, diverse usage patterns and storage capability of plug-in electric vehicles (PEVs) grow the elasticity of residential electricity demand remarkably. This elasticity can be utilized to form the daily aggregated demand profile and/or alter instantaneous demand of a system wherein a large number of residential PEVs share one electricity retailer or an aggregator. In this paper, we propose a demand response (DR) technique to manage vehicle-to-grid (V2G) enabled PEVs' electricity assignments (charging and discharging) in order to reduce the overall electricity procurement costs for a retailer bidding to a two-settlement electricity market, i.e., a day-ahead (DA) and a spot or real-time (RT) market. We show that our approach is decentralized, scalable, fast converging and does not violate users' privacy. Extensive simulations show significant overall cost savings can be achieved for a retailer bidding to an operational electricity market by using the proposed algorithm. This technique becomes more needful when the power grid accommodates a large number of intermittent energy resources wherein RT demand altering is crucial due to more likely contingencies and hence more RT price fluctuations and even occurring the so-called black swan events. Finally, such retailer could offer better deals to customers as well.

**Subject Area**: Black swan event, demand response (DR), electricity markets, plug-in electric vehicles (PEVs), residential load, retailer, smart grids, vehicle-to-grid (V2G)

**Reliability Studies of Distribution SystemsIntegrated With Electric Vehicles Under Battery-ExchangeMode** *Farzin, H,. Moeini-Aghtaie, M., & Fotuhi-Firuzabad, M.*

**Abstract:** Although the concept of vehicle-to-grid (V2G) has explicitly shown its benefits in improving the grid efficiency, it has not yet been furnished with effective evaluation methods in power system studies. This paper aims to propose an analytical approach by which the reliability impacts of electric vehicles (EVs) in distribution level can effectively be assessed. The studies are done for EVs integration under battery exchange (BE) oper-ating mode. In this regard, at first, different behaviors of EV us-ers under BE mode are extracted based on refueling patterns of conventional vehicles. Afterwards, an algorithm is presented to optimally break down the period of studies into a few time inter-vals during which fluctuations of distribution system load can be neglected. Subsequently for each time interval, probabilistic mod-el of available energy in batteries of BE station is extracted taking into account the battery exchange patterns of EV users. Convolv-ing the load model of system and available energy in batteries of BE station, calculation procedure of some commonly used relia-bility indices is introduced. A comprehensive study is also pre-sented through implementing the proposed approach on the IEEE 34-node test system. The obtained results demonstrate the effi-ciency of the proposed method in extracting the main benefits of EVs with the goal of enhancing the reliability performance of distribution systems.

**Subject Area**: Analytical approach, battery exchange (BE) mode, reliability studies

## Optimal Participation of an Electric Vehicle Aggregator in Day-Ahead Energy and Reserve Markets *Sarker, M.R., Dvorkin, Y.& Ortega-Vazquez, M.A.*

**Abstract:** In this paper, an extensive study on plug-in electric vehicle (PEV) driving characteristics, charging behavior and their impact on the utility is presented. The primary challenge in investigating the effects of PEV charging loads on the distribution system is taking care of the uncertainties. A detailed study on National Household Travel Survey (NHTS) data is carried out and the PEV charging behavior is modeled. Thereafter, a stochastic optimization model is proposed considering different PEV charging scenarios with their associated probabilities and the impact on system load, feeder loss and voltage deviation are studied. A Distribution Optimal Power Flow (DOPF) model with various objectives such as feeder loss minimization, energy drawn minimization and PEV charging cost minimization subject to feeder operational constraints including PEV charging within a 33-bus balanced distribution system is presented. In the uncontrolled charging case, the worst case scenarios are discussed. The proposed smart charging model provides with the optimal charging schedules which result in flattening the load profile.

**Subject Area**: Distribution optimal power flow; Plug-in electric vehicles; probability; smart charging; uncontrolled charging

# A stochastic distribution operations framework to study the impact of PEV charging loads *Shetty, Shubhalakshmi & Bhattacharya, Kankar*

**Abstract:** In this paper, an extensive study on plug-in electric vehicle (PEV) driving characteristics, charging behavior and their impact on the utility is presented. The primary challenge in investigating the effects of PEV charging loads on the distribution system is taking care of the uncertainties. A detailed study on National Household Travel Survey (NHTS) data is carried out and the PEV charging behavior is modeled. Thereafter, a stochastic optimization model is proposed considering different PEV charging scenarios with their associated probabilities and the impact on system load, feeder loss and voltage deviation are studied. A Distribution Optimal Power Flow (DOPF) model with various objectives such as feeder loss minimization, energy drawn minimization and PEV charging cost minimization subject to feeder operational constraints including PEV charging within a 33-bus balanced distribution system is presented. In the uncontrolled charging case, the worst case scenarios are discussed. The proposed smart charging model provides with the optimal charging schedules which result in flattening the load profile.

**Subject Area**: Distribution optimal power flow; Plug-in electric vehicles; probability; smart charging; uncontrolled charging

# Decentralize Coordinated Charging of Plug-In Electric Vehicles in Unbalanced Residential Networks to Control Distribution Transformer Loading, Voltage Profile and Current Unbalance *Moayed Moghbel, Mohammad A. S. Masoum,& Alireza Fereidouni*

**Abstract:** Utilization of plug-in electric vehicles (PEVs) in residential feeders is gaining popularity in recent years due to the societal awareness about greenhouse gas emission and the increasing of petrol price. The potential for network stress and congestion due to uncoordinated charging of PEVs is significant as they represent sizeable unbalanced loads with unpredictable locations, plug-in times, charging rates and durations. This paper aims to mitigate the detrimental impacts of electric vehicle charging on smart grid by implementing a decentralized coordinated PEV charging algorithm that will also improve the power quality of smart grid. The idea for the individual PEV chargers is to acquire distribution transformer loading through the smart meters to dynamically coordinate their charging times, rates and durations in order to improve the overall system voltage profile, reduce transformer stress and control current imbalance. Simulation results will be generated and analysed for an unbalanced three-phase 62 node residential network populated with PEV chargers using the Simulink-Matlab software.

**Subject Area**: PEV – Decentralize charging – Smart grid – Power quality

# Optimal distribution reconfiguration considering high penetration of electric vehicles *Ghaedi A, Fard ET, Fotoohabadi H, & Kavousi-Fard F.*

**Abstract:** The appearance of Plug-in Electric Vehicles (PEVs) in the electric grids is providing new opportunities when some new challenges are also created. Technically, PEVs are movable loads that can benefit to both owners and utilities in case of using Vehicle-to-Grid (V2G) technology. Therefore, this article aims to investigate the Distribution Feeder Reconfiguration (DFR) effect to optimally manage PEV performance in a probabilistic framework. The proposed stochastic framework will capture the uncertainties of location of PEVs as well as driving pattern and battery State-of-Charge (SOC). In addition, a new self-adaptive evolutionary swarm algorithm based on Social Spider Optimization (SSO) algorithm is proposed that will search the problem space globally. The simulation results on the IEEE standard test system shows the high performance of the proposed method.

**Assessing greenhouse gas emissions from electric vehicle operation in Australia using temporal vehicle charging and electricity emission characteristics** *Graham Mills & Iain MacGill*

**Abstract:** Significant interest exists in the potential for Electric Vehicles to be a source of Greenhouse Gas abatement. In order establish the extent to which EVs will deliver abatement however, a realistic understanding of the electricity and transport sector GHG emissions impacts arising from different approaches to integrating EVs into the power system is required. A key issue in this regard is the extent to which GHG emissions are a function of where and when EV charging will be enabled (or disabled) by the provision of recharging infrastructure and implementation of charging management strategies by the electricity industry. This paper presents an investigation of the GHG emissions arising from electricity and gasoline consumption by plug-in hybrid EVs under a range of standard EV-power system integration scenarios. An assessment framework is presented, and GHG emissions from EV use are assessed for the New South Wales (NSW) and South Australian (SA) pools of the Australian National Electricity Market (NEM) using retrospective electricity system generation data for the year 2011. Results highlight that there is a range of possible outcomes depending on the integration scenario and emissions accounting approach used. This range illustrates value of a temporally explicit assessment approach in capturing the temporal alignment of electricity sector emission intensity and EV charging. Results also show the importance of a clean electricity generation mix in order for EVs to provide a GHG abatement benefit beyond what would be achieved by a hybrid (but non plug-in) vehicle. The extent to which over-night charging in NSW is observed to produce higher emissions relative to un-managed charging also illustrates a possible trade-off between GHG emissions and benefits for electricity industry from EV charging at times of low demand.

# Matchmaking between vehicle miles traveled and fuel economy: the role of gasoline prices *Taha Kasim*

**Abstract:** This paper studies a potential effect of gasoline prices that has been overlooked in the literature. Due to heterogeneity in demand for vehicle miles traveled (VMT), when gasoline prices increase, the increased cost of operating an inefficient vehicle are greater for households that drive more. Thus, in equilibrium, after an increase in the gasoline prices there should be a stronger matching from households, based on their VMT, to the fuel economy of the cars they own. Potentially, this matching effect could save 15% of US gasoline consumption, even with no effect on individual VMT and no effect on the vehicle fleet. Using confidential data from the National Highway Transportation Survey, the effect of higher gasoline prices on such assortative matching is estimated using a variety of econometric models. For all the different model specifications, the matching effect is significant and quite robust. This is the first study to analyze this re-allocation or matching effect.

**Subject Area**: vehicle miles traveled, fuel economy, gasoline prices, matching effect

# Cost of EV battery wear due to vehicle to grid application *Lehtola, Timo*

**Abstract:** Vehicle to grid system (V2G) provides frequency regulation for electricity networks. Network operators receive benefits from V2G for more stable network and price difference when selling and buying electricity in networked markets. In this proposal, we estimate the annual cost for battery wear due to V2G application to be AU$ 770. Grid operators use 102 kWh per day battery capacity to exchange electricity between car batteries and electricity networks. The energy price used for frequency regulation is in this research project 2.07 AU cents per kWh. Intensive power exchange, between batteries and electricity network can cause extra wear for batteries, which is increasing cost. The model used in these calculations were based on Sanyo UR18650E Electric vehicle (EV) batteries at a size of 85 kWh battery package. Results demonstrate that V2G will provide inexpensive frequency regulation for power grid and generate profit for electricity network operators and electric car users.

**Subject Area**: Ancillary Services, Battery Ageing, Electric Vehicle,Up and Down Regulation, Vehicle to Grid

**Scalable Network-Constrained Electric Vehicle Charging in Multiphase Distribution Grids** *Zhang, Liang, Vassilis Kekatos, and Georgios B. Giannakis*

**Abstract:** Although electric vehicles are considered a viable solution to reduce greenhouse gas emissions, studies have shown that their uncoordinated charging will have a noticeably adverse influence on power network operation. To guarantee the secure and economic operation of distribution grids, a network constrained electric vehicle scheduling problem is formulated here. Leveraging a recently proposed linearized distribution grid model, the goal is to coordinate electric vehicle charging while minimizing the power supply cost, and respecting critical voltage regulation, power flow, and unbalance constraints. Optimizing variables across grid buses is accomplished using the alternating direction method of multipliers. Provisioning large-scale fleets, the task of scheduling co-located vehicles is handled by the recently revived Frank-Wolfe method. The derived charging scheme features affordable computational requirements from the vehicle controller and minimal information exchanges. Numerical tests demonstrate the efficiency of the novel schemes, and confirm the necessity of orchestrating vehicle charging across phases.

**Subject Area**: Linearized distribution flow model, alternating direction method of multipliers, Frank-Wolfe algorithm

# Evaluation of the charging effects of electric vehicles on power systems, taking into account optimal charging scenarios

*Moon, Sang-Keun, Wook-Won Kim, Je-Seok Sin, Mun-Su Na, and Jin-O. Kim*

**Abstract:** This paper aims to develop a management method considering load demand for electric vehicle charging. The method developed by means of modeling a stochastic distribution of charging and a demand dispatch calculation. Optimization processes have proposed to determine optimal demand shifting so that charging costs and demands can possibly be managed. The time of use electricity rate has been put into practice to change the tendencies of charging time. Nevertheless, since it focuses only minimizing costs of charging from vehicle owners, loads would be concentrated at a certain time and form a new peak load. The purpose of this paper is to suggest a scenario of load leveling. Therefore charging costs and demands can be managed suitably considering the discordance between electrical prices and system load fluctuations. In case study results, charging patterns and daily demands in the areas are investigated. And optimum solutions are conducted regarding costs and operation aspects by determining demand distribution proportions.

**Subject Area**: Demand forecasting, Electric vehicles, Load management, Optimal scheduling

# Distribution network reconfiguration with aggregated electric vehicle charging strategy *Cui, Hantao, Fangxing Li, Xin Fang, and Runsha Long*

**Abstract:** With a higher level of electric vehicle load penetrated in the distribution network, reconfiguration could be employed to minimize energy losses. Based on a second-order conic programming formulation, an improved set of network radiality constraints is proposed using power-flow based network connectivity conditions. This proves to be a computationally more efficient method compared to the spanning tree constraints. To incorporate electric vehicle charging in the reconfiguration model, two aggregated charging strategies are proposed: the arbitrary delay and the peak-avoiding delay. The decision of delay hours is formulated as constraints and co-optimized into the reconfiguration model. Case study on the IEEE 33-bus system illustrates the performance of the proposed model and the effectiveness of the proposed charging strategy.

**Subject Area**: Distribution network reconfiguration; electric vehicle charging strategy; network radiality constraints; second-order conic programming

# Kernel-based electric vehicle charging load modeling with improved latin hypercube sampling *Liang, Ming, Wenyuan Li, Juan Yu, and Lefeng Shi*

**Abstract:** Daily trip distance and end time of the last trip are two essential variables for home based electric vehicle (HBEV) charging load model. A non-parametric Gaussian kernel density estimation method is proposed to build the probability density distributions of these two variables. This method can improve the precision and adaptablity of the distributions compared with parametric estimation. A Latin hypercube sampling technique with cubic spline interpolation is presented to generate random samples of the two variables. This technique is much more efficient in computation than Monte Carlo simulation. Simulation results using three different charging modes demonstrate that a time-of-use electricity price policy can guide consumers to charge at valley load time, and thus can change the shape of HBEV load charging curves.

**Subject Area**: Computational modeling, Estimation, Interpolation, Kernel, Load modeling, Reliability, Silicon

## Real-time charging navigation of electric vehicles: A non-cooperative game approach *Hafez, Omar, and Kankar Bhattacharya*

**Abstract:** This paper presents a novel approach for modeling the 24-hour charging demand profile of a plug-in electric vehicle (PEV) charging station using queuing analysis. The proposed queuing model considers the arrival of PEVs as a non-homogeneous Poisson process with different arrival rates over the day. A distribution optimal power flow (OPF) model is used to study the impact of the PEV charging load of the charging station on distribution system operation. Various objective functions, such as total feeder losses, energy drawn by the local distribution company (LDC) and total cost of energy drawn by LDC are considered in this paper.

**Subject Area**: Analytical models, Charging stations, Load flow, Load modeling, Mathematical model, Queueing analysis, & Vehicles

# Modeling of PEV charging load using queuing analysis and its impact on distribution system operation *Hafez, Omar, and Kankar Bhattacharya*

**Abstract:** This paper presents a novel approach for modeling the 24-hour charging demand profile of a plug-in electric vehicle (PEV) charging station using queuing analysis. The proposed queuing model considers the arrival of PEVs as a non-homogeneous Poisson process with different arrival rates over the day. A distribution optimal power flow (OPF) model is used to study the impact of the PEV charging load of the charging station on distribution system operation. Various objective functions, such as total feeder losses, energy drawn by the local distribution company (LDC) and total cost of energy drawn by LDC are considered in this paper.

**Subject Area**: Analytical models, Charging stations, Load flow, Load modeling, Mathematical model, Queueing analysis, & Vehicles

## Estimating EV integration patterns considering spatial dispersion in distribution systems *Lin Cheng, Yao Chang, Manjun Liu & Qiang Wu*

**Abstract:** The integration pattern of an electric vehicle (EV) fleet usually consists of 4 parameters including arrival time, departure time, state-of-charge and the number of integrations. Though such patterns have been widely studied in the past few years, how the EVs are dispersed in power distribution systems, are not studied yet. However, neglecting the spatial aspect of EV integration is equivalent to neglecting the mobile nature of EVs, thus cause misestimating the impact or benefit brought by EVs. Therefore, this paper proposes to associate traveling purpose with nodal load types in a distribution system, so as to characterize the geographical aspect of EVs as much as possible. The proposed method is based on database statistics and state transition probabilities. Results reveal that significant differences can exist regarding the EV integration patterns at different locations.

# A trip-purpose based model of Plug-in Electric Vehicle charging demand

*Hilshey, Alexander Doster*

**Abstract:** This paper describes a method for trip-purpose based modeling Plug-in Electric Vehicle (PEV) travel profiles to be used in estimating charging load times and durations. The method uses concepts from Activity-Based Travel Demand modeling to schedule PEV driver activities resulting in driving times and durations, from which the PEV charging profile may be determined (including when the PEV is available to charge and the amount of charging needed). The model is built using statistics from the 2009 National Household Transportation Survey. The framework for the model is presented, and after completing minor calibrations, the model will be used, in future work, to develop a multi-day travel demand model which can be adjusted to capture specific travel behavior given various demographics, urban population density, or other desirable attributes which could allow the model to more accurately represent the PEV travel demand of a specific region or city.

# Optimal secondary distribution system design considering plug-in electric vehicles *S.F. Abdelsamad, W.G. Morsi, & T.S. Sidhu*

**Abstract:** In this paper, the problem of secondary distribution system (SDS) design considering plug-in electric vehicles (PEVs) charging demand is addressed using meta-heuristic optimization to minimize the overall secondary system costs. The objective function and the necessary constraints are mathematically formulated and presented. The effectiveness of the proposed SDS design approach is evaluated in terms of the overall SDS costs and transformer loss of life (LOL). The proposed design approach represents an effective tool for electric utilities to accommodate PEVs during the planning stage of SDS and also when retrofitting existing SDS.

# Co-simulation study of performance trade-offs between centralised, distributed, and hybrid adaptive PEV charging algorithms *Samah Mansour, Intissar Harrabi, Martin Maier, & Géza Joós*

**Abstract:** In this paper, we propose a decentralised algorithm for coordinating the charging of multiple plug-in electric vehicles (PEVs) and extend it to a hybrid version by including the PEV's charging strategies into the optimisation function. Going one step further, we also consider coordinated workplace charging integrating PV panels. The main focus of our work is to conduct a comparative study between a centralised benchmark algorithm, and the proposed decentralised and hybrid approaches from both communications and power perspectives. All algorithms are co-simulated over a converged fiber-wireless communication infrastructure of 342 residential customers. Power system results prove the efficiency of the proposed algorithms providing up to 19% peak shaving while meeting drivers' requirements. Communication results of the decentralised algorithm compared to a centralised benchmark scheme provided better performance, measuring an upstream traffic rate of 1.28 Mbps with a maximum delay of 0.629 ms. Compared to the decentralised algorithm, the hybrid algorithm showed a promising improvement for large fleets of PEVs accompanied with an overhead communication cost that is significantly less than that of the centralised algorithm.

# Impact of Second-Generation Plug-In Battery Electric Vehicles on the Aging of Distribution Transformers Considering TOU Prices *Assolami, Yasser O., and Walid G. Morsi*

**Abstract:** This paper investigates the impact of second-generation (SG) plug-in battery electric vehicles (PBEVs) on distribution transformer's insulation life considering the time-of-use (TOU) prices. The effect of dual Level 2 charging, 3.7 kW, and 6.6 kW on the loss of life (LOL) of a distribution transformer is also studied. The LOL results demonstrating the effectiveness of SG PBEVs charging as two clusters versus one cluster are discussed and conclusions are drawn.

**Subject Area**: Aging, Monte Carlo (MC) methods, power distribution

# Assessment Of Impacts Of Electric Vehicles On Low Voltage Distribution Networks In Turkey *Armağan Temiz*

**Abstract:** The number of Electric Vehicles (EVs) has reached a substantial value all over the globe due to economic and environmental factors. The increasing penetration of EVs to the distribution grids urges the requirement to investigate the impacts of EVs on the planning and operation of distribution networks. Despite the fact that there are numerous studies discussing the impacts of EVs on distribution grids, a particular study concerning the Turkish distribution networks does not exist. Therefore, this study focuses on analyzing the impacts of EVs on low voltage distribution networks in Turkey. Three distribution network models, two of them belonging to actual Turkish distribution network segments and one being generic, including different customer attributes and network structures are constructed and utilized throughout this study. An extensive EV model is developed using probabilistic models and assumptions. Gaussian distribution function for EV plug-in times and Weibull distribution function for daily travel times are adapted in Digsilent PowerFactory simulation tool. Monte Carlo based load flow simulations are performed in order to evaluate the response of the distribution networks to various EV and load scenarios considering different multi-tariff mechanisms. Furthermore, a methodology is developed to obtain and present network results based on transformer and cable overloads, voltage drops, and grid losses. This methodology will help the decision maker determine the necessary investments on the distribution networks and associated time frames. This approach will improve the planning process of distribution companies. Hence, distribution companies will submit more realistic and accurate investment plans to the regulatory agencies.

**Subject Area**: Electric Vehicles, Load Flow, Monte Carlo Simulation, Power Distribution Networks

# Resident electric vehicles charging optimization strategy in the smart grid

*Ruiqin, Duan & Zhongjing, Ma*

**Abstract:** Considering the stochastic nature of electric vehicles (EVs) charging activities, this paper is dedicated to schedule the resident EVs charging load in the smart grid. Three important factors of the EV charging process are taken into account and studied, including the characteristics of EV battery, the start time of EV charging and the initial state-of-charging (SOC) of EV battery. We present a resident EVs charging optimization scheduling strategy to minimize the variation of total power load in the specified time period. And then we propose an approximate evaluation method for the corresponding optimization problem. The simulation results illustrate that the proposed EVs charging scheduling strategy will reduce the total power load curve difference of peak and valley, and the proposed method is very promising to improve the daily load profile of power system.

**Subject Area**: Electric vehicle, Optimization scheduling, Probability model, Smart grid

# Economic operation of micro grid considering electric vehicle storage system
*Chao, Guang*

**Abstract:** With the growing consumption of traditional energy sources, increasing environmental pollution and gradually improvement of power quality requirements of the customs, distributed generation and clean energy technology based on renewable energy, have been widely applied in the grid. As an effective form for distribution generation to access into the grid, micro grid is a flexible, controllable autonomous systems organized by distributed power, energy storage and load by power control and energy management. Coupled with the increasing importance and the enormous potential of electric vehicles, the micro grid operation including energy storage power station of electric vehicles is gradually pointing out a direction for the worsened energy issues, environmental issues and the integration of power quality solution. How to optimize the micro grid containing electric vehicle storage station which is heavily influenced by storage configuration is an important issue to economical optimization operating. This thesis will firstly give a brief introduction and then analyze the relatively maturely used distribution generation photovoltaic, wind turbine, micro turbine and battery. Chapter 2 will analyze their output characteristics, power generation principles, operating characteristics and establish economic models for these micro grid unit according to their output cost curves. Then, according to relevant data, thesis will derive cell characteristics and trip characteristics of electric vehicles, build and construct a mathematical model and use an example by applying electric cars into cooperative scheduling to optimize load curve. Taking into account the impact of energy storage capacity configuration, after calculating and programming in the MATLAB by rain flow algorithm lifetime estimation, the investment of energy storage after converting into daily cost is listed in the objective function. After that, the thesis will divide the depth of electric vehicle involving into the micro grid into three degrees: as normal load, as shifting load and V2G sending back to grid. The unbalanced power of load shedding and wind turbine/photovoltaic will be considered in the model by introducing a penalty item, which is the penalty represented by the penalty coefficient. The study case about an industrial district will be given in the last part of the thesis. After calculating the model with proper parameters, the energy management center can work out and arrange the output of different distribution generation and send the result to the Micro grid controller. Under the circumstance of load demand and all the output constraints, the total cost is minimized. According to the result, because of the lack of supply from big grid when isolated island operation, the operation fee is high relatively speaking. The extra cost is spending on the storage system. As the coordinate dispatching element, electric vehicle can smooth the load curve and random source output effectively and even make a profit by sending power back to the grid in the spare time of the battery. Penalty cost is sensitive to the parameter and relatively small, which is coincide with the reality.

**Subject Area**: micro grid; electric vehicle; economic; optimization; grid connected; isolate island

**EVHomeShifter: Evaluating Intelligent Techniques for Using Electrical Vehicle Batteries to Shift When Homes Draw Energy from the Grid** *Brush, A. J., John Krumm, Sidhant Gupta, and Shwetak Patel*

**Abstract:** Time of use tiered pricing schedules encourage shifting electricity demand from peak to off-peak hours. Charging times for electric vehicles (EV) can be shifted into overnight hours, which are usually off-peak. EVs can also be used as energy storage devices, available during certain peak hours to power a house with electricity stored during off-peak hours. Studies suggest both techniques are practical, but were based on simulated demand patterns or large commercial fleets. To investigate feasibility on a per home basis, we collected data from 15 EV homes using the Lab of Things sensing infrastructure. We evaluate a scheme that powers homes with their car battery during expensive electricity periods and then charges the battery during cheaper periods. We show an average potential savings of $10.91/month for shifting charging times, and an additional $13.58/month for powering the home from the EV, even accounting for the inefficiencies of electric conversion.

**Subject Area**: Sustainability; electric vehicles; home energy use; sensing; Lab of Things; load leveling; residential

# Socially optimal electric driving range of plug-in hybrid electric vehicles

*Eleftheria Kontou, Yafeng Yin, & Zhenhong Lin*

**Abstract:** This study determines the optimal electric driving range of plug-in hybrid electric vehicles (PHEVs) that minimizes the daily cost borne by the society when using this technology. An optimization framework is developed and applied to datasets representing the US market. Results indicate that the optimal range is 16 miles with an average social cost of $3.19 per day when exclusively charging at home, compared to $3.27 per day of driving a conventional vehicle. The optimal range is found to be sensitive to the cost of battery packs and the price of gasoline. When workplace charging is available, the optimal electric driving range surprisingly increases from 16 to 22 miles, as larger batteries would allow drivers to better take advantage of the charging opportunities to achieve longer electrified travel distances, yielding social cost savings. If workplace charging is available, the optimal density is to deploy a workplace charger for every 3.66 vehicles. Moreover, the diversification of the battery size, i.e., introducing a pair and triple of electric driving ranges to the market, could further decrease the average societal cost per PHEV by 7.45% and 11.5% respectively.

**Subject Area**: Plug-in hybrid electric vehicle (PHEV); Optimal all-electric driving range; Minimum social cost; Recharging opportunities

# Identification of potential locations of electric vehicle supply equipment

*Brooker, R. Paul, and Nan Qin*

**Abstract:** Proper placement of electric vehicle supply equipment (charging stations) requires an understanding of vehicle usage patterns. Using data from the National Household Travel Survey on vehicle mileage and destination patterns, analyses were performed to determine electric vehicles' charging needs, as a function of battery size and state of charge. This paper compares electric vehicle charging needs with Department of Energy electric vehicle charging data from real-world charging infrastructure. By combining the electric vehicles charging needs with charging data from real-world applications, locations with high electric vehicle charging likelihood are identified.

# Optimal Allocation of PHEV Parking Lots to Minimize Distribution System Losses

*Fotuhi-Firuzabad, Mahmud, Ali Abbaspour, Mohsen Mazidi, and Mohamamd Rastegar*

**Abstract:** To tackle the air pollution issues, Plug-in Hybrid Electric Vehicles (PHEVs) are proposed as an appropriate solution. Charging a large amount of PHEV batteries, if not controlled, would have negative impacts on the distribution system. The control process of charging of these vehicles can be centralized in parking lots that may provide a chance for better coordination than the individual charging in houses. In this paper, an optimization-based approach is proposed to determine the optimum PHEV parking capacities in candidate nodes of the distribution system. In so doing, a profile for charging and discharging of PHEVs is developed in order to flatten the network load profile. Then, this profile is used in solving an optimization problem to minimize the distribution system losses. The outputs of the proposed method are the proper place for PHEV parking lots and optimum capacity for each parking. The application of the proposed method on the IEEE-34 node test feeder verifies the effectiveness of the method.

# Statistical Characterization of Electric Vehicle Charging in Different Locations of the Grid *Kaiwen Sun, Mushfiqur R. Sarker, and Miguel A. Ortega-Vazquez*

**Abstract:** The advent of electric vehicles (EVs) will bring forth large increases to the pre-existing demand in the power grid. Adverse impacts to the system will arise if the charging of these EVs is uncontrolled. In order to mitigate this challenge, as a first step the estimation of the additional power due to EV charging is crucial. The estimation is dependent upon the temporal (i.e. time) and spatial (i.e. location) characteristics of the EV charging process. A tool is developed in this work, which estimates the additional demand using Monte Carlo simulations performed on a large fleet of EVs over several days. The simulations include EV travel data within predefined residential, workplace, and commercial zones that are determined using traffic flow information. This tool can be used by system operators and other entities to determine the opportunities and challenges posed by additional EV demand. The results show the power consumptions at each hour of the day can be modelled by a normal distribution, thus simplifying the estimation procedure.

**Subject Area**: Electric Vehicles, Electricity Demand, Planning

## Assessment of distribution system margins to accommodate the penetration of plug-in electric vehicles  *Bin Humayd, A.S. & Bhattacharya, K.*

**Abstract:** Environmental concerns and depletion of fossil fuel resources have led to increased penetration of plug-in electric vehicles (PEVs) in recent times. However, such electrification of the transportation sector is expected to impact the distribution grid adversely. These effects will require local distribution companies (LDCs) to accurately assess the impact of PEV penetration and develop plans, policies and solutions for alleviating the consequent network constraints. This paper presents a novel framework to assess the appropriate level of PEV penetration that distribution systems can accommodate under normal and contingency conditions of operation. The model incorporates the impact of different factors such as charging level, vehicle types, vehicle users habits, feeder thermal limits, and bus voltage limits. The distribution system margins from PEV penetration are examined and compared across a wide range of scenarios.

# Assessment of motor vehicle use characteristics in three Indian cities *Rahul Goel, Dinesh Mohan , Sarath K. Guttikunda,& Geetam Tiwari*

**Abstract:** Estimates of emissions and energy consumption by vehicular fleet in India are not backed by reliable values of parameters, leading to large uncertainties. We report new methods, including primary surveys and secondary data sources, to estimate in-use fleet size, annual mileage (kilometers per year), and fuel efficiency of cars and motorised two-wheelers (MTW) for Delhi, and except fleet size and annual mileage of cars, for Visakhapatnam and Rajkot. We estimated that the official number of registered cars and MTW in Indian cities is more than two times the actual number of in-use vehicles. The private vehicular fleet in India is the youngest, its fuel efficiency one of the highest, and annual kilometers travelled is the lowest, compared to many high-income countries, such as the USA and those in European Union. Along with high renewal rate of fleet, the data suggest that it is possible for India to have one of the most fuel-efficient vehicle fleets in the world in the future, if fuel-efficiency standards and fiscal policies to contain growing dieselization are implemented in the country at the earliest.

**Subject Area**: India, Cars, Motorised two-wheelers, Fuel efficiency, In-use fleet size, Annual mileage

**Electrical vehicles impact analysis for distribution systems with THD and load profile study** *Fernandez, Daniel, Sergio Pedraza, David Celeita, and Gustavo Ramos*

**Abstract:** The aim of this study is to analyze the impact of Plug-in Electrical Vehicles (PEVs) in distribution systems. The research focuses in power quality (THD) and the additional power amount required in the systems due to PEVs, subjects to different penetration scenarios. The methodology proposed consists in modeling the regular electrical vehicles (EVs) behavior pattern based on the 2009's National Household Travel Survey. The general procedure which applies for any distribution system analysis is proposed and assessed in the IEEE 13 nodes test feeder system. The results validation was done with DSSim-PC software in co-simulation with MATLAB. The PEV's drivers behavior was acquired by a previous Monte Carlo simulation. Once this model is defined, the load profile of EVs charger is introduced in the simulation software. This data allows to assign the arrival time and a charging estimated time for each regular user in the distribution system. The proposed methodology could be potentially used as a planning tool for PEVs penetration in existing distribution systems, therefore EVs inclusion studies could be enhanced.

# Role of PV generated DC power in transport sector: Case study of plug-in EV

*Abdelhamid, M.; Singh, R.; & Haque, I.*

**Abstract:** This paper presents a multi-stage approach to the placement of charging stations under the scenarios of different electric vehicle (EV) penetration rates. The EV charging market is modeled as the oligopoly. A consumer behavior based approach is applied to forecast the charging demand of the charging stations using a nested logit model. The impacts of both the urban road network and the power grid network on charging station planning are also considered. At each planning stage, the optimal station placement strategy is derived through solving a Bayesian game among the service providers. To investigate the interplay of the travel pattern, the consumer behavior, urban road network, power grid network, and the charging station placement, a simulation platform (The EV Virtual City 1.0) is developed using Java on Repast.We conduct a case study in the San Pedro District of Los Angeles by importing the geographic and demographic data of that region into the platform. The simulation results demonstrate a strong consistency between the charging station placement and the traffic flow of EVs. The results also reveal an interesting phenomenon that service providers prefer clustering instead of spatial separation in this oligopoly market.

**Subject Area**: DC electricity; Grid; Photovoltaic; Plug-in Electric Vehicle; Solar Energy; Sustainable Transportation

# Integrated Energy Exchange Scheduling for Multimicrogrid System With Electric Vehicles *Wang, Dai, Xiaohong Guan, Jiang Wu, Pan Li, Peng Zan, and Hui Xu.*

**Abstract:** Electric vehicles (EVs) can be considered as flexible mobile battery storages in microgrids. For multiple microgrids in an area, coordinated scheduling on charging and discharging are required to avoid power exchange spikes between the multimicrogrid system and the main grid. In this paper, a two-stage integrated energy exchange scheduling strategy for multimicrogrid system is presented, which considers EVs as storage devices. Then, several dual variables, which are representative of the marginal cost of proper constraints, are utilized to form an updated price, thereby being a modification on the original electricity price. With this updated price signal, a price-based decentralized scheduling strategy is presented for the microgrid central controller. Simulation results show that the two-stage scheduling strategy reduces the electricity cost and avoids frequent transitions between battery charging/discharging states. With the proposed decentralized scheduling strategy, each microgrid only needs to solve its local problem and limits the total power exchange within the safe range.

**Subject Area**: Decentralized scheduling strategy; dual variable; electric vehicle (EV); energy exchange; microgrid; updated price signal

# Probabilistic Impact of Transportation Electrification on the Loss-of-Life of Distribution Transformers in the Presence of Rooftop Solar Photovoltaic

*Abdelsamad, Sherif F., Walid G. Morsi, and Tarlochan S. Sidhu*

**Abstract:** Electric vehicles (EVs) can be considered as flexible mobile battery storages in microgrids. For multiple microgrids in an area, coordinated scheduling on charging and discharging are required to avoid power exchange spikes between the multimicrogrid system and the main grid. In this paper, a two-stage integrated energy exchange scheduling strategy for multimicrogrid system is presented, which considers EVs as storage devices. Then, several dual variables, which are representative of the marginal cost of proper constraints, are utilized to form an updated price, thereby being a modification on the original electricity price. With this updated price signal, a price-based decentralized scheduling strategy is presented for the microgrid central controller. Simulation results show that the two-stage scheduling strategy reduces the electricity cost and avoids frequent transitions between battery charging/discharging states. With the proposed decentralized scheduling strategy, each microgrid only needs to solve its local problem and limits the total power exchange within the safe range.

## Load Management in a Residential Energy Hub with Renewable Distributed Energy Resources *Mohammad Rastegar & Mahmud Fotuhi-Firuzabad*

**Abstract:** This paper presents a residential energy hub model for a smart multi-carrier energy home consisting of plug-in hybrid electric vehicle (PHEV), combined heat and power (CHP), solar panels, and electrical storage system (ESS). The energy hub inputs are electricity and natural gas that provide electrical and heat demands at the output ports. In this paper, an optimization-based program is proposed to determine the optimal operation mode of the energy hub, to manage the energy consumption of responsive appliances, to schedule charging/discharging of PHEV and the storage system, and to coordinate solar panels operation with household responsive demand in response to day-ahead time-varying tariffs of electricity. The objective function is to minimize customer payment cost considering vehicle to grid (V2G) capability. Different case studies are conducted to probe the effectiveness of the proposed method and study the impacts of different electrical time-differentiated tariffs on the optimization results on daily and yearly basis.

## A Consumer Behavior Based Approach to Multi-Stage EV Charging Station Placement *Chao Luo, Yih-Fang Huang & Gupta, V.*

**Abstract:** This paper presents a multi-stage approach to the placement of charging stations under the scenarios of different electric vehicle (EV) penetration rates. The EV charging market is modeled as the oligopoly. A consumer behavior based approach is applied to forecast the charging demand of the charging stations using a nested logit model. The impacts of both the urban road network and the power grid network on charging station planning are also considered. At each planning stage, the optimal station placement strategy is derived through solving a Bayesian game among the service providers. To investigate the interplay of the travel pattern, the consumer behavior, urban road network, power grid network, and the charging station placement, a simulation platform (The EV Virtual City 1.0) is developed using Java on Repast.We conduct a case study in the San Pedro District of Los Angeles by importing the geographic and demographic data of that region into the platform. The simulation results demonstrate a strong consistency between the charging station placement and the traffic flow of EVs. The results also reveal an interesting phenomenon that service providers prefer clustering instead of spatial separation in this oligopoly market.

**Subject Area**: Electric vehicles; Carbon footprint; Energy consumption; Regional variations; Life cycle assessment

## Conventional, hybrid, plug-in hybrid or electric vehicles? State-based comparative carbon and energy footprint analysis in the United States *NC Onat, M Kucukvar, and O. Tatari*

**Abstract:** Electric vehicles (EVs), plug-in hybrid electric vehicles (PHEVs), and hybrid electric vehicles (HEVs) are often considered as better options in terms of greenhouse gas emissions and energy consumption compared to internal combustion vehicles. However, making any decision among these vehicle options is not a straightforward process due to temporal and spatial variations, such as the sources of the electricity used and regional driving patterns. In this study, we compared these vehicle options across 50 states, taking into account state-specific average and marginal electricity generation mixes, regional driving patterns, and vehicle and battery manufacturing impacts. Furthermore, a policy scenario proposing the widespread use of solar energy to charge EVs and PHEVs is evaluated. Based on the average electricity generation mix scenario, EVs are found to be least carbon-intensive vehicle option in 24 states, while HEVs are found to be the most energy-efficient option in 45 states. In the marginal electricity mix scenario, widespread adoption of EVs is found to be an unwise strategy given the existing and near-future marginal electricity generation mix. On the other hand, EVs can be superior to other alternatives in terms of energy-consumption, if the required energy to generate 1 kW h of electricity is below 1.25 kW h.

**Subject Area**: Electric vehicles; Carbon footprint; Energy consumption; Regional variations; Life cycle assessment

**Joint Shaping and Altering the Demand Profile by Residential Plug-in Electric Vehicles for Forward and Spot Markets in Smart Grids** *Farshad Rassaei, Wee-Seng Soh and Kee-Chaing Chua*

**Abstract:** Plug-in electric vehicles (PEVs) can significantly increase the elasticity of residential electricity demand. This elasticity can be employed to shape the daily aggregated electricity demand profile of a system comprised of a large number of residential PEVs' users sharing one electricity retailer or an aggregator. In this paper, we propose a joint demand shaping and altering algorithm for managing vehicle-to-grid (V2G) enabled PEVs' electricity assignments (charging and discharging) in order to diminish the overall electricity procurement costs for a retailer bidding to two-settlement electricity markets, i.e., a day-ahead (DA) and a real-time (RT) market. This approach is decentralized, scalable, fast converging and does not violate users' privacy. Our simulations' results demonstrate significant overall cost savings (up to 28%) for a retailer bidding to an operational electricity market by using our proposed algorithm. This becomes even more salient when the power system is integrating a large number of intermittent energy resources wherein RT demand altering is crucial due to more likely contingencies and hence more RT price fluctuations and even more so-called black swan events. Lower electricity procurement cost for a retailer finally makes it able to offer better deals to customers and expand its market capacity. This implies that customers can enjoy lower electricity bills as well.

**Subject Area**: Black swan event, demand altering, demand shaping, electricity markets, flexible load, Plug-in electric vehicles, residential load, retailer, smart grids, vehicle-to-grid.

# Energy consumption of electric vehicles based on real-world driving patterns: A case study of Beijing *Hewu Wang, Xiaobin Zhang, & Minggao Ouyang*

**Abstract:** This study assesses the energy reduction associated with Hybrid Electric Vehicles (HEVs), Plug-in Hybrid Electric Vehicles (PHEVs) and Battery Electric Vehicles (BEVs) compared to conventional vehicles (CVs) for real-world driving conditions in a specific geographic region (Beijing, China). To understand the driving patterns in Beijing, a passenger car travel survey has been conducted since 2012, including over 1000 vehicles. The initial results from driving range distribution have been calculated. In this study, first, a Utility Factor and the typical driving cycles based on 2000 days' worth of Global Position System (GPS) data are analyzed. Next, the real-world energy consumption of CVs, HEVs, PHEVs and BEVs are simulated. Finally, the fuel consumption of vehicles under different driving patterns is compared to provide data on the optimal electric vehicles and reliable test cycles for Beijing. We find that electric vehicles in Beijing, including HEVs, PHEVs and BEVs, yield more fuel reduction benefits than in the U.S. because of the severe driving conditions and short driving ranges. For PHEVs in Beijing, smaller batteries, corresponding to a 30–50 km Charging Depleting (CD) range, are preferred to meet the demands of most drivers and add less extra cost to the vehicle. We also confirm that the Chinese current suggested label values based on NEDC cycle underestimate the fuel consumption of vehicles and fuel reduction benefits of electric vehicles in Beijing. This study addresses the importance of developing and using the real-world driving cycles in designing and evaluating electric vehicles.

**Subject Area**: Electric vehicle; Plug-in hybrid electric vehicle; Driving patterns; Driving cycle; Driving range; Fuel consumption

## Charging ahead on the transition to electric vehicles with standard 120 V wall outlets

*Samveg Saxena, Jason MacDonald & Scott Moura*

**Abstract:** Electrification of transportation is needed soon and at significant scale to meet climate goals, but electric vehicle adoption has been slow and there has been little systematic analysis to show that today's electric vehicles meet the needs of drivers. We apply detailed physics-based models of electric vehicles with data on how drivers use their cars on a daily basis. We show that the energy storage limits of today's electric vehicles are outweighed by their high efficiency and the fact that driving in the United States seldom exceeds 100 km of daily travel. When accounting for these factors, we show that the normal daily travel of 85–89% of drivers in the United States can be satisfied with electric vehicles charging with standard 120 V wall outlets at home only. Further, we show that 77–79% of drivers on their normal daily driving will have over 60 km of buffer range for unexpected trips. We quantify the sensitivities to terrain, high ancillary power draw, and battery degradation and show that an extreme case with all trips on a 3% uphill grade still shows the daily travel of 70% of drivers being satisfied with electric vehicles. These findings show that today's electric vehicles can satisfy the daily driving needs of a significant majority of drivers using only 120 V wall outlets that are already the standard across the United States.

## Probabilistic Modeling of Nodal Charging Demand Based on Spatial-Temporal Dynamics of Moving Electric Vehicles *Tang, D. & Wang P.*

**Abstract:** High penetration of electric vehicles (EVs) as moving loads in power system have drawn increasing concerns about their negative impacts. Due to the spatial-temporal random dynamics of EVs, it is a challenge for identification and positioning of the space and time varying impacts. Most previous studies investigated system-wide EV charging demand based on data analysis with deterministic charging location and time. In this circumstance, this paper proposes a probabilistic model for nodal charging demand based on the spatial-temporal dynamics of moving EVs. Following the introduction to the integrated system with graph theory, a spatial-temporal model of moving EV loads is established based on random trip chain and Markov decision process (MDP). The nodal EV charging demands are derived from the charging probabilities of single and multiple EVs. The system studies show that this model is capable to assess the nodal charging demand due to the spatial-temporal distribution of moving EVs.

**Subject Area**: Electric vehicle (EV); load modeling; nodal charging demand; power system; smart grid

## A Profile of Charging/Discharging Loads on the Grid Due to Electric Vehicles Under Different Price Mechanisms *Mingyang Li & Bin Zou*

**Abstract:** In this paper, a profit maximization model of electric vehicle charging/discharging is constructed and is aimed at the maximum operating profits, while being constrained by power batteries charging/discharging capacities and the travel needs of electric vehicles, which can express the charging/discharging decision of electric vehicles well. A calculation and analysis of the economic benefit and charge distribution of electric vehicle charging/discharging have been made by simulating user travel needs with Monte Carlo method, on the basis of the user travel rule derived from National Household Travel Survey (NHTS) in 2009. The results indicate that the economic benefits of the rational charging/discharging model can be significantly improved by responding to the time of use and real-time electricity price. Meanwhile, due to the relatively cheaper off-peak electricity price at night in contrast to the expensive on-peak electricity price during the day, electric vehicles tend to charge at low load time and discharge inversely at peak load time in the distribution system so as to achieve peak load shifting. The battery storage function of electric vehicles is worth further developing.

**Optimizing the performance of vehicle-to-grid (V2G) enabled battery electric vehicles through a smart charge scheduling model** *Z. Li, M. Chowdhury, P. Bhavsar, & Y. He*

**Abstract:** A smart charge scheduling model is presented for potential (1) vehicle-to-grid (V2G) enabled battery electric vehicle (BEV) owners who are willing to participate in the grid ancillary services, and (2) grid operators. Unlike most V2G implementations, which are considered from the perspective of power grid systems, this model includes a communication network architecture for connecting system components that supports both BEV owners and grid operators to efficiently monitor and manage the charging and ancillary service activities. This model maximizes the net profit to each BEV participant while simultaneously satisfying energy demands for his/her trips. The performance of BEVs using the scheduling model is validated by estimating optimal annual financial benefits under different scenarios. An analysis of popular BEV models revealed that one of the existing BEVs considered in the study can generate an annual regulation profit of $454, $394 and $318 when the average daily driving distance is 20 miles, 40 miles and 60 miles, respectively. All popular BEV models can completely compensate the energy cost and generate a positive net profit, through the application of the scheduling model presented in this paper, with an annual driving distance of approximately 15,000 miles. Simulation analysis indicated that the extra load distribution from the optimized BEV charging operations were well balanced compared to the unmanaged BEV operations.

**Subject Area**: Battery electric vehicle, Vehicle to grid, Smart grid, Charge scheduling

**Multi-Lab EV Smart Grid Integration Requirements Study Providing Guidance on Technology Development and Demonstration** *T. Markel and A. Meintz, K. Hardy, B. Chen, and T. Bohn, J. Smart, D. Scoffield, and R. Hovsapian, S. Saxena, J. MacDonald, and S. Kiliccote, K. Kahl & R. Pratt*

**Abstract:** The U.S. Department of Energy's (DOE's) role to propel the development and deployment of science and technology to address the nation's future energy challenges should include the integration of renewables and interactions between the smart electricity grid of the future and the evolution of electrified transportation. DOE's EV Everywhere initiative intends to accelerate the adoption of electrified transportation. DOE's Office of Energy Efficiency and Renewable Energy's Grid Integration Initiative, working in support of DOE's Grid Tech Team, brings together five program offices to collaborate on ways to enhance the value proposition and the overall efficiency of a long-term system scenario built around energy efficiency and renewable energy technologies. These offices include Vehicle Technologies, Building Technologies, Fuel Cells Technologies, Wind & Water Power Technologies, and Solar Energy Technologies. The report begins with a discussion of the current state of the energy and transportation systems, followed by a summary of some Vehicle Grid Integration (VGI) scenarios and opportunities. The current efforts to create foundational interface standards are detailed, and the requirements for enabling PEVs as a grid resource are presented. Existing technology demonstrations that include vehicle to grid functions are summarized. The report also includes a data-based discussion on the magnitude and variability of PEVs as a grid resource, followed by an overview of existing simulation tools that can be used to explore the expansion of VGI to larger grid functions that might offer system and customer value. The document concludes with a summary of the requirements and potential action items that would support greater adoption of VGI.

**Subject Area**: PEV, electricity Grid, VGI

**Availability:** Markel, T., et al. "Multi-Lab EV Smart Grid Integration Requirements Study." (2015).  http://www.nrel.gov/docs/fy15osti/63963.pdf

# The Advancement Of Electric Vehicles – Case: Tesla Motors Disruptive Technology Requiring Systemic Innovating  *Lehtinen, Petri*

**Abstract:** Electric vehicles have existed for over 100 years as a disruptive innovation. Even though they have always been easier to use, quieter and cleaner, gasoline cars have beaten it in price, range and faster fueling. As gasoline cars have been the technological standard for the past 150 years there has been no motivation by car manufacturers to advance electric vehicles. By producing electric vehicles Tesla Motors has appropriately become the first successful startup car manufacturer in over 100 years. This research studies the systemic innovating of electric vehicles by Tesla Motors.

Disruptive innovation is widely researched and often connected to electric vehicles. However systemic innovation has been rarely researched and none has shown that electric vehicles can be seen as one since they require significant adjustments to the business system they are embedded in to succeed as a disruptive innovation. Therefore I suggest that in certain instances a disruptive innovation requires systemic innovating. In the context of electric vehicles systemic innovating can be done on the disruptive technology level of batteries, on the finished product level of the car and on the external level of services such as charging stations.

Tesla Motors is doubling the world"s lithium-ion battery production to enable inexpensive electric vehicles. It has produced an electric vehicle platform architecture that has advantages not seen in gasoline cars. It is also creating the standard for charging stations and its battery swapping technology is providing almost instant charging. As Tesla Motors is solving the challenges of high price, low range and slow charging, at the same time it is capitalizing and building on the unique advantages electric vehicles have always had and ultimately proving electric vehicles superiority. This is largely the result of the visionary of Tesla Motor"s CEO Elon Musk who is aiming to transform the world into sustainable energy and transportation through solar panels and batteries.

**Subject Area**: electric vehicle, EV, tesla motors, disruptive innovation, open innovation, systemic innovation, Elon Musk

# Life Cycle Air Emissions Impacts and Ownership Costs of Light-Duty Vehicles Using Natural Gas As a Primary Energy Source *Jason M. Luk, Bradley A. Saville, & Heather L. MacLean*

**Abstract:** This paper aims to comprehensively distinguish among the merits of different vehicles using a common primary energy source. In this study, we consider compressed natural gas (CNG) use directly in conventional vehicles (CV) and hybrid electric vehicles (HEV), and natural gas-derived electricity (NG-e) use in plug-in battery electric vehicles (BEV). This study evaluates the incremental life cycle air emissions (climate change and human health) impacts and life cycle ownership costs of non-plug-in (CV and HEV) and plug-in light-duty vehicles. Replacing a gasoline CV with a CNG CV, or a CNG CV with a CNG HEV, can provide life cycle air emissions impact benefits without increasing ownership costs; however, the NG-e BEV will likely increase costs (90% confidence interval: $1000 to $31 000 incremental cost per vehicle lifetime). Furthermore, eliminating HEV tailpipe emissions via plug-in vehicles has an insignificant incremental benefit, due to high uncertainties, with emissions cost benefits between −$1000 and $2000. Vehicle criteria air contaminants are a relatively minor contributor to life cycle air emissions impacts because of strict vehicle emissions standards. Therefore, policies should focus on adoption of plug-in vehicles in nonattainment regions, because CNG vehicles are likely more cost-effective at providing overall life cycle air emissions impact benefits.

**Subject Area**: Natural Gas; Air emissions; CNG; BEV; HEV

**Demand Response for Residential Electric Vehicles With Random Usage Patterns in Smart Grids** *Rassaei, F., Soh, W., & Chua, K.*

**Abstract:** Electric vehicles (EVs) are expected to become widespread in future years. Thus, it is foreseen that EVs will become the new high-electricity-consuming appliances in the households. The characteristics of the extra power load that they impose on the distribution grid follow the patterns of people's random usage behaviors. In this paper, we seek to provide answers to the following question: assigning real-world randomness to the EVs' availability in the households and their charging requirements, how can EVs' demand response (DR) help to minimize the peak power demand and, in general, shape the aggregated demand profile of the system? We present a general demand-shaping problem applicable for limit order bids to a day-ahead (DA) energy market. We propose an algorithm for distributed DR of the EVs to shape the daily demand profile or to minimize the peak demand. Additionally, we put these problems in a game framework. Extensive simulations show that, for certain practical distributions of EVs' usage, it is possible to accommodate EVs for all the users in the system and yet achieve the same peak demand as when there is no EV in the system without any changes in the users' commuting behaviors.

**Charging And Monitoring Of Electric Vehicles Based On Real Time Power System** *D Varghese*

**Abstract:** Electrical vehicles (EVs) have attracted growing attention in recent years. However, daily charging of EVs, throughout travelling and every one alternative time, particularly in peak hours it'll be build congestion on traffic. This project presents a hybrid simulation technique for real time operation of electron volt .Electric vehicle charging supported power for avoiding traffic knowledge congestion. Associate degree intelligent transport system is employed for charging and solar array is projected for speedy charging. Additionally to those options GPS and measuring instrument square measure won't to track EVs position, speed and direction for security. Supersonic sensors square measure well utilised for automatic obstacle detection throughout reverse gear. Operating states of electron volt will be viewed through simulation. Management strategies square measure enforced by victimization PIC microcontroller. Simulation results and experimental results are provided to validate the projected system. Once electricity was among the well-liked strategies for car propulsion, providing grade of comfort and easy operation that would not be achieved by the petrol cars of the time. The inner combustion engine (ICE) has been the dominant propulsion technique for motorcars; however power has remained common place in alternative vehicle varieties, like trains and smaller vehicles of all kinds. Throughout the previous few decades, environmental impact of the petroleum-based transportation infrastructure, in conjunction with the height oil, has semiconductor diode to revived interest in an electrical transportation infrastructure. EVs dissent from fossil fuel-powered vehicles in this the electricity they consume will be generated from a good vary of sources, together with fossil fuels, nuclear energy, and renewable sources like periodic event power, solar energy, and alternative energy or any combination of these. The carbon footprint and alternative emissions of electrical vehicles vary reckoning on the fuel and technology used for electricity generation.

## Probabilistic Agent-Based Model of Electric Vehicle Charging Demand to Analyse the Impact on Distribution Networks *Pol Olivella-Rosell, Roberto Villafafila-Robles, Andreas Sumper and Joan Bergas-Jané*

**Abstract:** Electric Vehicles (EVs) have seen significant growth in sales recently and it is not clear how power systems will support the charging of a great number of vehicles. This paper proposes a methodology which allows the aggregated EV charging demand to be determined. The methodology applied to obtain the model is based on an agent-based approach to calculate the EV charging demand in a certain area. This model simulates each EV driver to consider its EV model characteristics, mobility needs, and charging processes required to reach its destination. This methodology also permits to consider social and economic variables. Furthermore, the model is stochastic, in order to consider the random pattern of some variables. The model is applied to Barcelona's (Spain) mobility pattern and uses the 37-node IEEE test feeder adapted to common distribution grid characteristics from Barcelona. The corresponding grid impact is analyzed in terms of voltage drop and four charging strategies are compared. The case study indicates that the variability in scenarios without control is relevant, but not in scenarios with control. Moreover, the voltages do not reach the minimum voltage allowed, but the MV/LV substations could exceed their capacities. Finally, it is determined that all EVs can charge during the valley without any negative effect on the distribution grid. In conclusion, it is determined that the methodology presented allows the EV charging demand to be calculated, considering different variables, to obtain better accuracy in the results.

**Early Hydrogen Station Economics Analysis** *Changzheng Liu & Zhenhong Lin*

**Abstract:** Deployment of the hydrogen supply infrastructure is one of most critical issues that must be addressed for a successful market transition to fuel cell electric vehicles (FCEV). Not only must hydrogen refuelling infrastructure be constructed, it must also be commercially viable and sell hydrogen to customers at retail prices that will encourage the continued expansion of the vehicle market. The objective of this study is to develop a station deployment optimization model and analyze station network economics and risk of investment. The model optimizes key deployment decisions to meet fuel demand by trading off infrastructure cost and fuel accessibility cost. Decision variables are when, where to build and the size of stations. Fuel accessibility cost is relative to gasoline, measured by additional detour time in order to access hydrogen refuelling stations. A case study is conducted for the City of Santa Monica in California. Deployment schemes generated from the optimization model are relatively robust to assumed level of fuel inconvenience cost, suggesting that the importance of station scale economy outweighs fuel convenience, subject to the caveats of model limitations. The model does not capture the dynamic interaction between vehicle demand and refuelling convenience. If vehicle demand was modelled endogenously, the importance of refuelling convenience would be valued higher by the model. Another factor might be that the area of study is small, which limits potential detour time savings that could be achieved from adding more stations. Cash flow analysis results suggest that the station network at the study area (the city of Santa Monica) may endure negative cash flows for about a decade. Driving patterns of early FCEV adopters matter to the economics of city station network. If FCEV users on average have long annual driving distance and trips are concentrated within the region, the profitability of local station networks would be improved.

**Subject Area**: hydrogen station, optimization, cash flow analysis

**Availability:** Liu, Changzheng, and Zhenhong Lin. "Early Hydrogen Station Economics Analysis." http://www.a3ps.at/site/sites/default/files/downloads/evs28/papers/B4-01.pdf

# Probabilistic estimation of plug-in electric vehicles charging load profile *Nima H. Tehrani, & Peng Wang*

**Abstract:** Plug-in electric vehicles (PEVs) are widely considered as a sustainable mode of transport by countries worldwide due to high efficiency and low or zero carbon emissions. However, PEVs will add significant additional load to the existing power distribution system and it will be a challenge to meet the new demand. In this study, probabilistic modelling has been presented to estimate the system-wide PEV charging load within domestic grids. U.S. national household travel survey data set has been utilized to quantitatively determine the mobility behaviour of PEVs.

Uncertain nature of the problem in modelling and data preparation should be taken into account. Due to the existence of complex interdependencies between the system inputs, the problem definition leads to a multivariate uncertainty analysis problem. The modelling procedure is decomposed into two basic components: the modelling of the marginal distributions; and that of the stochastic dependence structure. In addition, Copula theory is presented for the multivariate modelling of dependent random variable. The results indicate that the PEVs can contribute to increase the load demand at certain hours, although the charging demand is very limited most of the time. Moreover, the probabilistic distribution of aggregated PEV charging demand is compared with that obtained by the Monte Carlo simulation. The numerical results have shown the effectiveness of the proposed methodology.

**Subject Area**: Load profile; Charging demand; PEV; Electric vehicle; Probabilistic modelling; Monte Carlo simulation

## Uncertainty-Based Design of a Bilayer Distribution System for Improved Integration of PHEVs and PV Arrays *ElNozahy, M. & Salama, M.*

**Abstract:** Recent years have seen increased interest in green technologies such as photovoltaic (PV) electricity and plug-in hybrid electric vehicles (PHEVs). Such technologies, however, have been found to be detrimental to distribution networks. This paper introduces a novel distribution system architecture that can better accommodate the expected growth in PV electricity and PHEVs. In the proposed architecture, the distribution system becomes a bilayer system composed of the traditional ac layer that serves existing system loads, plus an embedded dc layer that interfaces with PV arrays and PHEVs. A bidirectional converter interconnects the two layers and controls the power flows between them. This paper presents the key design and operational aspects of the proposed architecture, with consideration of different uncertainties inherent in the system. To this end, a probabilistic benchmark has been developed for modeling these uncertainties and for use with the sizing and scheduling of different system components. Monte Carlo (MC) simulations confirmed the technical and economic merit of the proposed design methodology.

**Subject Area**: Bilayer system; Monte Carlo (MC) simulation; direct current; photovoltaic (PV) arrays; plug-in hybrid electric vehicles (PHEVs)

**An optimization model of energy and transportation systems: Assessing the high-speed rail impacts in the United States** *Venkat Krishnan, Eirini Kastrouni, V. Dimitra Pyrialakou, Konstantina Gkritza, & James D. McCalley*

**Abstract:** This paper presents a long-term investment planning model that co-optimizes infrastructure investments and operations across transportation and electric infrastructure systems for meeting the energy and transportation needs in the United States. The developed passenger transportation model is integrated within the modeling framework of a National Long-term Energy and Transportation Planning (NETPLAN) software, and the model is applied to investigate the impact of high -speed rail (HSR) investments on interstate passenger transportation portfolio, fuel and electricity consumption, and 40-year cost and carbon dioxide ($CO_2$) emissions. The results show that there are feasible scenarios under which significant HSR penetration can be achieved, leading to reasonable decrease in national long-term $CO_2$ emissions and costs. At higher HSR penetration of approximately 30% relative to no HSR in the portfolio promises a 40-year cost savings of up to \$0.63 T, gasoline and jet fuel consumption reduction of up to 34% for interstate passenger trips, $CO_2$ emissions reduction by about 0.8 billion short tons, and increased resilience against petroleum price shocks. Additionally, sensitivity studies with respect to light-duty vehicle mode share reveal that in order to realize such long-term cost and emission benefits, a change in the passenger mode choice is essential to ensure higher ridership for HSR.

**Charging Behavior Impacts on Electric Vehicle Miles Travel: Who is Not Plugging in?** *Gil Tal; Michael A. Nicholas; Jamie Davies; & Justin Woodjack*

**Abstract:** The growing plug-in electric vehicle (PEVs) market features new models of battery electric vehicles (BEVs) and Plug-in hybrid vehicles (PHEVs) with varying battery sizes and electric driving range. How are these different models being used in the real world? A common assumption in PEV impact analysis is that PEV owners will maximize their vehicle utility by appropriately sizing their battery to their driving needs and by charging their vehicles as much as possible to recover the cost of the vehicle purchase. Based on these assumptions we expect a high correlation between PHEV owners usage of the vehicle and the number of plug-in events, and we expect drivers of PHEVs with small battery to plug in more than owners of vehicles with a larger battery and similar driving patterns. This paper examines the assumptions presented using a survey of more than 3,500 PEV owners conducted in California from May and June 2013. The online survey includes extensive data on driving and charging behavior using web-map questions and includes owners of all PEV models in the market including more than 600 Volts and 800 Plug-in Priuses. The results show that small battery PHEV electric vehicle miles traveled (eVMT) are lower than larger range PHEV or BEVs not only because of the battery size but also as a result of the public charging availability and charging behavior. Higher electric range PHEV and BEV drivers charge more often and report more charging opportunities in the same areas that smaller battery PHEVs could not find chargers.

**Subject Area**: PEVs; BEVs; PHEVs; battery size; electric driving range

# Power quality of actual grids with plug-in electric vehicles in presence of renewables and micro-grids *R. Romo, & O. Micheloud*

**Abstract:** The penetration of plug-in electric and hybrid-electric vehicles (PEVs and PHEVs) will increase significantly in the next 20 years. The insertion of PEVs in households will facilitate the use of renewable sources and possibly create economic benefits to users, as shown in a Mexican example here presented, but also will introduce some challenges such as how the penetration of PEVs affect the quality of existing power grids. The contribution of this work is to review the literature in reference to the power quality problems and to test them in a real distribution system based on the Mueller community in Austin, Texas that has PEVs and photovoltaic panels (PVs). The results show that a coordinated delay charge mode reduces the loading on transformers at peak hours and improves voltage regulation. Additionally, it is shown that photovoltaic panels introduce a power factor reduction during daytime in the main feeder. Corrective measures should be considered for high levels of PV penetration, such as reactive power support, VAr compensators or community energy storage, which can be presented as one potential solution to most of the problems listed in current literature. However, more research needs to be done in a much broader scale because power systems differ from each other and between countries, but there is a consensus that high power demand by PEVs leads to voltage statutory violations at some points in the grid and smart charging is required to operate the system efficiently.

# Scalable Real-Time Electric Vehicles Charging With Discrete Charging Rates

*Binetti, G.; Davoudi, A. ;   Naso, D. ;   Turchiano, B. ;   Lewis, F.L.*

**Abstract:** Large penetration of electric vehicles (EVs) can have a negative impact on the power grid, e.g., increased peak load and losses, that can be largely mitigated using coordinated charging strategies. In addition to shifting the charging process to the night valley when the electricity price is lower, this paper explicitly considers the EV owner convenience that can be mainly characterized by a desired state of charge at the departure time. To this end, the EV charging procedure is defined as an uninterruptible process that happens at a given discrete charging rate and the coordinated charging is formulated as a scheduling problem. The scalable real-time greedy (S-RTG) algorithm is proposed to schedule a large population of EVs in a decentralized fashion, explicitly considering the EV owner criteria. Unlike the majority of existing approaches, the S-RTG algorithm does not rely on iterative procedures and does not require heavy computations, broadcast messages, or extensive bi-directional communications. Instead, the proposed algorithm schedules one EV at a time with simple computations, only once (i.e., at the time the EV connects to the grid), and only requires low-speed communication capability making it suitable for real-time implementation. Numerical simulations with significant EVs penetration and comparative analysis with scheduling policies demonstrate the effectiveness of the proposed algorithm.

**Subject Area**: Charging; electric vehicle (EV); scheduling algorithm; smart grid.

# Voltage Security Considerations in Optimal Operation of BEVs/PHEVs Integrated Microgrids *Khorramdel, B. Khorramdel, H. ; Aghaei, J. ; Heidari, A. ; & Agelidis, V.G.*

**Abstract:** Nowadays, it is a common concern for modern electrical networks and energy management systems to derive an optimal operation management considering energy costs, pollutant emissions, and security, of the system in the presence of plu g-in electric vehicles (PEVs). In this paper, a multiobjective optimization problem is solved to schedule power sources in a typical microgrid, while PEVs are viewed as a stochastic factor. PEVs residing in a city are considered as probable loads and/or generations depending on how they interact with the utility grid. A novel stochastic methodology is used to calculate the 24 h expected power demand and generation of vehicles aggregated in municipal parking lots. The objective functions of the problem are voltage security margin to be maximized and the total power losses, the total electrical energy costs, and the total emissions of power sources, which should be minimized. Based on different scenarios, the impact of PEVs penetration on base load, voltage profile, and also the value of objective functions, are assessed. Numerical results show the effect of different fleets of PEVs, as well as on the operation of future microgrids.

**Subject Area**: Batteries, Cities and towns, Fuel cells, Microgrids, Probabilistic logic, Security, System-on-chip

## Potential to Electrify Miles with Different Plug-in Vehicle Innovation Paths *D. J. Santini, and Y. Zhou*

**Abstract:** With their high energy and power capabilities, lithium ion batteries allow many powertrain combinations and permutations. California regulators credit two plug-in technology innovation paths: (1) PHEVs spun-off from HEVs; (2) battery electric vehicles (BEV) and REX/BEVx spun off from BEVs, where x signifies limited gasoline engine range extension. A third path is the "Super EV" with 200+ mile range and >302 hp, far more than otherwise available BEVs. Data on 2014 commercial plug-in vehicles is presented. Past cost of ownership studies focusing on path 1 PHEVs and path 2 BEVs are discussed. Price and marketability implications are examined. A thought experiment is derived, informed by marketability and financial payback considerations, assuming regular use of 50-100% of a BEV battery pack and 100+% of a PHEV or REX/BEVx pack. The BEV is chosen by customers driving less miles than the hypothetical maximum electric range; PHEVs and REX/BEVx vehicles by those driving further. Promising potential to electrify miles nationwide is estimated with modified option 2 BEVx designs. Financially, the best path 2 market segment is new, low density single family construction where the vehicle makes long commutes at relatively high average speed. The REX/BEVx range extension feature can be effective because a significant proportion of total national miles (42%) is caused by a relatively few vehicles (12%) driving beyond the range of most currently available BEVs (~ 70 miles). Some 45% of those miles could be electrified by a BEVx with 70 miles of electric range with one charge per day. Adaptation of BEVx range extension would enhance REX/BEVx marketability, increasing national fleet-wide GHG and oil use reduction.

**Subject Area**: lithium ion batteries; PHEV; BEV; electric range

# Hierarchical Charge Control of Large Populations of EVs *Shao, C.; Wang, X. ; Wang, X;  Du, C.;  & Wang, B.*

**Abstract:** Cooperation between the controllable load, such as electrical vehicles (EVs) and the generation, provides the power system new operating strategies. A novel hierarchical charge control framework is proposed based on the Benders decomposition for large populations of EVs. The grid, unit, and accurate EV constraints can be considered. On the upper level, the cooperative dispatch scheme between the generation and the EV aggregators is obtained. On the lower level, the feasibility of the scheme is checked with EV constraints considered. The levels are coordinated by the Benders cuts. In addition, the distributed approximate Benders cuts is also proposed, which helps to protect user privacy and a three-level framework is developed based on the decentralized control. The case studies on IEEE Reliability Test System have verified the proposed framework and method is valid and feasible. The charge control based on it can minimize the grid operation cost and improve the unit operating efficiency.

**Subject Area**: Batteries; Discharges (electric); Indexes; Linear programming; Privacy Sociology; Statistics

# Exploring the Drivers' side of the "Blend Wall": U.S. Consumer Preferences for Ethanol Blend Fuels *Francisco X. Aguilar, Zhen Cai, Phillip Mohebalian, & Wyatt Thompson*

**Abstract:** Analysis of stated preferences from over 2,300 U.S. respondents show that general attitudes nationwide favor the use of ethanol as a motor fuel but a sizeable segment (~ 20%) indicated strong unwillingness to buy ethanol blend fuels. Results from a discrete choice experiment analyzed using mixed logit regressions show that, all else constant, price-per-gallon and miles-per-gallon dominated preferences for fuel attributes but ethanol content made the average consumer more likely to choose a blend fuel. Findings provide strong evidence of heterogeneity in preferences driven by attitudes but also affected by age and income. At a point of price per mile equivalence for ethanol and gasoline, in a market where gasoline, E20 and E85 were available with no regulatory, supply or technological constraints, E85 would dominate market share. In this case ethanol would account for 56% of volume of motor fuels consumed. Our results show a high level of consumer substitutability of gasoline with ethanol and willingness to choose high ethanol blend fuels - which could help expand ethanol use beyond the current regulatory and technological limits of the blend wall.

**Subject Area**: Ethanol fuel blends; Choice-based model; Mixed effects logistic regression; Market share analysis; US

# Robust Optimization for Bidirectional Dispatch Coordination of Large-Scale V2G *Bai, X. and Qiao, W.*

**Abstract:** This paper proposes a robust optimization (RO) model for bidirectional dispatch coordination of large-scale plug-in electric vehicles (PEVs) in a power grid in which the PEVs are aggregated to manage. The PEV aggregators are considered as a type of dispatchable demand response and energy storage resource with stochastic behaviors, and can supply load or provide ancillary services such as regulation reserve to the grid. The proposed RO model is then reformulated as a mixed-integer quadratic programming model, which can be solved efficiently. Computer simulations are performed for a power grid with ten generators and three PEV aggregators to validate the economic benefit of the RO model for bidirectional dispatch coordination of the PEVs and the robustness of the RO model to the uncertainty of the PEVs' stochastic mobility behaviors.

## Effects of Regional Temperature on Electric Vehicle Efficiency, Range, and Emissions in the United States *Tugce Yuksel and Jeremy J Michalek*

**Abstract:** We characterize the effect of regional temperature differences on battery electric vehicle (BEV) efficiency, range, and use-phase CO2 emissions in the U.S. The efficiency of a BEV varies with ambient temperature due to battery efficiency and cabin climate control. We find that annual energy consumption of BEVs can increase by an average of 15% in the Upper Midwest or in the Southwest compared to the Pacific Coast due to temperature differences. Greenhouse gas (GHG) emissions from EVs vary primarily with marginal regional grid mix – which has twice the GHG-intensity in the Upper Midwest as on the Pacific Coast. However, even within a grid region, BEV emissions vary by up to 22% due to spatial and temporal ambient temperature variation and its implications for vehicle efficiency and charging duration and timing. Cold climate regions also encounter days with substantial reduction in EV range: the average range of a Nissan Leaf on the coldest day of the year drops from 70 miles on the Pacific Coast to less than 45 miles in the Upper Midwest. These regional differences are large enough to affect adoption patterns and energy and environmental implications of BEVs relative to alternatives.

**Subject Area**: Battery efficiency; regional temperature; EV range

## Stochastic Modeling of Battery Electric Vehicle Driver Behavior Impact of Charging Infrastructure Deployment on the Feasibility of Battery Electric Vehicles  *Jing Dong, Zhenhong Lin*

**Abstract:** A stochastic modeling approach is proposed to characterize battery electric vehicle (BEV) drivers' behavior. The approach uses longitudinal travel data and thus allows more realistic analysis of the impact of the charging infrastructure on BEV feasibility. BEV feasibility is defined as the probability that the ratio of the distance traveled between charges to the BEV range is kept within a comfort level (i.e., drivers are comfortable with driving the BEV when the battery's state of charge is above a certain level). When the ratio exceeds the comfort level, travel adaptation is needed—use of a substitute vehicle, choice of an alternative transportation mode, or cancellation of a trip. The proposed stochastic models are applied to quantify BEV feasibility at different charging infrastructure deployment levels with the use of GPS-based longitudinal travel data collected in the Seattle, Washington, metropolitan area. In the Seattle case study, the range of comfort level was found to be critical. If BEV drivers were comfortable with using all the nominal range, about 10% of the drivers needed no or little travel adaptation (i.e., they made changes on less than 0.5% of travel days), and almost 50% of the drivers needed travel adaptation on up to 5% of the sampled days. These percentages dropped by half when the drivers were only comfortable with using up to 80% of the range. In addition, offering opportunities for one within-day recharge can significantly increase BEV feasibility, provided that the drivers were willing to make some travel adaptation (e.g., up to 5% of drivers in the analysis).

**Subject Area:** stochastic model; BEV; charging infrastructure

**Charging Behavior Impacts on Electric Vehicle Miles Traveled Who Is Not Plugging In?** *Gil Tal, Michael A. Nicholas, Jamie Davies, & Justin Woodjack*

**Abstract:** The growing market for plug-in electric vehicles (PEVs) features new models of battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) with varying battery sizes and electric driving ranges. How are the various models being used in the real world? A common assumption in PEV impact analysis is that PEV owners will maximize their vehicle's utility by appropriately sizing the battery to their driving needs and by charging their vehicle as much as possible to recover the cost of the vehicle purchase. On the basis of these assumptions, a high correlation between PHEV owner use of the vehicle and the number of plug-in events is expected, and drivers of PHEVs with a small battery are expected to plug in more than do owners of vehicles with a larger battery and similar driving patterns. The assumptions presented are examined through a survey of more than 3,500 PEV owners conducted in California in May and June 2013. The online survey included extensive data on driving and charging behavior using web map questions. Owners of all PEV models on the market, including more than 600 Volts and 800 Prius Plug-Ins, were surveyed. The results show that small-battery PHEV electric vehicle miles traveled are lower than longer-range PHEV or BEV electric vehicle miles traveled not only because of battery size but also because of public charging availability and charging behavior. Higher electric-range PHEV and BEV drivers charge more often and report more charging opportunities in areas where smaller-battery PHEVs could not find chargers.

**Subject Area:** PEVs; BEV's; PHEVs' charging behavior

# Steps Toward A Net-Zero Campus With Renewable Energy Resources *Andrew Clarke*

**Abstract:** With the increasing attention and support behind plug in hybrid electric vehicles, research must be conducted to examine the impacts of vehicles on electric distribution and transmission systems. This research aims first to model the behavior of vehicle battery chargers during system disturbances and mitigate any impacts. A distribution test system example is modeled and several different vehicle charger topologies are added. Faults are applied to the distribution system with vehicle chargers connected and the results are examined. Based on these results, a control strategy to mitigate their negative impacts is suggested. Photovoltaic panels are then added to the system and the study is repeated. Several services that plug in hybrid electric vehicles are capable of providing to the electric system are presented in order to allow electric vehicles to be seen as an asset to electric systems rather than a burden. These services are particularly focused on an electric system such as might be found on a college campus, which in this case is represented by the Clemson University electric distribution system. The first service presented is dynamic phase balancing of a distribution system using vehicle charging. Distribution systems typically face problems with unbalance. At most large car parks, a three phase electric supply is expected even though current standardized chargers are single phase. By monitoring system unbalance and choosing which phase a vehicle is allowed to charge from, unbalance between phases is reduced in a distribution system. The second service presented is a decentralized vehicle to campus control algorithm based on time of use rates. Using time of use electricity prices, discharging vehicle batteries during high prices and recharging at low prices is explored. Battery degradation as well as limits placed by required vehicle range availability are included in the decision on whether to charge or discharge. Electric utilities will also benefit from a reduction of load at peak times if vehicles discharge back to the campus. A comparison with stationary battery energy storage is included.

**Subject Area:** peak loading; vehicle batteries; electric vehicles

**Quantifying EV Battery End-of-Life through Analysis of Travel Needs with Vehicle Powertrain Models** *Samveg Saxena, Caroline Le Floch, Jason MacDonald, & Scott Moura*

**Abstract:** Electric vehicles enable clean and efficient transportation, however concerns about range anxiety and battery degradation hinder EV adoption. The common definition for battery end-of-life is when 70-80% of original energy capacity remains, however little analysis is available to support this retirement threshold. By applying detailed physics-based models of EVs with data on how drivers use their cars, we show that EV batteries continue to meet daily travel needs of drivers well beyond capacity fade of 80% remaining energy storage capacity. Further, we show that EV batteries with substantial energy capacity fade continue to provide sufficient buffer charge for unexpected trips with long distances. We show that enabling charging in more locations, even if only with 120V wall outlets, prolongs useful life of EV batteries. Battery power fade is also examined and we show EVs meet performance requirements even down to 30% remaining power capacity. Our findings show that defining battery retirement at 70-80% remaining capacity is inaccurate. Battery retirement should instead be governed by when batteries no longer satisfy daily travel needs of a driver. Using this alternative retirement metric, we present results on the fraction of EV batteries that will be retired with different levels of energy capacity fade.

**Subject Area:** electric vehicles; battery degradation; capacity fade; power fade; battery second life; battery retirement

## Peak-Minimizing Online EV Charging: Price-of- Uncertainty and Algorithm Robustification *Shizhen Zhao, Xiaojun Lin & Minghua Chen*

**Abstract:** We study competitive online algorithms for EV (electrical vehicle) charging under the scenario of an aggregator serving a large number of EVs together with its background load, using both its own renewable energy (for free) and the energy procured from the external grid. The goal of the aggregator is to minimize its peak procurement from the grid, subject to the constraint that each EV has to be fully charged before its deadline. Further, the aggregator can predict the future demand and the renewable energy supply with some levels of uncertainty. The key challenge here is how to develop a model that captures the prior knowledge from such prediction, and how to best utilize this prior knowledge to reduce the peak under future uncertainty. In this paper, we first propose a 2-level increasing precision model (2-IPM), to capture the system uncertainty. We develop a powerful computation approach that can compute the optimal competitive ratio under 2-IPM over any online algorithm, and also online algorithms that can achieve the optimal competitive ratio. A dilemma for online algorithm design is that an online algorithm with good competitive ratio may exhibit poor average-case performance. We then propose a new Algorithm- Robustification procedure that can convert an online algorithm with reasonable average-case performance to one with both the optimal competitive ratio and good average-case performance. The robustified version of a well-known heuristic algorithm, Receding Horizon Control (RHC), is found to demonstrate superior performance via trace-based simulations.

**Subject Area:** Electric Vehicles charging; aggregator; RHC

## A Comprehensive Analysis of Plug in Hybrid Electric Vehicles to Commercial Campus (V2C) *Andrew D. Clarke, Elham B. Makram*

**Abstract:** Vehicle to grid is an emerging technology that utilizes plug in hybrid electric vehicle batteries to benefit electric utilities during times when the vehicle is parked and connected to the electric grid. In its current form however, vehicle to grid implementation poses many challenges that may not be easily overcome and many existing studies neglect critical aspects such as battery cost or driving profiles. The goal of this research is to ease some of these challenges by examining a vehicle to grid scenario on a university campus, as an example of a commercial campus, based on time of use electricity rates. An analysis of this scenario is conducted on a vehicle battery as well as a stationary battery for comparison. It is found that vehicle to campus and a stationary battery both have the potential to prove economical based on battery cost and electricity rates.

# Understanding Fuel Cell Plug-In Hybrid Electric Vehicle Use, Design, And Functionality *Shawn Salisbury*

**Abstract:** The fuel cell plug-in hybrid electric vehicle (FCPHEV) has been shown to be a promising vehicle architecture in terms of cost, emissions reduction, and reducing petroleum use. It combines a high power battery pack and a small fuel cell to make a zero emissions vehicle with all of the capabilities of current consumer vehicles. Previous FCPHEV studies have projected vehicle cost, emissions, and efficiency, but little work has been performed towards understanding the use, design, and functionality of the architecture. This study presents several topics which will help to advance the state of the FCPHEV.

Plug-in hybrid vehicles, including FCPHEVs, can use two different sources of fuel depending upon how the vehicle is driven and charged. To quantify this fuel use, SAE J2841 establishes a utility factor method based upon transportation survey data that includes assumptions about vehicle use and battery charging habits. The utility factor model is an important tool for automakers, consumers, and researchers, and it is used by the EPA to determine the fuel economy of plug-in hybrid vehicles. In the Section A of this study, the utility factor model is examined and compared to data collected from over 1,400 Chevrolet Volts in order to assess its accuracy. Until now, there has been no large-scale set of vehicle data to which the model could be compared. Results show that the assumptions of the J2841 utility factor model are not representative of the driving behavior of this set of plug-in vehicles. A hydrogen fueled vehicle requires a high pressure gaseous fuel storage and delivery system that is very different than the fueling systems of current conventional vehicles. The design and execution of the system is critical to the safety and functionality of an FCPHEV, but previous literature on hydrogen fueled vehicles covers fuel systems in little detail. Section B of this study details the considerations that one must make when designing a high pressure hydrogen fuel system and provides an example of how those considerations were met for the FCPHEV built by Colorado State University in the EcoCAR 2 competition.

The FCPHEV built for the EcoCAR 2 competition is the first of its kind to publish real-world driving data. Data taken from the vehicle during on-road testing is analyzed in Section C of this study to prove the FCPHEV concept and increase the understanding of overall system operation. The results of the driving tests demonstrate the viability of the FCPHEV and highlight its advantages over current zero emissions vehicle architectures.

**Subject Area:** fuel cell plug-in hybrid electric vehicle;

# On the Complexity of Optimal Electric Vehicles Recharge Scheduling *Cristina Rottondi, Giacomo Verticale, & Giovanni Neglia*

**Abstract:** The massive introduction of Electric Vehicles (EVs) is expected to significantly increase the power load experienced by  the electrical grid, but also to foster the exploitation of renewable energy sources: if the charge process of a fleet of EVs is scheduled by an intelligent entity such as a load aggregator, the EVs' batteries can contribute in flattening energy production peaks due to the intermittent production patterns of renewables by being recharged when energy production surpluses occur. To this aim, time varying energy prices are used, which can be diminished in case of excessive energy production to incentivize energy consumption (or increased in case of shortage to discourage energy utilization). In this paper we evaluate the complexity of the optimal scheduling problem for a fleet of EVs aimed at minimizing the overall cost of the battery recharge in presence of time variable energy tariffs. The scenario under consideration is a fleet owner having full knowledge of the customers' traveling needs at the beginning of the scheduling horizon. We prove that the problem has polynomial complexity, provide complexity lower and upper bounds, and compare its performance to a benchmark approach which does not rely on prior knowledge of the customers' requests, in order to evaluate whether the additional complexity required by the optimal scheduling strategy w.r.t. the benchmark is worthy the achieved economic advantages. Numerical results show considerable cost savings obtained by the optimal scheduling strategy.

**Subject Area:** Optimization; Modeling; Electric Vehicles, Vehicle-to-Grid Interactions; Optimal Recharge Scheduling

**Quantifying EV Battery End-of-Life through Analysis of Travel Needs with Vehicle Powertrain Models** *Samveg Saxena, Caroline Le Floch, Jason MacDonald, & Scott Moura*

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# Understanding fuel cell plug-in hybrid electric vehicle use, design, and functionality *Salisbury, Shawn*

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**Subject Area:** Fuel Cell ; Plug-In Hybrid Vehicle

**Availability:** Salisbury, Shawn. Understanding Fuel Cell Plug-In Hybrid Electric Vehicle Use, Design, And Functionality. Diss. Colorado State University, 2014.
http://digitool.library.colostate.edu/R/34ACBLHN3LFS53RM5T2G63JSEE1DCMFQQQAUG9QK44GD6PCFBQ-00521

# 4. Environment

**A Consumption-Based Greenhouse Gas Inventory of San Francisco Bay Area Neighborhoods, Cities and Counties: Prioritizing Climate Action for Different Locations** *Jones, Christopher M. & Kammen, Daniel M.*

**Abstract:** This study develops a consumption-based greenhouse gas inventory of all San Francisco Bay Area census block groups, cities and counties. It is the first study to explore household carbon footprints at such fine geospatial resolution for any region. The methodology incorporates local consumption and emissions data wherever possible. In other cases, consumption is approximated using econometric analysis of national and statewide transportation and household consumption survey responses by S.F. Bay Area residents. The consumption-based method results in about 35% higher GHG emissions than the traditional territorial approach for the region, largely due to higher emissions from imported food and goods. Transportation is the largest source of emissions (33%), followed by food (19%), goods (18%), services (18%) heating fuels (5%), home construction (3%), electricity (2%) and 1% waste. Within the region there are large differences in the size of average household carbon footprints (HCF) between cities (>2.5x) and larger differences between neighborhoods within populous cities (~5x). These differences suggest large inequalities in climate responsibility within a single metropolitan area the composition of household carbon footprints also varies considerably between different locations, with vehicle ownership, income, household size and home size contributing the most to differences. The study concludes with recommendations to prioritize policies and programs for different locations.

**Subject Area**: Carbon footprint, consumption-based emission inventory, greenhouse gas inventory, climate change mitigation, input-output, life cycle assessment, San Francisco Bay Area

**Availability:** Jones, Christopher M., and Daniel M. Kammen. "A Consumption-Based Greenhouse Gas Inventory of San Francisco Bay Area Neighborhoods, Cities and Counties: Prioritizing Climate Action for Different Locations." Bay Area Air Quality Management District (2015). http://escholarship.org/uc/item/2sn7m83z.pdf

# Life cycle emissions and cost model for urban light duty vehicles *Lambros K. Mitropoulos & Lambros K. Mitropoulos*

**Abstract:** The growth of vehicle sales and use internationally requires the consumption of significant quantities of energy and materials, and contributes to the deterioration of air-quality and climate conditions. Advanced propulsion systems and electric drive vehicles have substantially different characteristics and impacts. They require life cycle assessments and detailed comparisons with gasoline powered vehicles which, in turn, should lead to critical updates of traditional models and assumptions. For a comprehensive comparison of advanced and traditional light duty vehicles, a model is developed that integrates external costs, including emissions and time losses, with societal and consumer life cycle costs. Life cycle emissions and time losses are converted into costs for seven urban light duty vehicles. The results, which are based on vehicle technology characteristics and transportation impacts on environment, facilitate vehicle comparisons and support policy making in transportation. Substantially, more sustainable urban transportation can be achieved in the short-term by promoting policies that increase vehicle occupancy; in the intermediate-term by increasing the share of hybrid vehicles in the car market and in the long-term by the widespread use of electric vehicles. A sensitivity-analysis of life cost results revealed that vehicle costs change significantly for different geographical areas depending on vehicle taxation, pricing of gasoline, electric power and pollution. Current practices in carbon and air quality pricing favor oil and coal based technologies. However, increasing the cost of electricity from coal and other fossil fuels would increase the variable cost for electric vehicles, and tend to favor the variable cost of hybrid vehicles.

## Connecting Household Socioeconomics and Travel Carbon Footprint: Empirical Results from High-Resolution GPS Household Travel Survey *Yao, Zhuo, Heng Wei, Andrew Rohne, Jonathan Corey, Harikishan Perugu, and Hao Liu*

**Abstract:** Household travel related carbon emissions have been identified as one of the major contributors of greenhouse gases. There is a strong theory support for the fact that household travels and its associated carbon footprints are greatly related with land use type and socioeconomics of the household. However, the current method for quantifying the carbon footprint related with household travel was estimated using aggregated vehicle activity data (i.e. average speed) from sources such as the National Household Travel Survey, American Community Survey, etc. As it gains more popularity, the GPS-based household travel survey stranded out because it provides high-resolution travel trajectory data which maximizes the capability of emission models and produces more accurate results. This research connects the household travel carbon footprint with the land use and socioeconomics of the household by utilizing the greater Cincinnati GPS household travel survey data. The household travels are accurately mapped and traced with their socioeconomics and demographic characteristics. Specifically, the carbon emissions were calculated by the MOVES model and compared across household number of workers, income, life cycle and area type. This research establishes a timely reference connecting household socioeconomic and demographic characteristics with its travel related carbon emissions using the best available high-resolution data. It provides solid grounds for analyzing, modeling and evaluating sustainable development strategies, adaptive planning policies etc. and contributes to regional carbon emission management strategies.

**Subject Area**: Carbon emissions; GHGs

**Modeling Travel Choices to Assess Potential Greenhouse Gas Emissions Reductions** *Nam, Richard; Dowds, Jonathan; Lee, Brian H Y; Aultman-Hall, Lisa & Johnson, Alyssa*

**Abstract:** This report summarizes a set of projects that examine different aspects of travel behavior that influence fuel consumption and greenhouse gas (GHG) emissions. Two of these projects, described in Sections 2 and 3, examined how households choose to allocate vehicles among drivers and the potential for alternative vehicle allocations among household members to reduce fuel consumption. These two projects drew on data from the National Household Travel Survey (NHTS) to estimate the potential fuel savings from intra-household vehicle reallocations that ensure that the relative usage of each vehicle in the household corresponds to that vehicle's relative fuel efficiency among all vehicles in the household. In Section 2, this analysis assumes that all vehicles can be substituted for one another regardless of their passenger and cargo capacities. Section 3 builds on this analysis by limiting potential reallocation to vehicles with similar passenger and cargo capacities. Section 4 of this report describes the execution the Northeast Travel Choice Survey (NTCS), which asked respondents a range of questions related to travel behavior, demographics, vehicle ownership, as well as about commute, home and work location characteristics. The results of the NTCS provided the basis for the final two projects summarized in this report. One of these projects, described in Section 5, examined the commuters' willingness to use ridesharing, one method for reducing overall vehicle miles traveled (VMT). Section 6 describes an analysis of the impact of workplace and commute-corridor accessibility on annual VMT.

**Subject Area**: Commuters; Commuting; Demographics; Fuel consumption; Greenhouse gases; Mode choice; Pollutants; Ridesharing; Surveys; Travel behavior; Vehicle miles of travel

# Big Data for Urban Sustainability: Integrating Personal Mobility Dynamics in Environmental Assessments *Hua Cai*

**Abstract:** To alleviate fossil fuel use, reduce air emissions, and mitigate climate change, "new mobility" systems start to emerge with technologies such as electric vehicles, multi-modal transportation enabled by information and communications technology, and car/ride sharing. Current literature on the environmental implications of these emerging systems is often limited by using aggregated travel pattern data to characterize personal mobility dynamics, neglecting the individual heterogeneity. Individual travel patterns affect several key factors that determine potential environmental impacts, including: charging behaviors, connection needs between different transportation modes, and car/ride sharing potentials. Therefore, to better understand these emerging systems and inform decision making, travel patterns at the individual level need to be taken into account in environmental assessments. Using vehicle trajectory data of over 10,000 taxis in Beijing, this research demonstrates the benefits of integrating individual travel patterns into environmental assessments through three case studies (vehicle electrification, charging station siting, and ride sharing) focusing on two emerging systems: electric vehicles and ride sharing. Results from the vehicle electrification case study show that individual travel patterns can impact the environmental performance of fleet electrification. When unit battery cost exceeds $200/kWh, vehicles with greater battery range cannot continuously improve travel electrification and may even reduce the overall electrification rate. At the current unit battery cost of $400/kWh, targeting subsidies to vehicles with battery range around 90 miles can achieve higher electrification rate. The public charging station siting case study demonstrates that individual travel patterns can better estimate charging demand and guide public charging infrastructure development. Charging stations sited according to individual travel patterns can increase electrification rate by 59% to 88% compared to the existing sites. Lastly, results from the ride sharing case study indicate that trip details extracted from vehicle trajectory data enable dynamic ride sharing modeling. Shared taxi rides in Beijing can reduce total fleet travel distance and air emissions by 33% with 10-minute travel time deviation tolerance. Only minimal tolerance to travel time change (4 minutes) is needed from the riders to enable significant ride sharing (sharing 60% of the trips and saving 20% of travel distance). In summary, vehicle trajectory data can be integrated into environmental assessments to capture individual travel patterns and improve our understanding of the emerging transportation systems.

**Subject Area**: EV, ride sharing; Beijing; public charging; environmental assessment

# Travel behaviour and CO2 emissions in urban and exurban London and New York *Caralampo Focas*

**Abstract:** Car travel and associated greenhouse gas emissions per capita in London's outer region are more than double than the ones of its metropolitan area. In New York's outer region car travel is four times per capita than what it is in its urban area. The comparative analyses are based on the UK National Travel Survey and the US National Household Travel Survey. The population outside Greater London' Green Belt and New York's periphery has been growing relentlessly since the 1950s. The transport structure of the South East of England and the New York Tri-State area has been largely shaped around the private car. Measures that aim to meet $CO_2$ emission targets will need address the nature of the car dependent developments of London's and New York's growing outer fringe. The paper compares the current travel structure of the outer regions of the two cities that are nearly exclusively moulded around the motorcar. Using specially commissioned spatial breakdowns of the respective household travel survey data, detailed travel behaviour is analysed for both the urban and exurban areas. The data illustrates the stark contrast in mobility of the urban and exurban areas of the cities. Through an analysis of current vehicle use, estimates of $CO_2$ emissions are made using established average emission factors per vehicle in each region. In our study of London and New York regions the exurban areas produce the bulk of car-based $CO_2$ emissions: 77% for the London region and 87% for the New York region. Furthermore, using existing population forecasts and estimates of future average $CO_2$ emissions per vehicle, future levels of $CO_2$ emissions from private vehicles are estimated. Our estimates show that the $CO_2$ emission reduction targets that have been set will not be met by a large margin.

**Energy and Emissions from US Population Shifts and Implications for Regional GHG Mitigation Planning** *Rachel Marie Hoesly, H. Scott Matthews, and Chris Hendrickson*

**Abstract:** Living in different areas is associated with different impacts; the movement of people to and from those areas will affect energy use and emissions over the US. The emissions implications of state-to-state migration on household energy and GHG emissions are explored. 3 million households move across state lines annually, and generally move from the North East to the South and West. Migrating households often move to states with different climates, and thus heating and cooling and needs, different fuel mixes, and different regional electricity grids which leads them to experience changes in household emissions as a result of their move. Under current migration trends, the emissions increases of households moving from the Northeast to the South and Southwest are balanced by the emissions decreases of households moving to California and the Pacific Northwest. The net sum of emissions changes for migrating households is slightly positive but near zero; however, that net zero sum represents the balance of many emission changes. Planning for continued low carbon growth in low carbon regions or cities experiencing high growth rates driven by migration is essential in order to offset the moderate emissions increases experienced by households moving to high carbon regions.

**Subject Area**: GHG; emissions; carbon growth

# Combined Application of Multi-Criteria Optimization and Life-Cycle Sustainability Assessment for Optimal Distribution of Alternative Passenger Cars in U.S. *Nuri Cihat Onat, Murat Kucukvar, Omer Tatari & Qipeng Phil Zheng*

**Abstract:** This research aims to advance the existing sustainability assessment framework for alternative passenger cars with a combination of life-cycle sustainability assessment and multi-criteria decision-making. To this end, sixteen macro-level sustainability impacts are evaluated for seven different vehicle types: internal combustion vehicles, hybrid electric vehicles, plug-in hybrid electric vehicles with all-electric ranges of 16, 32, 48, and 64 kilometers of electric powered drive, and battery electric vehicles. Additionally, two battery charging scenarios are considered in this analysis with respect to plug-in hybrid electric vehicles and battery electric vehicles; Scenario 1 is based on existing electric power infrastructure in the U.S., while Scenario 2 is an extreme scenario in which electricity to power battery electric vehicles and plug-in hybrid electric vehicles is generated entirely via solar charging stations. In this study, optimal vehicle distributions are calculated based on the environmental, social, and economic impacts of all vehicle types for each scenario. Various distributions are presented in accordance with the relative importance assigned to each indicator, with different weighting scenarios applied to account for variability in decision-makers' priorities, such as the assignment of higher weights to socio-economic indicators and lower weights to environmental indicators (e.g. minimizing greenhouse gas emissions). In a balanced weighting case (i.e when environmental and socio-economic indicators have equal importance) under Scenario 1, hybrid electric vehicles have the largest fleet share, comprising 91% of the optimal U.S. passenger car fleet, while internal combustion vehicles dominate the optimal fleet with 99.5% of the optimal fleet share when only socio-economic indicators are given priority. On the other hand, in a balanced weighting case under Scenario 2, the optimal U.S. passenger car fleet consists entirely (100%) of plug-in hybrid electric vehicles with 16 kilometers of all-electric range. In the majority of the considered weighting scenarios, battery electric vehicles were not given any share of the optimal vehicle fleet. The proposed framework can be used as a practical decision-making platform when deciding which vehicle type to promote given each vehicle type's respective environmental, social, and economic impacts. Considering that decision makers are often highly influenced by the "silo effect", i.e. a lack of communication among different agencies and departments, the proposed framework provides a holistic system-based approach to minimize the silo effect and can enhance the efficiency of future inter/cross/trans-disciplinary works. Furthermore, the outcomes of this study can pave the way for advancement in the state-of-the-art and state-of-the-practice of current sustainability research.

**Subject Area**: Life cycle sustainability assessment; alternative passenger cars; multi-criteria decision making; sustainable transportation; triple bottom line

**From Cradle to Junkyard: Assessing the life cycle Greenhouse Gas Benefits of Electric Vehicles** *Archsmith, James, Alissa Kendall, and David Rapson*

**Abstract:** U.S. programs subsidize electric vehicles (EVs) in part to reduce greenhouse gas (GHG) emissions. We model a suite of life cycle GHG emissions considerations to estimate the GHG abatement potential from switching from an internal combustion engine vehicle (ICE) to an EV in the continental U.S. The GHG intensity of EVs hinges on the electricity and ambient temperature when charged and operated. Both have high spatial and temporal heterogeneity, yet are typically modeled inadequately or overlooked entirely. We calculate marginal emissions, including renewables, for electricity by region and test forecasted grid composition to estimate future performance. Location and timing of charging are important GHG determinants, but temperature effects on EV performance can be equally important. On average, EVs slightly reduce GHGs relative to ICEs, but there are many regions where EVs provide a decisive benefit and others where EVs are significantly worse. The forecasted grid shifts from coal towards renewables, improving EV performance; the GHG benefit per EV in western states is roughly $425 today and $2400 in 2040.

**Subject Area**: Electric vehicles; greenhouse gas emissions; life cycle assessment

**Planning for Transportation** *Henrik Gudmundsson, Ralph P. Hall, Greg Marsden, Josias Zietsman*

**Abstract:** Transportation is fundamental to the development of society. It provides opportunities to interact with others, moves the goods we need, and supports a vibrant economy. This chapter introduces the demand for transportation and explores key trends and growth forecasts. These underline the on-going importance of transportation to social progress and the significant challenge that lies ahead in planning transportation in the face of growing population, rising incomes, and technological change.

**Subject Area**: Environmental Economics; Sustainable Development; Transportation; Environmental Management;  Landscape/Regional and Urban Planning; System Performance and Evaluation

# Emissions and Cost Implications of Controlled Electric Vehicle Charging in the U.S. PJM Interconnection

*Allison Weis, Jeremy J. Michalek, Paulina Jaramillo, and Roger Lueken*

**Abstract:** We develop a unit commitment and economic dispatch model to estimate the operation costs and the air emissions externality costs attributable to new electric vehicle electricity demand under controlled vs uncontrolled charging schemes. We focus our analysis on the PJM Interconnection and use scenarios that characterize (1) the most recent power plant fleet for which sufficient data are available, (2) a hypothetical 2018 power plant fleet that reflects upcoming plant retirements, and (3) the 2018 fleet with increased wind capacity. We find that controlled electric vehicle charging can reduce associated generation costs by 23%–34% in part by shifting loads to lower-cost, higher-emitting coal plants. This shift results in increased externality costs of health and environmental damages from increased air pollution. On balance, we find that controlled charging of electric vehicles produces negative net social benefits in the recent PJM grid but could have positive net social benefits in a future grid with sufficient coal retirements and wind penetration.

**Subject Area**: EV electricity demand; emissions; charging schemes

## Contextual Density and US Automotive CO2 Emissions across the Rural–Urban Continuum  *Perumal A & Timmons D.*

**Abstract:** Using data from the 2009 National Household Travel Survey, we quantify the effects of settlement patterns on individual driving habits and the resulting automotive carbon dioxide (CO2) emissions. We employ CO2 emissions to capture this impact accurately, as it reflects both vehicle miles traveled and any spatial differences in vehicle fuel efficiency choices. While previous studies have compared automotive travel in urban and suburban areas, our approach characterizes emissions across the entire US rural–urban gradient, focusing on the effects of population density. Rather than using categorical measures of contextual density (city, suburb, town, etc.), we use a geographical information system to calculate continuous measures of contextual density, that is, density at different proximities to households. These measures of contextual density allow us to model travel effects induced by the gravitational pull of the population densities of urban cores. Further, our methodological approach frames location choice as an endogenous treatment effect; that is, residential locations are not randomly assigned across our sample and significantly alter driving behavior. We find that individuals living in urban cores generate the lowest per capita automotive CO2 emissions, due to close proximities of population concentrations. Rather than attracting individuals who would likely have low CO2 emissions anyway, urban location apparently mitigates the emissions of people who would otherwise tend to have high automotive CO2 emissions. We find larger elasticities with respect to density than previous studies and also find that the attractive forces of population densities affect driving patterns at distances up to sixty-one kilometers outside of urban areas.

**Subject Area**: urbanization;  travel behavior; carbon emissions; residential location; endogenous treatment effects

**From Cradle to Junkyard: Assessing the life cycle Greenhouse Gas Benefits of Electric Vehicles** *Archsmith, James, Alissa Kendall, and David Rapson*

**Abstract:** U.S. programs subsidize electric vehicles (EVs) in part to reduce greenhouse gas (GHG) emissions. We model a suite of life cycle GHG emissions considerations to estimate the GHG abatement potential from switching from an internal combustion engine vehicle (ICE) to an EV in the continental U.S. The GHG intensity of EVs hinges on the electricity and ambient temperature when charged and operated. Both have high spatial and temporal heterogeneity, yet are typically modeled inadequately or overlooked entirely. We calculate marginal emissions, including renewables, for electricity by region and test forecasted grid composition to estimate future performance. Location and timing of charging are important GHG determinants, but temperature effects on EV performance can be equally important. On average, EVs slightly reduce GHGs relative to ICEs, but there are many regions where EVs provide a decisive benefit and others where EVs are significantly worse. The forecasted grid shifts from coal towards renewables, improving EV performance; the GHG benefit per EV in western states is roughly $425 today and $2400 in 2040.

**Subject Area**: Electric vehicles; greenhouse gas emissions; life cycle assessment

# Measurement of black carbon emissions from in-use diesel-electric passenger locomotives in California

*Nicholas W. Tang, Joshua S. Apte, Philip T. Martien, & Thomas W. Kirchstetter*

**Abstract:** Black carbon (BC) emission factors were measured for a California commuter rail line fleet of diesel-electric passenger locomotives (Caltrain). The emission factors are based on BC and carbon dioxide ($CO_2$) concentrations in the exhaust plumes of passing locomotives, which were measured from pedestrian overpasses using portable analyzers. Each of the 29 locomotives in the fleet was sampled on 4–20 separate occasions at different locations to characterize different driving modes. The average emission factor expressed as g BC emitted per kg diesel consumed was $0.87 \pm 0.66$ g kg$^{-1}$ ($\pm 1$ standard deviation, n = 362 samples). BC emission factors tended to be higher for accelerating locomotives traveling at higher speeds with engines in higher notch settings. Higher fuel-based BC emission factors (g kg$^{-1}$) were measured for locomotives equipped with separate "head-end" power generators (SEP-HEPs), which power the passenger cars, while higher time-based emission factors (g h$^{-1}$) were measured for locomotives without SEP-HEPs, whose engines are continuously operated at high speeds to provide both head-end and propulsion power. PM10 emission factors, estimated assuming a BC/PM10 emission ratio of 0.6 and a typical power output-to-fuel consumption ratio, were generally in line with the Environmental Protection Agency's locomotive exhaust emission standards. Per passenger mile, diesel-electric locomotives in this study emit only 20% of the $CO_2$ emitted by typical gasoline-powered light-duty vehicles (i.e., cars). However, the reduction in carbon footprint (expressed in terms of $CO_2$ equivalents) due to $CO_2$ emissions avoidance from a passenger commuting by train rather than car is appreciably offset by the locomotive's higher BC emissions.

**Subject Area**: Locomotive emissions; Black carbon; Particulate matter; Emission standards; Carbon footprint

**Comparison of Life Cycle Greenhouse Gases from Natural Gas Pathways for Light-Duty Vehicles** *Tong, Fan, Paulina Jaramillo, and Inês ML Azevedo*

**Abstract:** Low prices and abundant resources open new opportunities for using natural gas, one of which is the production of transportation fuels. In this study, we use a Monte Carlo analysis combined with a life cycle analysis framework to assess the greenhouse gas (GHG) implications of a transition to natural gas-powered vehicles. We consider six different natural gas fuel pathways in two representative light-duty vehicles: a passenger vehicle and a sport utility vehicle. We find that a battery electric vehicle (BEV) powered with natural gas-based electricity achieves around 40% life cycle emissions reductions when compared to conventional gasoline. Gaseous hydrogen fuel cell electric vehicles (FCEVs) and compressed natural gas (CNG) vehicles have comparable life cycle emissions with conventional gasoline, offering limited reductions with 100-year global warming potential (GWP) yet leading to increases with 20-year GWP. Other liquid fuel pathways (methanol, ethanol, and Fischer–Tropsch liquids) have larger GHG emissions than conventional gasoline even when carbon capture and storage technologies are available. Life cycle GHG emissions of natural gas pathways are sensitive to the vehicle fuel efficiency, to the methane leakage rates of natural gas systems, and to the GWP assumed. With the current vehicle technologies, the break-even methane leakage rates of CNG, gaseous hydrogen FCEV, and BEV are 0.9%/2.3%, 1.2%/2.8%, and 4.5%/10.8% (20-year GWP/100-year GWP). If the actual methane leakage rate is lower than the break-even rate of a specific natural gas pathway, that natural gas pathway reduces GHG emissions compared to conventional gasoline; otherwise, it leads to an increase in emissions

**Subject Area**: CNG, BWP, FCEV, BEV, GHG

# Emission Free Transportation for Swarthmore College *Erik Jensen &Tony Lee*

**Abstract:** n/a

**Subject Area**: Greenhouse gas emissions; EV charging; solar carport

**Technical Evaluation Of The Greenhouse Gas Emissions Reduction Quantification For The San Joaquin Council Of Governments' Sb 375 Sustainable Communities Strategy** *California Air Resources Board*

**Abstract:** The Sustainable Communities and Climate Protection Act of 2008 (Senate Bill 375) is intended to support the State's broader climate goals by encouraging integrated regional transportation and land use planning that reduces greenhouse gas (GHG) emissions from passenger vehicle use. Now in its sixth year of implementation, SB 375 has resulted in several regional Sustainable Communities Strategies (SCS) which are developed as part of the Regional Transportation Plan (RTP). These SCSs demonstrate whether, if implemented, the metropolitan planning organizations (MPOs) of California can meet the per capita passenger vehicle GHG emissions targets for 2020 and 2035 set by the California Air Resources Board (ARB or Board) in 2010. The evaluation identified several areas in which the MPO could improve the quality of its data inputs and assumptions for improved forecasting of GHG emissions in future planning cycles. Throughout this report are several recommendations for modeling improvements that should be considered by SJCOG in its 2016 update of the Three-County Model. If implemented, these recommended improvements should enable the model to better capture the GHG benefits of the land use and transportation strategies in SJCOG's next SCS.

**Subject Area**: Greenhouse gas emissions;

**Availability:** San Joaquin Council, Of Governments. "Technical Evaluation Of The Greenhouse Gas Emissions Reduction Quantification For The San Joaquin Council Of Governments'sb 375 Sustainable Communities Strategy." (2015). http://www.grassrootsoncall.com/wp-content/uploads/ec/210/staff_report_sjcog_scs_final.pdf

# The importance of grid integration for achievable greenhouse gas emissions reductions from alternative vehicle technologies *Brian Tarroja, Brendan Shaffer & Scott Samuelsen*

**Abstract:** Alternative vehicles must appropriately interface with the electric grid and renewable generation to contribute to decarbonization. This study investigates the impact of infrastructure configurations and management strategies on the vehicle–grid interface and vehicle greenhouse gas reduction potential with regard to California's Executive Order S-21-09 goal. Considered are battery electric vehicles, gasoline-fueled plug-in hybrid electric vehicles, hydrogen-fueled fuel cell vehicles, and plug-in hybrid fuel cell vehicles. Temporally resolved models of the electric grid, electric vehicle charging, hydrogen infrastructure, and vehicle powertrain simulations are integrated. For plug-in vehicles, consumer travel patterns can limit the greenhouse gas reductions without smart charging or energy storage. For fuel cell vehicles, the fuel production mix must be optimized for minimal greenhouse gas emissions. The plug-in hybrid fuel cell vehicle has the largest potential for emissions reduction due to smaller battery and fuel cells keeping efficiencies higher and meeting 86% of miles on electric travel keeping the hydrogen demand low. Energy storage is required to meet Executive Order S-21-09 goals in all cases. Meeting the goal requires renewable capacities of 205 GW for plug-in hybrid fuel cell vehicles and battery electric vehicle 100s, 255 GW for battery electric vehicle 200s, and 325 GW for fuel cell vehicles.

# Optimal distribution of electric vehicle types for minimizing total CO2 emissions *Barazesh, M. ; Saebi, J. & Hossein Javidi, D.B.M.*

**Abstract:** With the rapid growth of electric vehicles, power systems would face serious difficulties to supply the excessive electricity demand in the near future. In this paper, a planning method is introduced to prevent the environmental and technical issues that the introduction of electric vehicles may cause for nonsmart electricity grids. The idea of this method is to employ the differences between EV types in order to achieve the minimum total emission which is the sum of vehicles emission and power system emission. The proposed method considers the importance of decreasing urban area emission and determines the optimal number of every EV type. The IEEE RTS 24 system, and real world vehicle specifications is used to demonstrate the capability of the proposed method. Results suggest that for low daily trip distances, the best option depends on the priority of urban area emission reduction. On the other hand, for higher distances, the plug-in types would lead to lower total emissions.

**Subject Area**: Batteries; Fossil fuels; Hybrid electric vehicles; Optimization; Power generation Power systems

## Is Liberalism Now an Essentially Contested Concept? *Ruth Abbey*

**Abstract:** n/a

**Subject Area**: environment, liberalism

# Sustainability, Resiliency, and Grid Stability of the Coupled Electricity and Transportation Infrastructures: Case for an Integrated Analysis

*Jarod C. Kelly; Tulga Ersal; Chiao-Ting Li; Brandon M. Marshall; Soumya Kundu; Gregory A. Keoleian; Huei Peng; Ian A. Hiskens; and Jeffrey L. Stein*

**Abstract:** Electrified vehicles (EVs) couple transportation and electrical infrastructures, impacting vehicle sustainability, transportation resiliency, and electrical grid stability. These impacts occur across timescales; grid stability at the millisecond scale, resiliency at the daily scale, and sustainability over years and decades. Integrated models of these systems must share data to explore timescale dependencies, and reveal unanticipated outcomes. This paper examines EV adoption for sustainability, resiliency, and stability effects. Sustainability findings, consistent with previous studies, indicate that electrification generally reduces lifecycle greenhouse gas (GHG) emissions, and increases    and   . Electrified vehicles enhance vehicle resiliency (ability of vehicle to complete typical trips during fuel outage). Coupled results enhance EV resilience research, finding that a 16-km (10-mi) all-electric range plug-in hybrid EV improves resiliency   versus a gasoline-only vehicle. Increasing EV market share reduces grid stability. Stability depends upon charging profiles and background electrical demand. Stability-related grid outages increase with EV market penetration. This paper modeled these systems in their coupled form across timescales yielding results not obvious if the systems were modeled in isolation.

**Subject Area**: Sustainability, Resiliency, Electrical grid, Electrical grid stability, Transportation, Electric vehicles, Lifecycle assessment

# Regional Variability and Uncertainty of Electric Vehicle Life Cycle CO2 Emissions across the United States

*Mili-Ann M. Tamayao, Jeremy J. Michalek, Chris Hendrickson, and Inês M. L. Azevedo*

**Abstract:** We characterize regionally specific life cycle $CO_2$ emissions per mile traveled for plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) across the United States under alternative assumptions for regional electricity emission factors, regional boundaries, and charging schemes. We find that estimates based on marginal vs average grid emission factors differ by as much as 50% (using National Electricity Reliability Commission (NERC) regional boundaries). Use of state boundaries versus NERC region boundaries results in estimates that differ by as much as 120% for the same location (using average emission factors). We argue that consumption-based marginal emission factors are conceptually appropriate for evaluating the emissions implications of policies that increase electric vehicle sales or use in a region. We also examine generation-based marginal emission factors to assess robustness. Using these two estimates of NERC region marginal emission factors, we find the following: (1) delayed charging (i.e., starting at midnight) leads to higher emissions in most cases due largely to increased coal in the marginal generation mix at night; (2) the Chevrolet Volt has higher expected life cycle emissions than the Toyota Prius hybrid electric vehicle (the most efficient U.S. gasoline vehicle) across the U.S. in nearly all scenarios; (3) the Nissan Leaf BEV has lower life cycle emissions than the Prius in the western U.S. and in Texas, but the Prius has lower emissions in the northern Midwest regardless of assumed charging scheme and marginal emissions estimation method; (4) in other regions the lowest emitting vehicle depends on charge timing and emission factor estimation assumptions.

**Subject Area**: CO2; PHEVs; BEVs

**Stochastic comparative assessment of life-cycle greenhouse gas emissions from conventional and electric vehicles** *Arash Noshadravan, Lynette Cheah, Richard Roth, Fausto Freire, Luis Dias, & Jeremy Gregory*

**Abstract:** Purpose: Electric vehicles (EVs) are promoted due to their potential for reducing fuel consumption and greenhouse gas (GHG) emissions. A comparative life-cycle assessment (LCA) between different technologies should account for variation in the scenarios under which vehicles are operated in order to facilitate decision-making regarding the adoption and promotion of EVs. In this study, we compare life-cycle GHG emissions, in terms of CO2eq, of EVs and conventional internal combustion engine vehicles (ICEV) over a wide range of use-phase scenarios in the USA, aiming to identify the vehicles with lower GHG emissions and the key uncertainties regarding this impact. Methods: An LCA model is used to propagate the uncertainty in the use phase into the greenhouse gas emissions of different powertrains available today for compact and midsize vehicles in the US market. Monte Carlo simulation is used to explore the parameter space and gather statistics about GHG emissions of those powertrains. Spearman's partial rank correlation coefficient is used to assess the level of contribution of each input parameter to the variance of GHG intensity. Results and discussion: Within the scenario space under study, battery electric vehicles are more likely to have the lowest GHG emissions when compared with other powertrains. The main drivers of variation in the GHG impact are driver aggressiveness (for all vehicles), charging location (for EVs), and fuel economy (for ICEVs). Conclusions: The probabilistic approach developed and applied in this study enables an understanding of the overall variation in GHG footprint for different technologies currently available in the US market and can be used for a comparative assessment. Results identify the main drivers of variation and shed light on scenarios under which the adoption of current EVs can be environmentally beneficial from a GHG emissions standpoint.

## A Model System to Evaluate the Impacts of Vehicle Purchase Tax and Fuel Tax on Household Greenhouse Gas Emissions *Liu, Yan & Cirillo, Cinzia*

**Abstract:** This paper proposes a model system to forecast household-level greenhouse gas emissions (GHGEs) from private transportation and to evaluate the effects of car-related taxation schemes on vehicle emissions. The system contains four sub-models which specifically capture households' vehicle type and vintage, quantity, usage, and greenhouse gas emission rates (GHGERs) for different vehicle types. The vehicle GHGERs are calculated using MOVES 2014 (Motor Vehicle Emission Simulator 2014), which is authorized by the Environmental Protection Agency (EPA). The whole model system has been applied to the Washington D.C. Metropolitan Area. The authors employ the 2009 National Household Travel Survey (NHTS) with supplementary data from Consumer Reports, American Fact Finder and the 2009 State Motor-Vehicle Registrations (SMVR). Two tax schemes, vehicle purchase tax and fuel tax, have been proposed and their effects on vehicle GHGEs reduction are predicted. The average annual GHGEs per vehicle is 5.86 tons carbon dioxide-equivalent ($CO_2E$) gas without the proposed taxes. After implementing two taxation policies, the results show that:(1) The impacts on reducing GHGEs from fuel taxes are higher than those from purchase taxes; (2) Purchase taxes mainly reduce GHGEs by decreasing the car quantity for households with more vehicles; (3) Fuel taxes successfully reduce GHGEs by decreasing car usage of households with fewer vehicles. The model system can be extended to other zones, counties, states and nations.

**Subject Area**: Automobile ownership; Computer models; Environmental impacts; Fuel taxes; Greenhouse gases; Households; Sales tax; Travel surveys

# A benefit-cost assessment of new vehicle technologies and fuel economy in the U.S. market

*Richard A. Simmons, Gregory M. Shaver, Wallace E. Tyner, & Suresh V. Garimella*

**Abstract:** Increasingly stringent fuel economy and emissions regulations alongside efforts to reduce oil dependence have accelerated the global deployment of advanced vehicle technologies. In recent years, original equipment manufacturers (OEMs) and consumers have generally been successful in mutually deploying cleaner vehicle options with little sacrifice in cost, performance or overall utility. Projections regarding the challenges and impacts associated with compliance with mid- and long-term targets in the U.S., however, incur much greater uncertainty. The share of existing new vehicles that is expected to comply with future regulations, for example, falls below 10% by 2020. This article explores advanced technologies that result in reduced fuel consumption and emissions that are commercially available in 2014 Model Year compact and midsize passenger cars. A review of the recent research literature and publicly available cost and technical specification data addressing correlations between incremental cost and fuel economy is presented. This analysis reveals that a 10% improvement in the sales-weighted average fuel economy of passenger cars has been achieved between 2011 and 2014 at costs that are at or below levels anticipated by the regulations by means of reductions in weight, friction, and drag; advancements in internal combustion efficiency; turbocharging combined with engine downsizing; transmission upgrades; and the growth of hybrids. Benefit-cost analyses performed on best-selling models in the selected classifications reveal that consumers thus far are not substantially incentivized to purchase fuel economy. Under baseline conditions, benefit-cost ratios are above a breakeven value of unity for only 6 of 28 models employing improved fuel-economy technologies. Sales-weighted data indicate that the "average" consumer that elected to invest in greater fuel economy spent $1490 to realize a 17.3% improvement in fuel economy, equating to estimated savings of $1070. Thus savings were, on average, insufficient to cover technology costs in the baseline scenario. However, a sensitivity analysis reveals that a majority of new technologies become financially attractive to consumers when average fuel prices exceed $5.60/gallon, or when annual miles traveled exceed 16,400. The article concludes with techno-economic implications of the research on future fuel economy regulations for stakeholders. In general, the additional cost consumers incur in exchange for a given level of fuel economy improvement in the coming years will need to be steadily reduced compared to current levels to ensure that the expected benefits of fuel savings are financially warranted.

# Improvement of Default Local MOVES Input Data for the 2011 National Emissions Inventory

*John Koupal, Timothy DeFries, Cindy Palacios, Allison DenBleyker & Heather Perez*

**Abstract:** The Coordinating Research Council (CRC) sponsored a project to develop improved inputs for EPA's Motor Vehicle Emissions Simulator (MOVES), for use in the 2011 U.S. National Emissions Inventory (NEI). Under contract with CRC, ERG identified the most promising MOVES inputs for improvement, and performed a detailed review of candidate data sources for each. ERG then developed improved defaults for passenger car and light truck age distributions and populations and long-haul truck VMT allocations. Age distributions and vehicle populations were developed for every county in the U.S. based on vehicle registration data purchased from IHS, Inc. The age distributions showed an average age range of 4 to 16 years for cars and trucks vs. MOVES national default of 9 years. Long-haul truck VMT allocations were derived from the 2007 Freight Analysis Framework (FAF), producing unique allocations by region of the country, urban/rural and interstate/non-interstate, and are intended to replace the uniform long haul allocations currently used in MOVES. The updated long-haul fractions for combination trucks varied by region of the country, road type and urban/rural area, ranging from around 30 percent on urban unrestricted roads, to up to 90 percent for some rural restricted roads, in comparison to a static MOVES default of 59 percent. These updates will be used in the 2011 NEI, and provide a resource for emissions modelers at the federal, regional, state and municipal levels to improve local inventory and air quality modeling.

**Subject Area**: MOVES; National Emissions Inventory;

# Characterization of nanoparticle emissions and exposure at traffic intersections through fast–response mobile and sequential measurements

*Anju Goela, & Prashant Kumar*

**Abstract:** Quantification of disproportionate contribution made by signalised traffic intersections (TIs) to overall daily commuting exposure is important but barely known. We carried out mobile measurements in a car for size–resolved particle number concentrations (PNCs) in the 5–560 nm range under five different ventilation settings on a 6 km long busy round route with 10 TIs. These ventilation settings were windows fully open and both outdoor air intake from fan and heating off (Set1), windows closed, fan 25% on and heating 50% on (Set2), windows closed, fan 100% on and heating off (Set3), windows closed, fan off and heating 100% on (Set4), and windows closed, fan and heating off (Set5). Measurements were taken sequentially inside and outside the car cabin at 10 Hz sampling rate using a solenoid switching system in conjunction with a fast response differential mobility spectrometer (DMS50). The objectives were to: (i) identify traffic conditions under which TIs becomes hot–spots of PNCs, (ii) assess the effect of ventilation settings in free–flow and delay conditions (waiting time at a TI when traffic signal is red) on in–cabin PNCs with respect to on–road PNCs at TIs, (iii) deriving the relationship between the PNCs and change in driving speed during delay time at the TIs, and (iv) quantify the contribution of exposure at TIs with respect to overall commuting exposure. Congested TIs were found to become hot–spots when vehicle accelerate from idling conditions. In–cabin peak PNCs followed similar temporal trend as for on–road peak PNCs. Reduction in in–cabin PNC with respect to outside PNC was highest (70%) during free–flow traffic conditions when both fan drawing outdoor air into the cabin and heating was switched off. Such a reduction in in–cabin PNCs at TIs was highest (88%) with respect to outside PNC during delay conditions when fan was drawing outside air at 25% on and heating was 50% on settings. PNCs and change in driving speed showed an exponential–fit relationship during the delay events at TIs. Short–term exposure for ~2% of total commuting time in car corresponded to ~25% of total respiratory doses. This study highlights a need for more studies covering diverse traffic and geographical conditions in urban environments so that the disparate contribution of exposure at TIs can be quantified.

**Policymaking Should Consider the Time-dependent Greenhouse Gas Benefits of Transit-oriented Smart Growth** *Nahlik, Matthew J., and Mikhail V. Chester*

**Abstract:** Cities are increasingly developing greenhouse gas (GHG) mitigation plans and reduction targets based on a growing body of knowledge about climate change risks, and changes to passenger transportation are often at the center of these efforts. Yet little information exists for characterizing how quickly or slowly GHG emissions reductions will accrue given changes in urban form around transit, and whether benefits will accrue quickly enough to meet policy year targets (such as reaching 20% of 1990 GHG emissions levels by 2050). Even more complicated is when cities focus on achieving GHG reductions through integrated transportation and land use planning, as changes in emissions can occur across many sectors (such as transportation, building energy use, and electricity generation). Using the Los Angeles Expo line, a framework is developed to assess how financing schemes can affect the rate of redevelopment and resulting life-cycle GHG emissions from travel and building energy use. The framework leverages an integrated transportation and land use life-cycle assessment model that captures upfront construction of new development near transit and the long-term changes in household energy use for travel and buildings. The results show that for the same amount of development around the Expo line, it is possible to either meet (if aggressive redevelopment happens early) or not meet (if significant redevelopment does not start until decades out) state GHG goals by 2050. The time-based approach reveals how redevelopment schedules should be considered when setting strategies for meeting future GHG emission targets.

**Subject Area**: GHG; climate change; emissions targets

# Real-world fuel economy and CO2 emissions of plug-in hybrid electric vehicles

*Patrick Plötz, Simon Funke, & Patrick Jochem*

**Abstract:** Plug-in hybrid electric vehicles (PHEV) combine electric propulsion with an in-ternal combustion engine. Their potential to reduce transport related green-house gas emissions highly depends on their actual usage and electricity provi-sion. Various studies underline their environmental and economic advantages, but are based on standardised driving cycles, simulations or small PHEV fleets. Here, we analyse real-world fuel economy of PHEV and the factors influencing it based on about 2,000 actual PHEV that have been observed over more than a year in the U.S. and Germany. We find that real-world fuel economy of PHEV differ widely among users. The main factors explaining this variation are the annual mileage, the regularity of daily driving, and the likelihood of long-distance trips. Current test cycle fuel economy ratings neglect these factors. Despite the broad range of PHEV fuel economies, the test cycle fuel economy ratings can be close to empiric PHEV fleet averages if the average annual mile-age is about 17,000 km. For the largest group of PHEV in our data, the Chevro-let Volt, we find the average fuel economy to be 1.45 litres/100 km at an aver-age electric driving share of 78%. The resulting real-world tank-to-wheel CO2 emissions of these PHEV are 42 gCO2/km and the annual CO2 savings in the U.S. amount to about 50 Mt. In conclusion, the variance of empirical PHEV fuel economy is considerably higher than of conventional vehicles. This should be taken into account by future test cycles and high electric driving shares should be incentivised.

**Subject Area**: electric vehicles, plug-in hybrid electric vehicles, real-world fuel economy, utility factor

# 5. Policy and Mobility

**Heat exposure during non-motorized travel: Implications for transportation policy under climate change** *Karner, Alex, David M. Hondula, and Jennifer K. Vanos*

**Abstract:** Transportation planning agencies around the world are increasingly seeking to develop transportation systems that encourage walking, bicycling, and transit use in order to simultaneously achieve public health and environmental sustainability goals. Under future scenarios that will see increasing global mean temperatures, trips that entail physical exertion outdoors are likely to account for substantial portions of some individuals' overall exposure to potentially dangerous air temperatures. This exposure pathway is poorly understood. In this study we develop a new method to assess outdoor heat exposure during non-motorized travel by combining simulated urban meteorology and transportation-activity data. We demonstrate its utility through application to several real-world planning issues using data from the San Francisco Bay Area. Specifically, we examine spatial and social disparities in heat exposure and find that socially disadvantaged (low-income people and zero-vehicle households) groups are disproportionately exposed to transport-related heat. Since the propensity to walk and bicycle tends to decrease with socioeconomic status (SES) and because lower SES groups are more vulnerable to heat-related health impacts, efforts to mitigate heat exposure can be of disproportionate benefit to these groups. Finally, we demonstrate how the results can be used to supplement more traditional indicators of heat vulnerability that to date do not directly account for actual length of outdoor exposure. The methodology developed here has the potential to guide healthy, sustainable, and equitable urban planning efforts.

**Subject Area:** Planning; Urban; Climate; Policy; Health; Heat

## Review of On-Street Parking Fees *Dibas, Mahmoud I., Asma A. Aljassmi, and Mohammad N. Ibrahim*

**Abstract:** Government policy on the price of paid parking requires careful consideration of a number of issues especially those relating to economic and social matters to ensure its policies benefit the city and its population. During recent consultation with most Abu Dhabi stakeholders, it was pointed out that the level of parking fees should be used as one of the parking demand management measure. However, what is the appropriateness of the current parking prices in Abu Dhabi and how much is the flexibility to change the fees is the content of this paper.

# Taxing vehicle miles traveled: The Traffic Choices Experiment in the Puget Sound region *Davide Cerruti*

**Abstract:** Driving creates a number of externalities, including congestion, emissions of conventional air pollutants and greenhouse gases, road wear and tear, and accidents. In principle, these externalities could be corrected by charging drivers a tax for each mile driven, but the effectiveness of such measures when implemented in practice is unclear. This paper analyzes the implementation of a tax on vehicle miles traveled in the Seattle, WA, metropolitan area between 2005 and 2006. Prior to the beginning of the trial, the travel behavior of 276 volunteer households was recorded through devices installed in their vehicles. During the trial period participants had to pay a toll for each mile driven. The rate changed with the hour of the day, the day of the week and the type of road. The results from my analysis show that on average in the first week of the trial period participants reduced their miles driven by 6.83% for each 10 cents/mile toll. The effect of the toll system disappears after the first week, with the exception of miles driven in highways. This calls for caution when inferring about taxes and other economic incentives or disincentives based on short-lived programs and on behaviors within a narrow window of the implementation of the program itself. There is also a strong heterogeneity in household response to the toll, with higher-income households and households with children being less responsive whereas households used to drive often or during high-toll times and roads show a higher reduction in miles.

# An equity analysis of fuel tax and VMT fee based on the revenue-neutral principle *Song, Shunfeng, Grace L. Morris, and Zong Tian*

**Abstract:** Facing the challenges of the existing fuel tax system to sustainably support future transportation needs in the states, scholars and government officials are studying a vehicle miles travelled (VMT) fee system to replace or supplement the current fuel tax system. As is often the case with policy changes, concerns over the distributional impact of the VMT fee have been voiced by groups, especially those representing low-income households. Using the 2009 National Household Travel Survey, we calculate and compare the fuel tax and VMT fee that each household is paying or would pay if the revenue-neutral principle is applied, examine the burdens of the fuel tax and a VMT fee, and estimate the change from paying the fuel tax to paying a VMT fee. Our empirical results show that a revenue-neutral VMT fee would on average produce small income redistribution from the rich to the poor.

**Pay Up! Long Hours and Low Pay Leave Workers at a Loss** *Allyson Fredericksen*

**Abstract:**  Momentum has built around $15 as the magic number that will allow workers to make ends meet. From Seattle to Los Angeles to New York, a $15 wage has been touted as a way for working families to move beyond living paycheck-to-paycheck. But, is $15 really enough to ensure financial stability? Since 1999, the Alliance for a Just Society has produced an annual living wage report calculating what it actually costs to make ends meet for households in selected states. For the first time this year, the Job Gap Economic Prosperity Series includes a living wage for all 50 states and Washington, D.C.

**Subject Area:** Living Wage, Transportation Costs

**Availability:** Fredericksen, Allyson. "Long Hours and Low Pay Leave Workers at a Loss." Alliance for Just Society (2015). http://allianceforajustsociety.org/wp-content/uploads/2015/10/Pay-Up-Revised-FINAL.pdf

# Livability and LEED-ND: The Challenges and Successes of Sustainable Neighborhood Rating Systems *Nicola Alexandra Szibbo*

**Abstract:** A rating system known as Leadership in Energy and Environmental Design for Neighborhood Development, LEED-ND, (USGBC 2011) was developed in 2007 to assess sustainability at the neighborhood scale. Although at this time LEED for buildings is a well-known and well-established program in the United States, LEED for Neighborhood Development is less widely recognized since it was developed in 2007 as compared to LEED for buildings. LEED-ND requires that certified developments meet credit areas in three main categories: a) smart location and linkage (SLL), b) neighborhood pattern and design (NPD), and c) green infrastructure and buildings (GIB). LEED-ND goes above and beyond singularly requiring sustainable mobility, traditional neighborhood design, or green building; rather, it incorporates the above three categories into a single rating system. To date, prior LEED rating systems (New Construction and Existing Buildings) have focused on the building scale, as have most critiques of such metrics (Del Percio 2004; Dermisi 2009; Humbert et al. 2007; Hodapp 2008). Few authors have ventured to analyze the neighborhood rating system with the exception of Garde (2009) and Ewing et al. (2013) and Sharifi and Murayama (2013b), who have only used only secondary scorecard data and other aggregated data to assess the success or predict outcomes of LEED-ND neighborhoods. No post-occupancy studies have been conducted to date that take into consideration the resident's perception and stated preferences. Additionally, no studies have examined in detail the provision of affordable housing within LEED-ND developments.

**Subject Area:** Livability, LEED-ND

## A Longitudinal Analysis of Cars, Transit, and Employment Outcomes *Michael J. Smart, Ph.D. and Nicholas J. Klein, Ph.D.*

**Abstract:** Access to cars and transit can influence individuals' ability to reach opportunities such as jobs, health care, and other important activities. While access to cars and public transit varies considerably across time, space, and across populations, most research portrays car access as a snapshot in time; some people have a car and others do not. But does this snapshot approach mask variation in car ownership over time? And how does access to particular types of transportation resources influence individuals' economic outcomes? The authors improve upon existing research by using panel data from 1999 to 2013 from the Panel Study of Income Dynamics (PSID) to examine levels of automobile access in groups that have variable access: poor families, immigrants, and people of color. They further employ two new national datasets of access to jobs using public transit. These datasets are used to examine the effect of transit and automobile access on income growth over time within families, controlling for a number of relevant variables. The research found that for most families, being "carless" is a temporary condition. While 13% of families in the US are carless in any given year, only 5% of families are carless for all seven waves of data examined in the analysis. The research also found that poor families, immigrants, and people of color (particularly blacks) are considerably more likely to transition into and out car ownership frequently and are less likely to have a car in any survey year than are non-poor families, the US-born, and whites. The research also found that improving automobile access is associated with a decreased probability of future unemployment and is associated with greater income gains. However, the analysis suggests that the costs of owning and maintaining a car may be greater than the income gains associated with increased car ownership. The relationship between public transit and improved economic outcomes is less clear. The research found that living in areas with access to high-quality public transportation has no relationship with future earnings. However, transit serves an important purpose in providing mobility for those who cannot or choose not to own a car.

**Subject Area:** Car ownership; Public transit; Transit accessibility; Panel data; Economic outcomes

# Building Inequality: The Permanence of Infrastructure and the Limits of Democratic Representation *Simon Ejdemyr, Clayton Nall, & Zachary O'Keeffe*

**Abstract:** Past research has shown that improving democratic representation leads to more equal distribution of resources. However, we show that responsiveness to democratization depends substantially on public policies' "stickiness." While some policies such as social welfare spending are persistent primarily due to entrenched special interests, physical infrastructure is by nature unresponsive to changes at the ballot box. We test these claims using data on US highway construction, exploiting 1960s Supreme Court rulings that outlawed state legislative malapportionment. Drawing upon an original database of highways built between 1934 and 2011, we find that state governments invested more in highways in overrepresented counties between 1934 and 1960, and these investments persisted even after the Court-mandated equalization. States also continued to send more highway money to previously overrepresented counties, even as they balanced per capita spending in other categories. Infrastructures inherent durability prevents translation of improved representation into more equitable public spending.

**Subject Area:** physical infrastructure; highway investmen

**Quantifying the Costs of School Transportation** *Noreen McDonald , Ph.D., Ruth Steiner, Ph.D., Virginia Sisiopiku, Ph.D., W. Mathew Palmer, MURP, Benjamin Lytle, Jeff Tsai, & Thomas Cook*

**Abstract:** While there has been attention to the costs of school busing, there has been little analysis of the multi-modal costs of school transportation and how those costs vary with the local environment. This study identifies the individual capital and operations cost items for each primary mode of transportation—automobile, school bus, bike, and walking—to allow for the consistent collection of data between states and school districts. Nine public elementary schools were selected from Florida representing areas with high, medium and low densities of student populations. The same criteria were used to select 11 schools in North Carolina representing medium and low density environments. School districts, published reports, and professionals associated with the design and planning of the study schools were consulted to gather cost and other relevant information. A school site visit was conducted to determine the travel mode split at each study school. Based on these results, the researchers have documented cases that suggest that school travel modes and costs are related to built environment characteristics surrounding a school site – the greater pedestrian accessible residential density around a school site, the higher the rates of walking, bicycling and driving to school and the lower rates of bus ridership. Correspondingly, dense accessible school sites exhibit lower public costs.

**Subject Area:** school transportation

# FERRIES: Reduce fares for car passengers *Ann Dasch, Anderson Island*

**Abstract:** n/a

**Subject Area:** Washington State Ferries toll

**Availability:** The News Tribune. FERRIES: Reduce Fares for car passengers; September 25, 2015; http://www.thenewstribune.com/opinion/letters-to-the-editor/article36614412.html

Optimal policy instruments for externality-producing durable goods under present bias *Garth Heutel*

**Abstract:**  When consumers exhibit present bias, the standard solution to market failures caused by externalities—Pigouvian pricing—is suboptimal. I investigate policies aimed at externalities for present-biased consumers. Optimal policy includes an instrument to correct the externality and an instrument to correct the present bias. Either instrument can be an incentive-based policy (e.g. a tax on fuel economy) or a command-and-control policy (e.g. a fuel economy mandate). Under consumer heterogeneity, a command-and-control policy may dominate an incentive-based policy. Calibrated to the US automobile market, simulation results suggest that the second-best gasoline tax is 3–30% higher than marginal external damages. The optimal price policy includes a gasoline tax set about equal to marginal external damages and a fuel economy tax that increases the price of an average non-hybrid car by about $550–$2200 relative to the price of an average hybrid car.

**Subject Area:** Present bias, Energy policy, Gasoline tax, Quasi-hyperbolic discounting

# Handbook of Research Methods and Applications in Transport Economics and Policy; Chapter 18 Airlines *Chris Nash, Steve Morrison*

**Abstract:** Transport economics and policy analysis is a field which has seen major advances in methodology in recent decades, covering issues such as estimating cost functions, modelling of demand, dealing with externalities, examining industry ownership and structure, pricing and investment decisions and measuring economic impacts. This Handbook contains reviews of all these methods, with an emphasis on practical applications, commissioned from an international cast of experts in the field.

**Subject Area:** applied general equilibrium, network, road pricing, commuting, polycentricity, environmental taxation, double-dividend

# Congestion pricing in urban polycentric networks with distorted labor markets: a spatial general equilibrium model for the area Randstad *Ioannis Tikoudis*

**Abstract:** The paper presents a polycentric general equilibrium model with congestion externalities and distortionary labor taxation calibrated to fit the key empirical regularities of the regional economy and transport system of Randstad conglomeration. In line with more stylized models, marginal external cost pricing (i.e. a quasi first-best Pigouvian toll that ignores the pre-existing taxation in the labor market) is shown to generate considerable welfare losses. Surprisingly, the quasi first-best Pigouvian toll is welfare decreasing even when the road tax revenue is used to finance labor tax cuts. This is due to the large deviation of marginal external costs from the optimal toll levels, as the latter are found to be negative in many of the network links. Approximations of the key double-dividend effects show that, in those links, the tax interaction effect is strong enough to outweigh both the revenue-recycling and the Pigouvian effect.

**Subject Area:** applied general equilibrium, network, road pricing, commuting, polycentricity, environmental taxation, double-dividend

**AARP Letter Urges Key Senate Committee to Pass "Livable Communities Act"**
*AARP Media Relations*

**Abstract:** WASHINGTON— AARP Senior Vice President David Sloane sent a letter late yesterday to members of the Senate Committee on Banking, Housing and Urban Affairs urging them to pass the "Livable Communities Act" and send the legislation to a vote before the full Senate. "Too many communities are struggling to grasp the impact of our country's collective aging population on the fundamental issues of where and how we all live," said Sloane. "We can't continue to apply 1950's answers to 21st Century challenges. The 'Livable Communities Act' would be a critically important resource to leaders who want to make sure that Americans can safely stay in their homes and get to the places they need and want to go in their communities."

**Subject Area:** aging in place; elderly; livable communities

**Availability:** AARP Press Center 2010

**Urban Design in the Arab World: Reconceptualizing Boundaries** *Dr Robert Saliba*

**Abstract:** n/a

**Subject Area:** urban design

## Panel Paper: The Potential Impact of a VMT Tax on Automobile Usage in the United States *Wang, Yiwei*

**Abstract:** In this paper, I use vehicle attribute data and NHTS data to study households' vehicle usage in response to fuel cost changes depending on the types of vehicles they own. My analysis includes two steps. The first step is to use empirical data to assess households' sensitivity of miles driven to the changes in their driving costs, which includes fuel costs and taxes. In the second step, I simulate the effect on driving behavior of a uniform VMT tax structure that does not discriminate vehicle type or MPG and would generate the same amount of tax revenue as a gasoline tax does using the parameters obtained from the first step and controlling for household's socio-demographic regional heterogeneity. My results suggest that households respond to fuel cost changes differently conditioning on their revealed vehicle choices. A uniform VMT tax would make people use their high MPG vehicles less and their low MPG vehicles more, compared to a gasoline tax. A VMT tax would also affect households' choice of new vehicle purchases in the long run. In particular, high MPG vehicles, including hybrid vehicles and electric vehicles (EV), would become less attractive in terms of driving costs. This research contributes to the existing literature on VMT taxation as the first study that estimates its impact on both driving behavior and vehicle purchases. More importantly, it aims to inform the ongoing policy discussion on using a VMT tax as an infrastructure funding mechanism to offset the losses of revenue generated from gasoline taxes, due to increasingly fuel-efficient vehicles. This issue has become particularly urgent, as the current CAFE standards set by the Obama administration which seek to almost double the MPG of vehicles by 2025 are expected to further bolster the usage of fuel-efficient vehicles.

**Subject Area:** VMT taxation, fuel costs, fuel efficiency

# Income, Location Efficiency, and VMT: Affordable Housing as a Climate Strategy  *Henrik Gudmundsson, Ralph P Hall, Greg Marsden, Josias Zietsman*

**Abstract:** This paper combines detailed travel-survey, transit-service, and land-use data to estimate a model for predicting the role of income and location efficiency in reducing household vehicle-miles traveled (VMT). The research then applies this model to census data collected in the most transit-rich areas of California. The research finds strong justification for California's current support of location-efficient affordable housing as a strategy to reduce VMT and mitigate climate change.

**Subject Area:** vmt, climate change, location efficiency

## Sustainable Transportation: Indicators, Frameworks, and Performance Management *Henrik Gudmundsson, Ralph P Hall, Greg Marsden, Josias Zietsman*

**Abstract:** n/a

**Subject Area:** sustainable transportation

**Availability:** Black, John A., Antonio Paez, and Putu A. Suthanaya. "Sustainable urban transportation: performance indicators and some analytical approaches." Journal of urban planning and development (2002). http://ascelibrary.org/doi/10.1061/(ASCE)0733-9488(2002)128%3A4(184)

# Agent-based modeling and simulation for the coordinated pricing strategy of the electric vehicle battery switching station *Zhang, Zhanguo, Peng Han, Jinkuan Wang, Yan Li, and Yinghua Han*

**Abstract:** The pricing strategy is critical for the construction and operation of the battery switching stations as well as the service quality to the EV owners. In this paper, the regularity of the EV owners is estimated, and cost of the operation of the battery switching station is analyzed. Then, this paper proposed an agent-based model of the battery switching service in the station, which, by establishing the detailed EV and battery agents through coding their states and transitions, enables the whole-scene observation of the EV refueling request, the simulation of the battery switching station, and the assessment of different pricing strategies. Furthermore, considering the current high cost of the EV batteries and their quality decreasing due to recharging times, this paper proposed a battery-condition-based coordinated pricing strategy, and developed a 3D computer simulation platform to verify the effectiveness of the proposed model and the performance of the coordinated pricing strategy. Simulation denotes that the model can well reveal the driving regularity of the EV owners and the decreasing in batteries, which will be of significant meanings in making decisions on the configuration of the station and finding the optimized pricing strategy. Due to the severe fluctuation in the battery quality in the simulation, the cost of the battery is dominant in the station cost compared with the electricity price, and the proposed pricing is a preferred way in making up the battery cost of the station while providing fair service for the EV owners.

**Subject Area:** pricing; battery switching station; EV;

**Reimagining Surface Transportation Reauthorization Pro-Market Recommendations for Policy Makers** *Marc Scribner*

**Abstract:** Many transportation policy observers estimate that stagnating revenues and increases in fuel efficiency will cause the current fuel tax–reliant Highway Trust Fund to implode sometime within the next 15 years. Until that implosion, fuel taxes will become extremely regressive, as the wealthy would avoid the taxes with new, highly fuel efficient or all-electric vehicles, shifting the fuel tax burden to the working poor. This is an outcome no one wants to see.

**Subject Area:** Highway trust fund; fuel tax

# Assessment of motor vehicle use characteristics in three Indian cities  *Rahul Goel, Dinesh Mohan, Sarath K. Guttikunda, & Geetam Tiwari*

**Abstract:**  Estimates of emissions and energy consumption by vehicular fleet in India are not backed by reliable values of parameters, leading to large uncertainties. We report new methods, including primary surveys and secondary data sources, to estimate in-use fleet size, annual mileage (kilometers per year), and fuel efficiency of cars and motorised two-wheelers (MTW) for Delhi, and except fleet size and annual mileage of cars, for Visakhapatnam and Rajkot. We estimated that the official number of registered cars and MTW in Indian cities is more than two times the actual number of in-use vehicles. The private vehicular fleet in India is the youngest, its fuel efficiency one of the highest, and annual kilometers travelled is the lowest, compared to many high-income countries, such as the USA and those in European Union. Along with high renewal rate of fleet, the data suggest that it is possible for India to have one of the most fuel-efficient vehicle fleets in the world in the future, if fuel-efficiency standards and fiscal policies to contain growing dieselization are implemented in the country at the earliest.

## Case 2:13-Cv-00193 Document 392-1 Page 1 In The United States District Court For The Southern District Of Texas Corpus Christi Division *Daniel Chatman*

**Abstract:** I was retained to analyze the travel burdens associated with the State of Texas provision that individuals generally must present one of several approved forms of photo identification in order to cast an in-person ballot that will be counted. More specifically, I was retained to investigate the travel burdens associated with citizens of voting age who do not already hold an accepted photo ID to travel to an officially designated location to apply for and obtain a photo identification card called an Election Identification Certificate (EIC). In this report I focus on the time required to access an EIC location by car, via public transportation, or on foot, because time is the most salient and readily quantifiable of the various costs involved in travel. The main output of the analysis and of this report is an estimate of travel time burdens across the population of all citizens of voting age, by race/ethnicity, as well as a description of different rates of poverty among the racial/ethnic groups generally and an estimate of travel time burdens among those burdened by poverty.

**Subject Area:** driver's license; transit burden, voting

# Empirical distributions of vehicle use and fuel efficiency across space: Implications of asymmetry for measuring policy incidence *Jonathan A. Cook, James N. Sanchirico, Deborah Salon, & Jeffrey Williams*

**Abstract:** Concerns about local air pollution and climate change have prompted all levels of government to consider a variety of policies to reduce vehicle dependence and fuel consumption, as the transportation sector is one of the largest sources of local and global emissions. Because many of the policy options under consideration are market-based (e.g., gasoline tax, carbon tax), it is important to consider how the impacts would vary across space and affect different subpopulations. Evaluating incidence is relevant for both the expected costs and benefits of a particular policy, however detailed data on vehicle-miles traveled (VMT) and fuel consumption allowing for the distributions of these variables to be estimated at a fine geographic scale is rarely available. This paper uses a unique dataset with more than 20 million vehicles in California to derive estimates of VMT and fuel consumption in order to examine the spatial distribution of impacts for an increase in the price of gasoline as well as the consequences of using different statistics for policy evaluation. Results show that VMT and fuel consumption distributions are not symmetrically distributed and vary significantly within transportation planning regions. To understand the potential implications of this asymmetry, we do a back of the envelope comparison using the mean and mode of the VMT or fuel consumption distribution for policy analysis. We find that assuming a symmetric distribution can lead to a divergence of 20–40% from the estimates based on the empirical distribution. Our results, therefore, introduce caution in interpreting the incidence of policies targeting the transportation sector based on averages.

**Subject Area:** VMT; Fuel consumption; Transportation policy; Climate policy; Spatial analysis; Policy incidence

# Optimal policy instruments for externality-producing durable goods under present bias *Garth Heutel*

**Abstract:** When consumers exhibit present bias, the standard solution to market failures caused by externalities—Pigouvian pricing—is suboptimal. I investigate policies aimed at externalities for present-biased consumers. Optimal policy includes an instrument to correct the externality and an instrument to correct the present bias. Either instrument can be an incentive-based policy (e.g. a tax on fuel economy) or a command-and-control policy (e.g. a fuel economy mandate). Under consumer heterogeneity, a command-and-control policy may dominate an incentive-based policy. Calibrated to the US automobile market, simulation results suggest that the second-best gasoline tax is 3–30% higher than marginal external damages. The optimal price policy includes a gasoline tax set about equal to marginal external damages and a fuel economy tax that increases the price of an average non-hybrid car by about $550–$2200 relative to the price of an average hybrid car.

**Subject Area:** Present bias; Energy policy; Gasoline tax; Quasi-hyperbolic discounting

**Racialized Mobility Transitions in Philadelphia: Connecting Urban Sustainability and Transport Justice** *Mimi Sheller*

**Abstract:** National level statistics show a decade-long decline in the use of cars in the United States as well as other developed countries. This transition has been connected to growth in more sustainable forms of urban transport such as walking, bicycling, and increased use of transit, as well as changes in urban spatial planning. This article examines the recent trends toward more sustainable mobility in Philadelphia, in order to locate these cultural changes in a specific spatial, cultural, and racial context. The article raises the crucial yet often ignored issue of how urban spatial form and mobility regimes in post-industrial cities like Philadelphia are highly inflected by racial space and racialized mobilities. It suggests that wider trends toward decreasing young white automobility in cities across the U.S. must be situated in relation to changing patterns of suburbanization of poverty, gentrification of city centers, and struggles over public transit access and investment. The specific case is analyzed in relation to multi-level transition theories, cultural analysis of mobility frames and discourses, and the addition of local observation of everyday transport drawing on perspectives from mobilities research. A focus on racial space and transport inequality adds new insights to understanding the limits of any transition that may be taking place in the American automobility regime, and it expands how such transitions are being culturally framed and promoted.

**Subject Area:** millennials, race, VMT, poverty

# Conceptualising and Measuring Spatial Indicators of Employment Through a Liveability Lens

*Hannah Badland, Melanie Davern, Karen Villanueva, Suzanne Mavoa, Allison Milner, Rebecca Roberts, & Billie Giles-Corti*

**Abstract:** Employment is a well-known social determinant of health and wellbeing and important for the liveability of a region. Yet, spatial data are rarely used to understand barriers and facilitators of accessing employment within a city. Therefore it remains challenging to plan cities that provide equitable opportunities for urban job seekers. This paper sought to: (1) identify urban planning and neighbourhood spatial attributes that facilitate access to employment; (2) conceptualise how neighbourhood attributes that facilitate accessible urban employment may be related to health and wellbeing behaviours and outcomes; and (3) isolate potentially important neighbourhood-level spatial measures that policy-makers and planners could use to assess urban employment accessibility. A conceptual framework was developed through a social determinants of health lens, where more upstream (e.g., neighbourhood attributes) and more downstream (e.g., behaviours, intermediate outcomes) determinants of urban employment were identified in relation to long-term health and social outcomes of interest. Six potential neighbourhood spatial measures of employment were identified. These were classified into measures of: access to employment (n = 4), local employment (n = 1), and neighbourhood employment level (n = 1). The spatial measures proposed rely on routinely collected administrative datasets existing within Australia (i.e., census data); therefore can be replicated over time and data are available nationally. Together, this research identified a suite of potential (and readily available) spatial measures that can be used to assess selected neighbourhood attributes as they relate to urban employment access. Such spatial measures can be used to inform future planning decisions that integrate policies across multiple sectors, thereby improving employment accessibility in an urban context.

**Transport Challenges in Rural Indiana** *V. Dimitra Pyrialakou, Brigitte Waldorf, & Konstantina Gkritza*

**Abstract:** In this publication we look at the transport situation in Indiana's rural counties. We first explore the transport need in Indiana's rural counties. Next we look at the public transportation availability in rural counties and proximity to hospitals, schools, and recreational opportunities. In combination, public transportation availability and proximity to services determine a county's accessibility levels. Comparing needs and accessibility, we then identify the counties with the greatest transport challenges, that is, those counties with the largest gaps between needs and accessibility. Finally, we discuss the planning and policy implications for addressing the mismatch between transport needs and available opportunities and resources in rural Indiana.

**Subject Area:** rural Indiana transport

**Reforming the Taxation of Vehicle Use and Ownership** *Stef Proost, Kurt van Dender and Jonas Eliasson*

**Abstract:** In many economies, motor fuel taxes have long been the main instruments for generating tax revenues from the transport sector. Nowadays they are also rationalized on the grounds of reducing congestion, carbon emissions, local air pollution, energy dependency, and sometimes accident costs. However, for several reasons, there is now much debate about reforming or partially replacing these taxes. This debate raises several kinds of research questions, including efficient design of such tax instruments and what factors affect their design in reality, CTS organised an international symposium where recent research regarding these issues was presented. This report summarises some findings from the symposium.

**Subject Area:** Fuel tax, vehicle tax, transport pricing

# Optimal Fuel Taxes and Heterogeneity of Cities *Prof. Dr. Georg Hirte, & Stefan Tscharaktschiew Ph.D.*

**Abstract:** In the United States all levels of jurisdictions are allowed to levy supplements to the federal fuel tax level. While fuel tax differentials at the state level are substantial, there is a relatively small differentiation across cities. This seems surprising given the heterogeneity of U.S. metropolitan areas. Against this background, the objective of the present paper is to analyze whether the current small level of tax differentiation across heterogeneous metropolitan areas is justified on efficiency grounds. We employ a spatial urban computable general equilibrium approach and calculate optimal gasoline taxes for an average U.S. prototype urban area characterized by a medium degree with respect to the spatial distribution of jobs (implying a medium spatial expansion of the urban area, medium degree of externalities, medium public transit share etc.) and for cities that differ with respect to these and further characteristics. We find that in our prototype urban economy the optimal gasoline tax is higher than current rates as suggested by previous studies calculating nationwide optimal gasoline taxes. Furthermore, it is shown that optimal tax levels may vary considerably across heterogeneous cities, much more than actual tax rates. This implies that stronger spatial fuel tax differentiation across cities could raise social welfare. However, we also show that setting an optimal spatially uniform tax, i.e. a uniform tax that maximizes the sum of the benefits generated in all cities, is capable to generate a significant fraction of the maximum achievable welfare gain under optimal city specific locally differentiated gasoline taxes. Interestingly, such an optimal uniform tax could deviate from all city specific optimal fuel tax levels. This suggests that the additional benefit from spatial fuel tax differentiation might actually be relatively small, in our case the efficiency premium is less than one-thirds.

**Subject Area:** Fuel tax; Gasoline tax; Urban economics; Tax differentiation; Job sprawl

## Streets to Live In: Justice, Space, and Sharing the Road *Laura M. Hartman, & David Prytherch*

**Abstract:**  Public streets are central to the built environment, where individuals seek a fair share of the roadway's benefits and harms. But the American street, an asphalt landscape typically defined and designed for cars, can be inaccessible, unhealthy, and dangerous for the non-motorized, whose transportation choices have the smallest ecological footprint. Concern for social equity and sustainability requires rethinking the street geographically and ethically, and asking: "In what sense is the street a space of justice (or injustice)? How do traditional street regulation and design manifest ethical priorities? And what might a more just street look like, in theory and practice?" Such questions prompt one to engage both the spatial and moral, thus drawing from critical geography and ethics (including religion) to analyze roadways in terms of fairness and relational wholeness, and argue for what might be called a shalom street. Engaging such ethical concepts with the technical vocabularies of street regulation and design requires analyzing how national model standards and their interpretation (in the case study state of Ohio) enforce and materialize justice (or injustice) on the street.The promise of more just alternatives such as more sustainable and fair "Complete Streets" to live in needs to be explored.

**Subject Area:** social justice; public policy

**The Social Justice (of) Movement: How Public Transportation Administrators Define Social Justice** *Wellman, Gerard C.*

**Abstract:** Throughout the United States' troubled history of race and gender relations, the simple ability to travel from one location to another has been a crucial element of social justice. Keeping African-Americans, women, and other minority groups "in their place" frequently became a preoccupation of dominant groups to limit other groups' physical and social mobility (Domosh & Seager, 2001, p. 115). Homer Plessy's 1892 arrest for riding in a railcar reserved for Caucasians became the basis of the United States Supreme Court's "separate but equal" doctrine which remained in place for sixty years. Rosa Parks' legendary refusal to move to the back of an illegally segregated city bus in Montgomery, Alabama not only led to a boycott of Montgomery's transit system, but also affirmed the use and place of civil disobedience to protest violations of civil and social justice (Banks, 1994; Parks & Haskins, 1992). The 1961 Freedom Riders' protests of segregated public buses through the very use of public buses, and the Southern violence that greeted them, exposed how the simple act of using publicly-provided transportation facilities can, itself, be a political act. Thus, among many notable others, Homer Plessy, Rosa Parks, and the Freedom Riders revealed the inextricably close relationship between physical mobility and social justice.

**Subject Area:** social justice; public policy

**Availability:** Wellman, Gerard C. "The Social Justice (of) Movement: How Public Transportation Administrators Define Social Justice." Public Administration Quarterly 39.1 (2015): 117.
https://www.questia.com/library/journal/1G1-406518385/the-social-justice-of-movement-how-public-transportation

# A Tour Characterization Framework Incorporating An Activity Stop Sequencing Model System

*Garikapati, Venu M., Daehyun You, Ram M. Pendyala, Kyunghwi Jeon, Vladimir Livshits, and Peter S. Vovsha*

**Abstract:** Activity-based models (ABMs) adopt the notion of tours to model activity-travel patterns, as the concept of a tour closely mimics the way in which individuals chain their activities in the real world. Each tour may be defined by a primary destination (corresponding to a primary purpose) and may also include a multitude of secondary stops on the way to the primary destination (outbound half tour) or on the way back (inbound half tour). This paper presents a tour characterization framework capable of simulating all of the secondary stops on a tour, the time allocated to each of the activities, and the sequence of stops on a tour. The first component that simulates the mix of activities and their corresponding durations was presented in an earlier paper (Garikapati et al, 2014). This paper presents the stop sequencing component capable of determining the order in which activities will be pursued on outbound and inbound half tours. Model estimation results and comparisons between observed and predicted stop-sequencing patterns are presented. The models are found to perform quite well in replicating the observed stop making patterns. The overall tour characterization framework is designed to accommodate the continuous treatment of time in ABMs in practice.

# Road Traffic Congestion: A Concise Guide *John C. Falcocchio, & Herbert S. Levinson*

**Abstract:**  This book on road traffic congestion in cities and suburbs describes congestion problems and shows how they can be relieved.

**Subject Area:** traffic congestion; mobility; speed

**Availability:** Falcocchio, John C., and Herbert S. Levinson. "Road Traffic Congestion: A Concise Guide." http://link.springer.com/content/pdf/10.1007/978-3-319-15165-6.pdf

# The Impact of Traffic Congestion on Mobility *John C. Falcocchio, & Herbert S. Levinson*

**Abstract:**  Mobility is the ability of people and goods to travel easily, safely, quickly and reliably. Trip mobility varies with the speed of travel, and it may be defined as the number of trips taken and their distance (trip-miles) within the traveler's daily travel time and cost budgets. Therefore, lower speeds resulting from traffic congestion reduce mobility.

**Subject Area:** traffic congestion; mobility; speed

## A Model System To Evaluate The Impacts Of Vehicle-Related Taxation Policies On Household Greenhouse Gas Emissions  *Liu, Yan*

**Abstract:**  This thesis proposes a model system to forecast household-level greenhouse gas emissions (GHGEs) from private transportation and to evaluate effects of car-related taxation schemes on vehicle emissions. The system contains four sub-models which specifically capture households' vehicle type and vintage, quantity, usage, and greenhouse gas emissions rates for different vehicle types. An integrated discrete-continuous vehicle ownership model is successfully implemented, while MOVES2014 (Motor Vehicle Emission Simulator 2014) is utilized. The model system has been applied to the Washington D.C. Metropolitan Area. The 2009 National Household Travel Survey (NHTS) with supplementary data from the Consumer Reports, the American Fact Finder and the 2009 State Motor Vehicle Registrations (SMVR) are used for estimations and predictions. Three tax schemes, vehicle ownership tax, purchase tax and fuel tax, have been proposed and their impacts on vehicle GHGEs reduction are predicted. The proposed model system can be extended to other regions, counties, states and nations.

**Subject Area:** Discrete Choice Model; Emission Reduction; Greenhouse Gas; Integrated Vehicle Ownership Model; MOVES; Taxation Policy

# Transport policy and the car divide in the UK, the US and France: beyond the environmental debate *Porter, Christopher, David Kall, Daniel Beagan, Richard Margiotta*

**Abstract:**  This document is the Final Report for NCHRP Project 25-38, Input Guidelines for Motor Vehicle Emissions Simulator Model (MOVES). The other major product of this research is a resource document, titled Developing Inputs for the Motor Vehicle Emissions Simulator Model: Practitioners' Handbook, that provides information for practitioners on how to develop local inputs for the U.S. Environmental Protection Agency's MOVES model. Four tools, along with supporting documentation (MOVES Tool Documentation), were also developed to assist MOVES users in developing specific inputs.

**Subject Area:** Vehicle inventory; MOVES source types

**Transport policy and the car divide in the UK, the US and France: beyond the environmental debate** *Olivier Coutard, Gabriel Dupuy, & Sylvie Fol*

**Abstract:** Public aid programs to subsidize the auto-mobility of low-income households are at the heart of a trade-off between economic, environmental and social concerns. This article will analyze comparative research into the origins and development of such programs in three countries characterized by different levels of car dependence (France, the UK and the US). It will show that these programs, which are of obvious benefit for the households in question and have largely escaped criticism, despite undermining policies that restrict the use of cars, remain of marginal importance in all three countries. This reasons for this are twofold: firstly, auto programs are not an appropriate solution to the difficulties encountered by a significant portion of poor households and, secondly, wider development of such policies would constitute a considerable political gamble, especially as they risk destabilizing the mechanisms for funding public transit and weakening their social legitimacy.

**Subject Area:** public aid; auto programs; public transit

# Pay-As-You-Drive Insurance Its Impacts on Household Driving and Welfare

*Brice G. Nichols, & Kara M. Kockelman*

**Abstract:** Vehicle-miles traveled (VMT) can greatly affect crash risk and, therefore, insurance costs, but accurately assessing VMT has been challenging for insurance agencies. Affordable technology now allows insurance companies to track VMT better and has prompted pilot programs and further research of mileage-based, or pay-as-you-drive (PAYD), insurance. Research shows that PAYD programs can discourage extraneous driving and thereby save drivers money (but reduce consumer welfare by less than consumer cost savings) and reduce crash risks, insurers' costs, and externalities. Studies consider aggregate, national, and statewide effects of PAYD policies, with some focus on equity effects, but much heterogeneity is ignored. This study bolsters existing work by predicting PAYD effects with the use of National Household Travel Survey (NHTS) data. These data are used to model driver response to driving cost changes and an insurance pricing model (per vehicle) according to actual loss data and risk factors by vehicle type. This study anticipates PAYD impact variations across a sample of NHTS households and vehicle types and finds that on average households save enough on reduced insurance and travel costs to cover lost welfare from VMT reductions. Results suggest that the average (light-duty) vehicle will be driven 2.7% less (237 fewer annual miles per year), with average consumer benefits of only $2.00 per vehicle with a premium that is partially fixed and partially mileage based. Drivers with the lowest annual VMT needs are expected to receive the largest welfare benefits, thanks to a convex relationship between VMT and crash losses. This analysis provides support to existing literature that PAYD policies can reduce VMT and insurance pricing equity without harming driver welfare.

**Subject Area:** pay as you drive insurance; VMT

# A simple empirical analysis on the link between socioeconomic status and spatial mobility *Keita, Moussa*

**Abstract:** Considering spatial mobility as an important dimension of human capability with direct implications for well-being, this study examines the link between individuals' socioeconomic status and their degree of mobility. We use data from the National Household Travel Survey (NHTS) conducted in United States in 2009 by the US Department of Transportation. We construct two complementary mobility variables: one translating the average distance individuals travel by day and the other capturing the average number of trips made by individuals in a day. Using both exploratory and multivariate linear regressions analyzes, our results show that socioeconomic status determines significantly individuals' degree of mobility. We found that mobility is significantly higher among the most educated individuals and those with high income levels. It also appears strong heterogeneity in the mobility according to gender or individuals' age. We found, in particular, that men are more mobile than women in terms of distance traveled. But conversely, women are much more mobile than men in terms of frequency of trips.

**Subject Area**: spatial mobility, socio-economics status

# Sustainability Of Multimodal Intercity Transportation Using A Hybrid System Dynamics And Agent-Based Modeling Approach *Ludovic F. Hivin*

**Abstract:** Demand for intercity transportation has increased significantly in the past decades and is expected to continue to follow this trend in the future. In the meantime, concern about the environmental impact and potential climate change associated with this demand has grown, resulting in an increasing importance of climate impact considerations in the overarching issue of sustainability. This results in discussions on new regulations, policies and technologies to reduce transportation's climate impact. Policies may affect the demand for the different transportation modes through increased travel costs, increased market share of more fuel efficient vehicles, or even the introduction of new modes of transportation. However, the effect of policies and technologies on mobility, demand, fleet composition and the resulting climate impact remains highly uncertain due to the many interdependencies. This motivates the creation of a parametric modeling and simulation environment to explore a wide variety of policy and technology scenarios and assess the sustainability of transportation. In order to capture total transportation demand and the potential mode shifts, a multimodal approach is necessary. The complexity of the intercity transportation System-of-Systems calls for a hybrid Agent-Based Modeling and System Dynamics paradigm to better represent both micro-level and macro-level behaviors. Various techniques for combining these paradigms are explored and classified to serve as a hybrid modeling guide. A System Dynamics approach is developed, that integrates socio-economic factors, mode performance, aggregated demand and climate impact. It is used to explore different policy and technology scenarios, and better understand the dynamic behavior of the intercity transportation System-of-Systems. In order to generate the necessary data to create and validate the System Dynamics model, an Agent-Based model is used due to its capability to better capture the behavior of a collection of sentient entities. Equivalency of both models is ensured through a rigorous cross-calibration process. Through the use of fleet models, the fuel burn and life cycle emissions from different modes of transportation are quantified. The radiative forcing from the main gaseous and aerosol species is then obtained through radiative transfer calculations and regional variations are discussed. This new simulation environment called the environmental Ground and Air Mode Explorer (eGAME) is then used to explore different policy and technology scenarios and assess their effect on transportation demand, fleet efficiencies and the resulting climate impact. The results obtained with this integrated assessment tool aim to support a scenario-based decision making approach and provide insight into the future of the U.S. transportation system in a climate constrained environment.

**Subject Area**: Agent-based model; fleet models; intercity transportation; environmental impact

**Promoting Sustainable Travel Modes for Commute Tours: A Comparison of the Effects of Home and Work Locations and Employer-Provided Incentives** *Dr. Hongwei Dong, Dr. Liang Ma & Dr. Joseph Broach*

**Abstract:** By using data from the 2011 Oregon Household Activity Survey, conducted in the Portland, Oregon, metropolitan area, this study conducts tour-based analyses of commute mode choice and applies them to evaluate and compare the effects of three sets of variables: the built environment at home, the built environment at workplace, and employer-provided financial incentives. The analysis results suggested that compared to the built environment at home, the built environment at workplace showed more additional explanatory power, illustrating the importance of including work location related variables in the models that simulate commute mode choice and trip chaining. Furthermore, we found that employer-provided financial incentives, in particular, parking fees at workplaces and the provision of subsidized transit passes, could also be very efficient policy levers to encourage commuters to use more sustainable commute modes, especially public transit. While the model results clearly show that the effects of many variables vary by tour complexity, we did not find strong evidence to the hypothesis that trip-chaining creates a barrier to shifting commuters' travel mode from auto to non-auto modes.

# Environmental Policy And Vehicle Safety: The Impact Of Gasoline Taxes

*Damien Sheehan-Connor*

**Abstract:** Policies to reduce carbon emissions by vehicles, such as fuel economy standards and gasoline taxes, have impacts on vehicle weight and thus on safety. This paper develops a model that separately identifies the impact of vehicle weight on mortality and selection effects that impact accident propensity. The main results are that (1) the safety externalities associated with heavy vehicles are greater than the environmental ones; (2) under fuel economy standards, vehicle weights have recently decreased with little likely effect on accident deaths; and (3) similar environmental benefits could be combined with substantial reductions in deaths by implementing higher gasoline taxes. (JEL H23, D62)

# 6. Special Population Groups

**Retirees Get Back on Their Bikes** *Laura Johannes*

**Abstract:**  More older people are taking up biking, often after decades away from a sport they once loved. In a recent poll, some 20% of people age 50 and older say they've ridden a bike in the past year, up from 16% in 2011, according to AARP.

**Subject Area:** retirees; bicycling

**Availability:** Johannes, Laura. "Retirees Get Back on Their Bikes Some people ride for the health benefits. Others do it to feel young again" (November 29, 2015).
http://www.wsj.com/articles/retirees-get-back-on-their-bikes-1448852636

# Gender Differences In Mobility Of Hispanic Immigrants *Miwa Matsuo*

**Abstract:**  The U.S. immigrant population is steadily increasing, and approximately half of this population is Hispanic. This paper aims to understand the mobility of Hispanic immigrants, particularly whether gender differences exist in their mobility. Using National Household Travel Survey data for 2009, this paper finds that the gender difference in mobility is greater among Hispanics, particularly for low-income Hispanic immigrants, than for other populations. Hispanic female immigrants are substantially less likely to be drivers than their male counterparts and females of other race/ethnicity groups. Moreover, the probability of being a driver is persistently low for Hispanic female immigrants even after years of residing in the U.S., while driver status of females in other race/ethnicity groups increases quickly as they stay longer in the U.S. Hispanic female immigrants are likely not actively choosing to be non-drivers; if they are drivers, they drive more than females of other race/ethnicity groups. Although regression analysis does not prove causal relationships between low-income status and driver status, there are policy implications if barriers to becoming a driver limit training or employment and contribute to low-income status. More detailed analysis is anticipated to detail the mobility challenges Hispanic female immigrants face.

**Subject Area:** Mobility, Immigrants, Hispanics, Gender, National Household Travel Survey, Driver

## Move Over Millennials: The Auto Industry is Interested in Your Grandparents
*Jennifer Goff*

**Abstract:**  Kyle Stock of Bloomberg Business recently declared the elderly as the future of the U.S. auto industry. The reason why is multifold but this turn to seniors (in millennial parlance: the olds) is less surprising than it first appears. Stock explains, "American seniors have never been healthier or wealthier. At the same time, cars have never been crammed with more features to safeguard drivers with fuzzier vision, slower reactions, and stiffer necks."

**Subject Area:** elderly, millenials

**Availability:** Goff, Jennifer. Quoted" *Move Over Millennials: The Auto Industry is Interested in Your Grandparents* October 16, 2015. https://www.thezebra.com/insurance-news/2167/seniors-auto-industry/

# Caregiving, Transport-Related, and Demographic Correlates of Sedentary Behavior in Older Adults The Senior Neighborhood Quality of Life Study

*White MN, King AC, Sallis JF, Frank LD, Saelens BE, Conway TL, Cain KL,& Kerr J.*

**Abstract:** Objective: Excess sedentary time predicts negative health outcomes independent of physical activity. The present investigation examined informal caregiving duties and transportation-related factors as potential correlates of sedentary behavior in older adults. Method: Average daily sedentary time was measured via accelerometer in adults ages 66 years and older (N = 861). Caregiving variables included dog ownership and informal family caregiving status. Transportation variables included driver status, walking distance to public transit, and reported presence of pedestrians and bicyclists in one's neighborhood. Results: In multivariate models, owning a dog and being a driver were associated with less sedentary time (p ≤ .01). Educational status and geographic region modified the association between dog ownership and sedentary time, and age modified the association between driver status and sedentary time. Discussion: This study identified that older adult dog owners and drivers were less sedentary. Both factors may create opportunities for older adults to get out of their homes.

**Subject Area:** sedentary behavior; physical activity; older adults; elderly

**Car today, gone tomorrow: The ephemeral car in low-income, immigrant and minority families** *Klein, Nicholas J., and Michael J. Smart*

**Abstract:** Most transportation research in the United States uses cross-sectional, "snapshot" data to understand levels of car access. Might this cross-sectional approach mask considerable variation over time and within households? We use a panel dataset, the Panel Study of Income Dynamics (PSID), for the years 1999–2011 to test this question. We find that for most families, being "carless" is a temporary condition. While 13 % of families in the US are carless in any given year, only 5 % of families are carless for all seven waves of data we examine in the PSID. We also find that poor families, immigrants, and people of color (particularly, blacks) are considerably more likely to transition into and out car ownership frequently and are less likely to have a car in any survey year than are non-poor families, the US-born, and whites.

**Trips to medical care among persons with disabilities: Evidence from the 2009 National Household Travel Survey** *Debra L. Brucker & Nicholas G. Rollins*

**Abstract:** Using data from the 2009 National Household Travel Survey (NHTS), we use multivariate techniques to examine travel patterns of persons with disabilities as they access medical care. We find no difference in the distance traveled but do find that trips to medical care by persons with disabilities take longer amounts of time than trips taken by persons without disabilities, holding other variables constant. Access to private transportation is similar for both persons with and without disabilities. Policy implications are discussed.

**Subject Area:** Medical care; disability;

**Availability:** Draft submission for publication

**Understanding Older Drivers: An Examination of Medical Conditions, Medication Use, and Travel Behavior** *Sandra Rosenbloom & Robert Santos*

**Abstract:** This first phase of an Urban Institute study funded by the AAA Foundation for Traffic

Safety focuses on creating baseline information on older driver behavior, medication use, and medical conditions from two large national data bases: the 2009 National Household Travel Survey (NHTS) and the 2011 National Health and Aging Trends Study (NHATS). Overall our findings suggest that: Older drivers are substantially more likely to report having a medical condition or a disability than younger drivers. Medication use and polypharmacy (the use of multiple medications) is very high among older drivers. Older drivers who report using medications or having a medical condition are more likely to self-regulate all aspects of their driving behavior. Gender differences in all aspects of medication use, travel behavior, and driving self-regulation among those 65 and older are extremely large. Older drivers still drive frequently and for some distance, even when practicing self-regulation. Increasing income is associated with more driving and less self-regulation among older drivers for reasons not immediately clear.

**Subject Area:** Older drivers; medical condition; disability;

## Mode Choices of Millennials: How Different? How Enduring? *Robert B. Case, PE, PhD, Seth Schipinski*

**Abstract:** It has been written that nationwide Millennials (born 1982-2000) use cars less often and alternative modes (bike, walk, public transit) more often than previous generations. Therefore, this analysis seeks to determine whether we should plan for a quantum leap in demand for alternative transportation for commuting in Hampton Roads' future when Millennials and following generations comprise the workforce. To answer this question, HRTPO staff measured how Millennials' mode choices differ from other generations in Hampton Roads, finding Millennials twice as likely to use alternative modes. In order to forecast usage of alternative transportation in Hampton Roads, staff developed a model (based on NHTS surveys) incorporating various factors—including generation— which impact alternative transportation usage to work. First, our regression revealed that usage of alternative transportation to work is a function of at least seven (7) factors—1. Income, 2. Age, 3. Era, 4. Generation, 5. MSA size, 6. Urbanized Area status, 7. Gender—concluding that the HRTPO should consider all seven (7) of these factors when planning alternative transportation infrastructure for commuting. Second, our regression revealed that being a part of the Millennial generation is a positive factor concerning usage of alternative transportation. Based on a model forecast, if all other things (besides generation) were the same in the future as today (income, age, etc.), HRTPO staff would expect usage of alternative transportation for commuting in Hampton Roads to increase from 5.3% (2010) to 6.9% (2050).

**Subject Area:** millennials; alternative modes; commuting

**The Effect of Commuting Patterns on HIV Care Attendance Among Men Who Have Sex With Men (MSM) in Atlanta, Georgia** *Dasgupta, Sharoda, Michael R. Kramer, Eli S. Rosenberg, Travis H. Sanchez, Landon Reed, and Patrick S. Sullivan.*

**Abstract:** Background: Travel-related barriers to human immunodeficiency virus (HIV) care, such as commute time and mode of transportation, have been reported in the United States. Objective: The objective of the study was to investigate the association between public transportation use and HIV care attendance among a convenience sample of Atlanta-based, HIV-positive men who have sex with men (MSM), evaluate differences across regions of residence, and estimate the relationship between travel distance and time by mode of transportation taken to attend appointments. Methods: We used Poisson regression to estimate the association between use of public transportation to attend HIV-related medical visits and frequency of care attendance over the previous 12 months. The relationship between travel distance and commute time was estimated using linear regression. Kriging was used to interpolate commute time to visually examine geographic differences in commuting patterns in relation to access to public transportation and population-based estimates of household vehicle ownership. Results: Using public transportation was associated with lower rates of HIV care attendance compared to using private transportation, but only in south Atlanta (south: aRR: 0.75, 95% CI 0.56, 1.0, north: aRR: 0.90, 95% CI 0.71, 1.1). Participants living in south Atlanta were more likely to have longer commute times associated with attending HIV visits, have greater access to public transportation, and may live in areas with low vehicle ownership. A majority of attended HIV providers were located in north and central Atlanta, despite there being participants living all across the city. Estimated commute times per mile traveled were three times as high among public transit users compared to private transportation users. Conclusions: Improving local public transit and implementing use of mobile clinics could help address travel-related barriers to HIV care.

**Subject Area:** men who have sex with men; HIV care; commuting patterns; public transportation

## A Brief Research Report on Understanding the Meaning of Driving for Older Americans: A Korean's Perspective on Two Cultures  *Claire Su-Yeon Park; Saunjoo Lee Yoon; Catherine Adele Hamilto & Christa Louise Cook*

**Abstract:**  This discussion paper used a brief qualitative research report to understand the meaning of driving to older Americans from the perspective of a Korean researcher in order to increase cultural sensitivity. In-depth audio-recorded interviews were conducted with two older Americans by the Korean researcher. A conventional content analysis was performed, resulting in the conceptual model describing their meaning of driving according to life cycle. The Korean researcher's autobiographical journal, a coding scheme, peer debriefing, and thick description with quotes were utilized to ensure the trustworthiness of study findings. Participants described the meaning of driving throughout their lifespan as having four themes: Starting to be autonomous, Staying autonomous, Losing autonomy, and Regaining autonomy. Unlike older Koreans, having driving privileges greatly influences the feeling of autonomy among older Americans. In order to provide culturally-sensitive care for older Americans, it is imperative to recognize the loss of autonomy that results from losing their driving privileges.

# The relationship between age and driving attitudes and behaviors among older Americans *Alexander J Mizenko, Brian C Tefft, Lindsay S Arnold, & Jurek G Grabowski*

**Abstract:** Background: Due to a decreasing birth rate and longer life expectancy, the proportion of Americans over the age of 65 is expected to rise in coming years. Drivers over 65 drive two billion miles yearly, a number that will increase. For that reason, it is imperative to understand their attitudes and perceptions. It is also important to understand whether drivers over 65 can be treated as one cohesive group, or if there are differences among them. Methods: A web-enabled survey was conducted among Americans in the years 2011–2013. Responses from 1793 persons over 65 regarding attitudes towards driving behaviors, support for safety interventions, and engagement in unsafe behaviors were analyzed. Respondents were stratified by age: 65–69, 70–74, and 75 and older. Age groups were compared using logistic regression. Other potential explanatory factors were analyzed and controlled for. Results: The three groups were similar on many outcomes. However, statistically significant differences were found between them with regard to perceptions on speeding and the support for speed cameras, among other outcomes. In nearly all cases, those 75 and older were the most "pro-safety." However, when adjusted for demographic characteristics other than age, a larger proportion of respondents 75 and older reported engaging in red light running and drowsy driving in the last 30 days, and the difference was statistically significant. Conclusion: Older drivers are strongly "pro-traffic safety." However, the finding that those 65–69 are less so is concerning. This is especially true if it is the result of a cohort effect instead of an age effect. The increase in certain behaviors among those 75 and older is also concerning; drivers over this age are more prone to fatal injury when involved in a motor vehicle crashes. This poses a public health issue as the 75 and older population expands.

**Subject Area:** Traffic, Safety, Seniors, Driving, Aging

**Research on the Travel Behavior of Landless Farmers in the Process of Urbanization—A Case Study in China** *Qing Li and Xiaohong Chen*

**Abstract:** In the process of urbanization in China, the number of landless farmers reached 40-50 million and continues to rise. Their travel pattern is different from the native citizens and is less stable. It is essential to understand their travel behaviors for policy makers. Unfortunately, few studies in this area have been conducted. By using the data from Household Travel Survey in Zhoushan City, this paper examines the landless farmers' travel behaviors and makes a comparison with the native residents. It is found that landless farmers make fewer trips and have different trip purposes. Moreover, owing to the low level of automobile ownership and inadequate public transit service, landless farmers are experiencing severely low mobility and relying on mopeds, while they show an inclination towards cars with economic assimilation. Finally, based on the implications of these findings, some recommendations are put forward for transportation policy makers to meet landless farmers' needs and guide their travel behavior.

**Subject Area:** mobility, farmer, China, travel behavior

# Are Millennials Really the "Go-Nowhere" Generation? *Noreen C. McDonald*

**Abstract:** Problem, research strategy, and findings: News reports and academic articles contend that Millennials (those born in the last two decades of the 20th century) are different from earlier generations in their consumption and travel patterns. This article investigates the travel behavior of young American adults and compares the behavior of Millennials with those of previous generations using data from the 1995, 2001, and 2009 National Household Travel Surveys. The analysis uses descriptive statistics to profile trends and regression models to identify the factors associated with decreased travel by Millennials. In fact, automobility declines for all Americans between 1995 and 2009, but the drops are largest for Millennials and younger members of Generation X starting in the late 1990s. Decreases in driving are not compensated by increases in the use of other modes for travel, nor do decreased trip distances explain the downturn in automobility. Among young adults, lifestyle-related demographic shifts, including decreased employment, explain 10% to 25% of the decrease in driving; Millennial-specific factors such as changing attitudes and use of virtual mobility (online shopping, social media) explain 35% to 50% of the drop in driving; and the general dampening of travel demand that occurred across all age groups accounts for the remaining 40%. Takeaway for practice: These changes highlight two challenges to planners and policymakers: managing increases in automobility as Millennials age and their economic fortunes improve, and developing improved planning processes that deal robustly with the uncertain future presented by Millennials who may continue to make very different travel choices than comparable people did in the past.

**Subject Area:** Millennials, automobility, peak travel, travel behavior, licensure

# Factors affecting children's journeys to school: a joint escort-mode choice model *He, Sylvia Y., and Genevieve Giuliano.*

**Abstract:** A child's mode of travelling to school is influenced by, or dependent on, parental choices. Thus, an increasing proportion of car trips may reflect parental choices and constraints. Whether a parent can escort their children to school may depend on their scheduling and spatial constraints, e.g., work schedule and job location in relation to home and school locations. This research aims to understand the effect of household bundling constraints on a child's escort-mode choice. In this study, school trip data are drawn from the 2001 SCAG (Southern California Association of Governments) Post Census Regional Household Travel Survey. The study area is the five-county Los Angeles region. Our findings show that the parents', especially the mother's, increased working hours and more distant job locations result in an increased likelihood of several alternative escort-mode choices. Mothers who work longer hours and further away from home are less likely to chauffeur their children. These trips have been substituted by alternative escort choices such as independent travel and being escorted by fathers, or alternative mode choices such as active commuting and busing. The effect of increased working hours may be offset by the option of flexible working hours, which allows parents to arrange more escort trips. This study elucidates an important aspect in explaining children's changing mode choice in journeys to school and sheds light on current policy efforts in reducing children's car dependency.

# Mode Choices of Millennials: How Different? How Enduring? *Hampton Roads TPO Robert B. Case, PE, PhD & Seth Schipinski*

**Abstract:** It has been written that workers currently aged 15-33—known as the Millennial generation— tend to use cars less often, and use alternative modes more often, than those of previous generations. This analysis seeks therefore to determine whether—in fact—such persons do have high usage of alternative modes ("How Different?"), and whether that behavior is expected to continue in the future ("How Enduring?"), i.e. whether we should plan for much higher demand for alternative transportation in the future in Hampton Roads. To answer this question, HRTPO staff isolated generational effects from age and period effects by compiling and regressing a dataset of National Household Travel Survey (NHTS) records from three different years: 1983, 1995, and 2008/2009. The analysis revealed highly significant relationships between alternative mode usage for commuting and nearly all of the independent variables selected, allowing the authors to provide an answer to the stated question.

## Chapter 4 The Influence of Parent's Perceptions and Residential Self-Selection to the Children's Travel Modes at Single Parent Households *Yusak O. Susilo*

**Abstract:** Purpose: This chapter investigates the impacts of households' residential self-selection, parents' perceptions and travel patterns on their children's daily travel mode shares, among single parent households. Methodology/approach: To capture the complexity of the relationships between parent and children daily travel mode choices, an integrated model structure is introduced and the model estimated with simultaneous equation modelling. Findings: The results show that, beside the daily activity-travel engagements of the parent, both parents' perceptions and his/her residential self-selection reasons play significant roles in influencing their children daily travel mode shares. The parent's perceptions play more significant roles in influencing children's travel modes shares, whilst the residential self-selection reasons have more significant influence on the parent's travel mode choice. Research limitations/implications: The finding of this study reveals a fact that wherever the children live, their travel behaviour tend to be 'neutral' and open to influence by their parents throughout their childhood. Originality/value: This study adds to our understanding of the interactions between parents' attitudes and behaviours with their children's travel patterns. This study focuses on single parent households, on which there is very little literature.

## Health Care Provider Mobility Counseling Provision to Older Adults: A Rural/Urban Comparison

*Andrea L. Huseth-Zosel, Gregory Sanders, Melissa O'Connor, Heather Fuller-Iglesias, & Linda Langley*

**Abstract:** The current study examined rural–urban differences in health care provider (HCP) perceptions, attitudes, and practices related to driving safety/cessation-related anticipatory guidance provision to older adults. A cross-sectional survey was conducted with HCPs in several north central states. Exploratory factor analysis was used to examine dimensions of HCP perceptions and attitudes related to mobility counseling. Binary logistic regression analyses were conducted to determine if HCP rurality was significantly predictive of HPC provision of mobility counseling by age. Rural HCPs were less likely than urban HCPs to provide mobility counseling to their patients aged 75 or older. Rural HCPs were less likely to refer patients to a driving fitness evaluation resource if they had questions related to driving issues, and were less likely to perceive there were adequate resources to help with driving issues. Rural–urban differences in HCP mobility counseling provision may contribute to potential health disparities between urban and rural patients. Both rural and urban HCPs need training about older driver issues, so they may educate their patients about driving safety/cessation. Future research should examine the association between rural–urban differences in HCP mobility counseling provision and rural older adult overrepresentation in motor vehicle injuries and fatalities statistics.

## The Transition from Driver to Passenger and the Role of Senior-Friendly Transportation Options." *Nina M. Silverstein, Jana Hunkler, Helen Kerschner, William Henry, & Noah Berger*

**Abstract:** Most older drivers are safe drivers.It is not about age— it is about medical conditions that impact critical driving skills. Most older adults in the USA get around their communities as drivers in their own passenger vehicles. Female non drivers outnumber male non drivers three to one. Driving cessation is associated with Increased social isolation Increased symptoms of depression and accelerated health declines.

**Subject Area:** active transportation; elderly; walkability

**Older Adult Active Transportation in Massachusetts** *Marguerite Hutcheson*

**Abstract:**  Active transportation can facilitate healthy aging through improved mobility and physical health. Living in a walkable environment is linked to increased active transportation among older adults. Yet there is a gap in research on active transportation and its relationship to walkability among older adults living in Massachusetts. My research addresses this gap through descriptive GIS mapping and quantitative analysis of age-based trends in transportation using data from the 2010-2011 Massachusetts Travel Survey (MTS) and Walk Score®. The main findings were that overall travel and rates of active transportation tended to decrease with age (p<0.01). ZIP codes with higher Walk Scores® also had higher rates of walking for both younger and older adults. Though these results cannot establish causation, they can be useful in efforts to make neighborhoods friendlier to older adult pedestrians.

**Subject Area:** active transportation; elderly; walkability

# Who escort children: mum or dad? Exploring gender differences in escorting mobility among parisian dual-earner couples *Benjamin Motte-Baumvol, Olivier Bonin, & Leslie Belton-Chevallier*

**Abstract:** The present article looks to pinpoint explanatory factors for the sharing of escorting of children in dual-earner families. It proposes a detailed analysis of inequalities and interactions in dual-earner families when it comes to escorting children by taking into account the characteristics of trips to and from school for children, the characteristics of the parents' occupations, and the characteristics of the household. Compared with earlier research, the model considers more detailed data about the escorts' jobs, such as specific working hours, which provide a better understanding of the constraints on parents and insight into the choices made when both parents are in a position to escort their children. The findings depart somewhat from those of earlier work on the question because more specific data are considered. They show a marked gender inequality in escorting because mothers in dual-earner families do more than two-thirds of the escorting. But the factors explaining the sharing of escorting act almost symmetrically for both parents, with the effect of work starting and finishing times being preponderant. These models confirm that the inequality kicks in ahead of this: mothers in dual-earner households are more often than fathers in jobs with short working hours and which are more compatible with escorting.

# Travel patterns & socio-demographic correlates of global positioning system (GPS) derived walking & vehicle trips among churchgoing Latinas *Natalicio Serrano*

**Abstract:** *Presentation:* Travel behaviors play an important role in public health. Vehicle Time: linked to increased obesity. Walking: Increased walking reduces the risk of CVD2. Latinos: Spend about 59 min/day in a vehicle. More likely to walk for leisure related travel than their white counterparts.

**Subject Area:** Latinas; church; walking; physical activity and location measurement system

**Availability:** Serrano, Natalicio. "Travel patterns & socio-demographic correlates of global positioning system (GPS) derived walking & vehicle trips among churchgoing Latinas."
http://activelivingresearch.org/sites/default/files/2015_PAPromotion_Serrano.pdf

# National older driver crash trends *Jessica B. Cicchino*

**Abstract:** *Presentation:* Trends in crash rates and driving in older populations

**Subject Area:** senior, crashes, fatalities, survivability

# Vulnerability modeling of casinos in the United States: A case study of Philadelphia *Moira Conway*

**Abstract:**  As the number of states that have legalized casino gaming has continued to increase in the United States, it is important to consider one of the most important costs identified in international gambling research, that of problem gambling. This project seeks to examine the potential impacts of problem gaming in the major metropolitan area of Philadelphia, which is currently the largest city in the United States with an open commercial casino. To understand the vulnerability to problem gaming of the neighborhoods where casinos are located in the metropolitan area of Philadelphia, a GIS vulnerability model was created in order to examine the accessibility to the casinos of those most vulnerable to problem gaming. The results show that three out of the four casinos in metropolitan Philadelphia are located in areas where people are vulnerable to problem gaming. These findings demonstrate a need for public policy to mitigate the potential impacts of problem gaming on the community. The GIS model created for this project is the first vulnerability study of a major urban area in the United States and has the potential to be expanded to contribute to gambling research within the United States and abroad.

**Subject Area:** GIS; Casinos; Philadelphia

## Lakritz: Fear factor harms children *Naomi Lakritz*

**Abstract:**  Discussion on the low rates of biking and walking to school

**Subject Area:** bike, walk, school

**Analysis of the Transportation Disadvantaged in an Aging Society** *Sungyop Kim, and Gudmundur F. Ulfarsson*

**Abstract:** Older adults have been reported as one of the most transportation disadvantaged groups. In particular, mobility challenges for older minority females are notable. This study investigates personal, household, and residential environment factors associated with transportation mobility of older minority females age 65+ using the 2009 National Household Travel Survey conducted in the U.S. Principal Component Analysis and a linear regression model are employed to develop a mobility measure and to examine various factors on the measure. This study found that U.S. born older minority females have distinctly different characteristics from foreign born older minority females with regards to mobility. Public transit use is positively associated with older minority populations' mobility and not driving reduces the mobility level. Older minority women in low income households have lower mobility levels, but those with a college degree have higher mobility levels. This study concludes that older minority populations are not homogenous, thus, more in-depth research on various sub-groups of older minority populations is warranted in an increasingly diverse aging society.

**Subject Area:** aging; transportation disadvantaged; minority; mobility

# Multi-Modal School Transportation Planning - Part I *Todd Litman*

**Abstract:** This lesson describes why and how to improve school transportation options, particularly active modes such as walking and bicycling. School leaders play important roles in collaborating with communities when planning transportation options to encourage the use of alternative transportation modes. Improving travel options is an important and timely issue because walking and bicycling provide direct benefits to students and parents, and indirect benefits to the community at large from reduced vehicular traffic. Many people would prefer to drive less and rely more on alternative modes, provided they are safe and convenient (LaPlante, 2010). Thus, communities may desire to plan for walking and bicycling improvement in collaboration with school leaders.

**Subject Area:** school transportation; bike and walk

**Availability:** <mark>missing a citation</mark>

http://online.tarleton.edu/ACEF/MultiModalSchoolTransportationPlanningPartI/PartIFinalMultiModalSchoolTransportationPlanning_print.html

# Bounding the Potential Increases in Vehicles Miles Traveled for the Non-Driving and Elderly Populations and People with Travel-Restrictive Medical Conditions in an Automated Vehicle Environment *Harper, Corey, Mangones, Sonia, Hendrickson, Chris T, & Samaras, Constantine*

**Abstract:** Automated vehicles represent a technology that promises to increase mobility and accessibility not only to the senior population but also to non-drivers and people with medical conditions. This paper estimates the impact of a fully automated vehicle environment on the total vehicle miles traveled (VMT) by the current U.S. population 19 and older due to an increase in mobility from the non-driving and elderly populations and people with travel-restrictive medical conditions. The primary source of data for this project is the 2009 National Household Transportation Survey (NHTS), which provides information on current travel characteristics of the U.S. population. The changes to the total VMT are estimated by examining three possible demand wedges. In demand wedge one, the assumption made is that non-drivers would travel as much as the drivers within each age group and gender. Demand wedge two assumes that the driving elderly without medical conditions will travel as much as young adults (ages 19-64) within each gender. Demand wedge three makes the assumption that drivers with medical conditions will travel as much as the drivers without medical conditions within each age group and gender in a fully autonomous and connected vehicle environment. The combination of the results from all three demand wedges represents an upper bound of 297 billion miles or a 12% increase in overall VMT. Since traveling has other costs than driving effort, this estimate serves to bound the potential increase from these populations to inform the scope of the challenges, rather than forecast specific VMT scenarios.

**Subject Area:** Aged drivers; Intelligent vehicles; Persons with disabilities; Traffic forecasting; Travel demand; Vehicle miles of travel

# The influence of parents' travel patterns, perceptions and residential self-selectivity to their children travel mode shares *Yusak O. Susilo, & Chengxi Liu*

**Abstract:** Using the UK National Travel Survey from 2002 to 2006, this paper investigates the influence of households' residential self-selectivity, parents' perceptions on accessibilities and their travel patterns on their children daily travel mode share. In doing this, this study introduces a model structure that represents the complex interactions between the parents' travel patterns, their perceptions on public transport services and their reported residential self-selectivity reasons and the children travel mode shares. This structure is analysed with structural equation modelling. The model estimation results show that parents' residential self-selectivity, parents' perceptions and satisfactions on accessibilities and their daily travel patterns significantly influence the children's daily travel mode shares. However, the effects are not uniform across household members. This study has revealed that households' residential self-selectivity behaviours have more correlations with the children's non-motorised mode shares, whilst the parents' perceptions and satisfactions on transport infrastructure and public transport service qualities have more correlations with parents' mode shares. The results also confirm that parents' non-motorised modes use in travelling is highly correlated with the children's physically active travel mode shares. However, at the same time, the results also show that the effects of mothers' car use to the children travel mode shares is more apparent than fathers'.

# Accident patterns and prospects for  maintaining the safety of older drivers

*Gert Weller, Nora Strauzenberg, Margit Herle, Bernhard Schlag and Susann Richter*

**Abstract:**  In most OECD countries, seniors are currently the fastest growing demographic group and this trend is likely to continue for the next two or three decades. Forecasts suggest that by 2030, every fourth person will be older than 65 years (Schlag, 2008b). In OECD countries, it is expected that in 2050 more than a quarter of the population will be older than 65 years (OECD, 2012). In OECD countries the proportion of people over 80 years will rise from 4 % in 2010 to more than 10 % in 2050 (Colombo, Llena-Nozal, Mercier, & Tjadens, 2011). In addition to the economic and financial effects from this demographic shift, there will also be a greater focus on transport safety for older people. The reason for this is the interaction between this demographic shift and increased mobility, especially in the demographic group of elderly drivers (Schlag, 2008b). Thus, there is a strong need for political and social debate that is solutionoriented. The project "Safer Mobility for Elderly Road Users" (SaMERU) is intended to significantly contribute to this debate at the European level. Part of this project is to assess the risks to older transport users, based on scientific work and detailed analysis on accident figures. It is also highly recommended that communication be improved between doctors and patients in terms of mobility advice because doctors have an important role to play in assessing driving capability (Eby & Molnar, 2009). Another key factor of fostering the mobility of elderly people is sustainable town planning and transport planning that adequately takes into consideration the requirements and age limitations of this target group (see Chapter 3). This should include a number of various aspects. Accessibility, transport options and civil infrastructure should all be incorporated into planning. This report mainly discusses the structural measures which contribute to this goal.

**Subject Area:** elderly safety; accidents;

**Availability:** Weller, Gert, et al. "Accident patterns and prospects for maintaining the safety of older drivers."
http://www.researchgate.net/profile/Bernhard_Schlag/publication/271072405_Accident_patterns_and_prospects_for_maintaining_the_safety_of_older_drivers/links/54bcddd70cf29e0cb04c4a70.pdf

# 7. Survey, Data Synthesis, and Other Applications

**What About Proxy Reporting Bias Over Time** *Hubert Verreault & Catherine Morency*

**Abstract:** In the transportation planning process, most of the model use data collected in a household survey.  The needs in modeling and planning are for the AM peak, which basically is for working activity. Increasingly, travel authorities are interested to know and the model the people trips in other times of the day. These periods are not only characterized by working activity, but with less recurrent activity like leisure and shopping. Trips related to these activities are less known to other members of the household. In the Montreal household survey, only one person who knows theoretically the best trips made by the household members, responds for all other. If respondents do not report all trips made by the indirect participant, some key indicators may be biased. This paper aims to demonstrate the existence of proxy respondent bias and to look for trends over time. Data from the past five available surveys of the Montreal Origin-Destination household surveys are used for this study. The paper is organized as follows. First, background elements on proxy respondent bias are presented. The general methodology is then detailed, namely the research objectives, the information system on which relies the trend analysis as well as the description of factors having an incidence on proxy respondent bias evolution. The following sections present and discuss the results of the analysis using typical travel behaviors. The paper then proposes some conclusion and perspectives.

**Subject Area:** household survey, proxy respondent bias, travel survey methods, self-respondents, decomposition method

**Availability:** Verreault, Hubert, and Catherine Morency. "What about Proxy Respondent bias Over Time?." McGill (2015). https://www.cirrelt.ca/DocumentsTravail/CIRRELT-2015-55.pdf

# Navigation Made Personal: Inferring Driving Preferences from GPS Traces

*Delling, Daniel, Andrew V. Goldberg, Moises Goldszmidt, John Krumm, Kunal Talwar, and Renato F. Werneck*

**Abstract:** All current navigation systems return efficient source-to destination routes assuming a "one-size-fits-all" set of objectives, without addressing most personal preferences. Although they allow some customization (like "avoid highways" or "avoid tolls"), the choices are very limited and require some sophistication on the part of the user. In this paper we present, implement, and test a framework that generates personalized driving directions by automatically analyzing users' GPS traces. Our approach learns cost functions using coordinate descent, leveraging a state-of-the-art route planning engine for efficiency. In an extensive experimental study, we show that this framework infers user-specific driving preferences, significantly improving the route quality. Our approach can handle continental-sized inputs (with tens of millions of vertices and arcs) and is efficient enough to be run on an autonomous device (such as a car navigation system) preserving user privacy.

**Privacy and spatial pattern preservation in masked GPS trajectory data** *Dara E. Seidl, Piotr Jankowski & Ming-Hsiang Tsou*

**Abstract:** Personal trajectory data are increasingly collected for a variety of academic and recreational pursuits. As access to location data widens and locations are linked to other information repositories, individuals become increasingly vulnerable to identification. The quality and precision of spatially linked attributes are essential to accurate analysis; yet, there is a trade-off between privacy and geographic data resolution. Obfuscation of point data, or masking, is a solution that aims to protect privacy and maximize preservation of spatial pattern. Trajectory data, with multiple locations recorded for an entity over time, is a strong personal identifier. This study explores the balance between privacy and spatial pattern resulting from two methods of obfuscation for personal GPS data: grid masking and random perturbation. These methods are applied to travel survey GPS data in the greater metropolitan regions of Chicago and Atlanta. The rate of pattern correlation between the original and masked data sets declines as the distance thresholds for masking increase. Grid masking at the 250-m threshold preserves route anonymity better than other methods and distance thresholds tested, but preserves spatial pattern least. This study also finds via linear regression that median trip speed and road density are significant predictors of trip anonymity.

**Subject Area:** Privacy, GPS, masking, obfuscation, trajectory

## The relationship between land use and automobile travel utility: A Multiple Indicators Multiple Causes approach *Tae-Hyoung Tommy Gim*

**Abstract:** The relationship between land use and the utility of automobile travel is examined by refining the utility concept, particularly by combining the microeconomic utility theory, which is concerned with the disutility of travel, and the perspective on the positive utility. A conceptual model is accordingly developed and then adjusted considering different purposes of travel. The purpose-specific models are tested through a Multiple Indicators Multiple Causes approach in Seoul, Korea, using datasets from a sample survey and geographic information systems. The major finding is that land use affects the utility mainly by changing synergy and affective utility rather than instrumental utility, which encompasses disutility variables. Among land use variables, the utility is found to be the most sensitive to the number of transit facilities for commuting and shopping travel and land use balance for leisure travel.

# Development of A Vehicle Fleet Composition Model System: Results From An Operational Prototype *You, Daehyun, Venu Garikapati, Ram Pendyala, Chandra Bhat, Subodh Dubey, Kyunghwi Jeon, and Vladimir Livshits*

**Abstract:** This paper presents the estimation and validation results of a vehicle fleet composition simulator that can be integrated with a larger activity-based microsimulation model system. The motivation behind the development of this fleet composition simulator is two-fold. First, it is desirable to predict the vehicle fleet mix to accurately quantify the emission profile in a region as vehicle technologies and fuel types evolve. This will provide planners the ability to evaluate the potential impacts of a host of emission control strategies. Second, knowledge of household vehicle fleet mix will enable modeling the 'type' of vehicle at the trip/tour level in existing activity based models (ABMs). This will not only add to the behavioral representation of travel in ABMs but also facilitate an accurate assessment of emission hotspots, and emissions along specific travel sheds. A heuristic algorithm is applied together with other model components to accurately predict the fleet mix of individual households where vehicle types are defined by body type and age. The model system performs well in replicating the base year fleet mix patterns for the Greater Phoenix metropolitan region, for which the model was developed.

**Subject Area:** vehicle fleet composition simulator, vehicle fleet mix, vehicle ownership modeling, travel demand forecasting, activity-based modeling

# Detecting Activity Type from GPS traces using spatial and temporal information *Tao Feng, Harry & J.P. Timmermans*

**Abstract:** Detecting activity types from GPS traces has been important topic in travel surveys. Compared to inferring transport mode, existing methods are still relatively inaccurate in detecting activity types due to the simplicity of their assumptions and/or lack of background information. To reduce this gap, this paper reports the results of an endeavour to infer activity type by incorporating both spatial information and aggregated temporal information. Three machine learning algorithms, Bayesian belief network, decision tree and random forest, are used to investigate the performance of these approaches in detecting activity types. The test is based on GPS traces and prompted recall data, collected in the Rijnmond region, The Netherlands. Results show that the random forest model has the highest accuracy. The model incorporating spatial and temporal information can predict activity types with an accuracy of 96.8% for the used dataset. These findings are expected to benefit research on the use of GPS technology to collect activity-travel diary data.

**Subject Area:** activity type, GPS, random forest

**Aggregation Bias in Discrete Choice Models with an Application to Household Vehicle Choice** *David Brownstone, Timothy Wong, David Bunch*

**Abstract:** A challenge for many discrete choice modeling applications is related to the level of detail that can be used when defining the competing options in the choice set.  One frequent problem has been the tradeoff between level of detail and the resulting size of the choice set: adding more detail can quickly lead to very large choice sets that exceed the practical capabilities for model estimation.  In the area of vehicle choice, researchers have resorted to modeling the choice of "vehicle class," where vehicle class is defined to represent an aggregation of a much larger set of vehicles (frequently by averaging of attributes).  (An alternative approach is to randomly draw a sample of more highly detailed alternatives to represent the choice set.   This approach is outside the scope this study.)  A related issue is the level of detail available from, e.g., household survey data on their choices.  For example, most surveys (including the National Household Travel Survey, NHTS) only collect information about household vehicle model year, make, and model (e.g. 2008 Honda Civic), but this is not enough information to uniquely identify the exact vehicle chosen from a set of at least 6 distinct 2008 Honda Civic varieties.  In this case, the recorded choice is only "partially observed" relative to the level of detail that could otherwise be possible.  This is potentially critical, because important vehicle attributes (performance, fuel operating cost, and price) can vary substantially across these varieties.  The effect of level detail and/or aggregation on the properties of estimators is an area that has been largely unexplored.

**Subject Area:** discrete choice model; aggregation bias; vehicle choice

# Comparative Performance Evaluation of Relational and NoSQL Databases for Spatial and Mobile Applications *Santos, Pedro O., Mirella M. Moro, and Clodoveu A. Davis Jr*

**Abstract:** Recently, limited available resources for physical capacity expansion have generated supports for short-term operational improvements. Yet, only a few studies have dealt with evaluating these operational strategies effectively within the traditional transportation planning process even though suitable operational strategies impact to not only specific corridors or regions but also the whole transportation network. This is because it is generally perceived that integrating travel demand models with operational analysis approaches is quite difficult due to different constraints, modeling structures and required data sets. In this regard, the concept of methodological framework to evaluate operational strategies with travel demand models is developed and validated by the proper case study (i.e., High Occupancy Toll lanes deployment in the Hampton Roads area in Virginia, U.S.) in this research. The proposed framework consists of three major components: 1) the selection of an appropriate operational analysis approach, 2) the disaggregation of daily traffic volumes to peak period volumes, and 3) the alignment of modeling elements between the travel demand model and operational tool. Key contributions from this research are that 1) the proposed methodology enables the evaluation of travel behavioral changes without microscopic simulation, especially in terms of capturing network flow pattern changes caused by behavioral shifts after operational strategy deployment, 2) the proposed framework eliminates assumptions required when only operational tools are used to evaluate operational strategies, 3) the disaggregation method of a daily trip distribution matrix into peak period matrices by using survey data is developed, 4) specific details influencing integration in terms of data types, peak period link capacity, volume-delay functions, and link impedance are identified. Consequently, even though this research still has some limitations (e.g., inherent weakness of travel demand models), this can be a starting point to develop more detailed guidelines as well as a good reference for practitioners and researchers who wish to evaluate operation strategies within transportation planning process.

## Robust Online Algorithms for Peak-Minimizing EV Charging under Multi-Stage Uncertainty *Zhao, Shizhen, Xiaojun Lin, and Minghua Chen*

**Abstract:** We study robust online control algorithms for EV (electrical vehicle) charging under the scenario of an aggregator serving a large number of EVs together with its background load, using both its own renewable energy (for free) and the energy procured from the external grid1. The goal of the aggregator is to minimize its peak procurement from the grid, subject to the constraint that each EV has to be fully charged before its deadline. Further, the aggregator can predict the future demand and the renewable energy supply with some levels of uncertainty. The key challenge here is how to develop a model that captures the prior knowledge from such prediction, and how to best utilize this prior knowledge to reduce the peak under future uncertainty. In this paper, we first propose a 2-level increasing precision model (2-IPM), to capture the system uncertainty. We develop a powerful computational approach that can compute the optimal competitive ratio under 2-IPM over any online algorithm, and also online algorithms that can achieve the optimal competitive ratio. A dilemma for online algorithm design is that an online algorithm with good competitive ratio may exhibit poor average-case performance. We then propose a new Algorithm-Robustification procedure that can convert an online algorithm with reasonable average-case performance to one with both the optimal competitive ratio and good average-case performance. The robustified version of a well-known heuristic algorithm, Receding Horizon Control (RHC), is found to demonstrate superior performance via trace-based simulations.

**Subject Area:** robust online algorithm; EV charging; grid

## Proof-of-Concept for Methodological Framework to Evaluate Operational Strategies with Travel Demand Models  *Ma, Jiaqi, Changju Lee, and Michael J. Demetsky*

**Abstract:** Recently, limited available resources for physical capacity expansion have generated supports for short-term operational improvements. Yet, only a few studies have dealt with evaluating these operational strategies effectively within the traditional transportation planning process even though suitable operational strategies impact to not only specific corridors or regions but also the whole transportation network. This is because it is generally perceived that integrating travel demand models with operational analysis approaches is quite difficult due to different constraints, modeling structures and required data sets. In this regard, the concept of methodological framework to evaluate operational strategies with travel demand models is developed and validated by the proper case study (i.e., High Occupancy Toll lanes deployment in the Hampton Roads area in Virginia, U.S.) in this research. The proposed framework consists of three major components: 1) the selection of an appropriate operational analysis approach, 2) the disaggregation of daily traffic volumes to peak period volumes, and 3) the alignment of modeling elements between the travel demand model and operational tool. Key contributions from this research are that 1) the proposed methodology enables the evaluation of travel behavioral changes without microscopic simulation, especially in terms of capturing network flow pattern changes caused by behavioral shifts after operational strategy deployment, 2) the proposed framework eliminates assumptions required when only operational tools are used to evaluate operational strategies, 3) the disaggregation method of a daily trip distribution matrix into peak period matrices by using survey data is developed, 4) specific details influencing integration in terms of data types, peak period link capacity, volume-delay functions, and link impedance are identified. Consequently, even though this research still has some limitations (e.g., inherent weakness of travel demand models), this can be a starting point to develop more detailed guidelines as well as a good reference for practitioners and researchers who wish to evaluate operation strategies within transportation planning process.

**Subject Area:** travel demand model; operational analysis; operational strategy

# Time use in travel surveys and time use surveys – Two sides of the same coin?

*Regine Gerike, Tina Gehlert, & Friedrich Leisch*

**Abstract:** An in-depth understanding of travel behaviour determinants, including the relationship to non-travel activities, is the foundation for modelling and policy making. National Travel Surveys (NTS) and time use surveys (TUS) are two major data sources for travel behaviour and activity participation. The aim of this paper is to systematically compare both survey types regarding travel activities and non-travel activities. The analyses are based on the German National Travel Survey and the German National Time Use Survey from 2002.

The number of trips and daily travel time for mobile respondents were computed as the main travel estimates. The number of trips per person is higher in the German TUS when changes in location without a trip are included. Location changes without a trip are consecutive non-trip activities with different locations but without a trip in-between. The daily travel time is consistently higher in the German TUS. The main reason for this difference is the 10-min interval used. Differences in travel estimates between the German TUS and NTS result from several interaction effects. Activity time in NTS is comparable with TUS for subsistence activities.

Our analyses confirm that both survey types have advantages and disadvantages. TUS provide reliable travel estimates. The number of trips even seems preferable to NTS if missed trips are properly identified and considered. Daily travel times are somewhat exaggerated due to the 10-min interval. The fixed time interval is the most important limitation of TUS data. The result is that trip times in TUS do not represent actual trip times very well and should be treated with caution.

We can use NTS activity data for subsistence activities between the first trip and the last trip. This can potentially benefit activity-based approaches since most activities before the first trip and after the last trip are typical home-based activities which are rarely substituted by out-of-home activities.

**Subject Area:** Time use; Travel survey; Time use survey; Travel time; Mobility; Number of trips

# Aggregation Bias in Discrete Choice Models with an Application to Household Vehicle Choice *Timothy Wong, David Brownstone and David Bunch*

**Abstract:** This paper studies the practice of aggregating choices within discrete choice models. Researchers often do not observe choices at the exact level they are made, and hence aggregate choices to the level that is observed. Modeling choices at a fine level of detail can also lead to large choice sets that exceed the practical capabilities for model estimation. However, the practice of aggregation misspecifies the true choice set of interest. We investigate this concern within the context of the Berry, Levinsohn, and Pakes (BLP) choice model for micro- and macro-level data. We compare the practice of aggregating choices to specifications from two papers that address these concerns (McFadden, 1974; Brownstone and Li, 2014), with application to vehicle choice data. We find that aggregation affects both the point estimates and standard errors obtained from the model. In particular, standard errors are smaller with aggregation. This result has significant empirical implications. Discrete choice models are widely used to estimate consumer valuation of fuel efficiency, a quantity that is relevant to energy analysts concerned that consumers undervalue fuel efficiency technologies (the "energy paradox"). If so, then there is space for policies that increase adoption of such technologies. However, estimates of consumer valuation across vehicle choice studies are inconclusive. The findings of this paper suggest that this disparity may be partly explained by the practice of aggregating choices. In addition, the BLP model applied here is usually estimated sequentially, and the standard errors derived from this process are inconsistent. Thus, this paper also derives consistent standard errors for the model and examines their performance compared to the sequential standard errors that are commonly used.

**Subject Area:** Choice-set aggregation; Discrete choice; Energy paradox; Fuel efficiency; Vehicle choice.

# Econometric Models in Transportation *Timothy Chong Ji Wong*

**Abstract:** The three chapters in this dissertation study and apply econometric models to answer questions in transportation economics. Chapter 1 and 2 analyze the Berry, Levinsohn and Pakes (BLP) discrete choice model for combined micro- and macro-level data. Chapter 1 considers the concerns of choice set aggregation and estimating consistent standard errors within the BLP Model. These concerns are studied within the context of a vehicle choice application with interest in estimating household valuation of fuel efficiency. Chapter 2 studies the numerical properties of the maximum likelihood approach to estimating this BLP model. Chapter 3 applies a Poisson-Log Normal panel data model to study the effect of red light cameras on collision counts in Los Angeles. The camera program suffered from weaknesses in enforcement that dampened the effectiveness of the program over time. The model considered here controls for this dampening effect.

Chapter 1 finds that choice set aggregation affects the point estimates obtained from the BLP model and causes standard errors to be too small. The use of inconsistent sequential standard errors also underestimates the magnitude of standard errors. These findings may partly explain. the disparity across existing estimates from choice models on the value households place on vehicle fuel efficiency.

Chapter 2 finds that the maximum likelihood estimation approach is able to find the global minimum regardless of choice of starting values, optimization routine used and tightness of convergence criteria. These findings highlight the benefits of estimating the BLP model on combined micro- and macro-level datasets using the maximum likelihood approach compared to using the nested fixed point approach and only macro level data where numerical stability is difficult to obtain.

Chapter 3 finds that controlling for the dampening effect from poor enforcement, the Los Angeles Automated Red Light Camera program decreased red light running related collisions but increased right-angle and injury collisions, as well as collisions overall.

**Subject Area:** discrete choice; BLP; fuel efficiency, maximum likelihood estimation

# Exploring New Directions for the National Household Travel Survey *Jean Daniel Saphores, Sarah Chesebro, Thera Black & Stacey Bricka*

**Abstract:** Task force outreach to the NHTS data user community during this first phase of activities revealed a number of recurring observations from members of that community:

• Widespread need for the data and national trend analysis provided by the NHTS were evident in outreach activities.

• NHTS data are used for a variety of purposes by many different user groups; their needs differ widely.

• Expectations of what the NHTS should be often differ from its actual mission and purpose, which can lead to opinions that it falls short of delivering data some users would like.

• While the NHTS clearly fulfills its mission as a nationally representative survey of travel behavior, users are increasingly interested in statistically valid data from more detailed geographies, including state and MPO geographies and rural areas.

• Satisfaction with the frequency of the NHTS depends on intended uses of the data.

• Many users would like the next NHTS to take advantage of technological advances in survey sampling and design (e.g., GPS data). However, others note that maintaining a phone based survey sample would help maintain comparability with data from previous surveys.

• The NHTS provides extensive data. However, many users noted that they need help translating these data into useful information. While existing tools enable access to a wide array of NHTS data, some users would like additional tools to more easily create user-defined reports.

• Many potential users are not aware of the NHTS and how it can be used.

• Some users noted that the value of NHTS data could be increased with guidance on how to effectively fuse it with other standard datasets.

These observations, along with the extensive detailed findings generated by the many users engaged by the task force, provide a rich repository of considerations to be weighed during the next phase of work, when other factors and constraints will be addressed.

**Subject Area:** NHTS; survey design;

# Incorporating Behavioral Effects from Vehicle Choice Models into Bottom-Up Energy Sector Models

*David S Bunch, Kalai Ramea, Sonia Yeh, and Chris Yang*

**Abstract:** Many different types of models are used for evaluating climate---change---related Programs and policies, because analysis requirements can vary widely depending on the specific nature of the problem being investigated. Limitations on data and methodology typically ensure that models have various strengths and weaknesses, requiring researchers to make tradeoffs when choosing models. In the case of energy systems, a frequent distinction is between "top down" models (e.g., computable general equilibrium, or CGE models) that address energy systems within the context of the larger economy, versus "bottom up" models (e.g., so---called E4, or "energy/economy/environment/engineering" models), that model the energy system at a much higher level of detail, but simplify the relationship to the rest of the economy. Most attention has been on integrating these two types of models. However, researchers have also been concerned that E4 models, despite their vaunted high level of detail, produce results that are an unrealistic representation of consumer market behavior, calling into question their value for making policy decisions. This is particularly true for household vehicle technology choice, an important sub---sector of the energy system.
At the same time, there is a large and well---established literature on modeling household vehicle choice and usage decisions (using discrete and discrete---continuous models). But, the methods and approaches used in this literature differ dramatically from those used in E4 models, and so it has been unclear how to bridge the gap. This paper demonstrates a practical approach for incorporating behavioral effects from vehicle choice models into E4 models. It is based on principles of economic theory that form a common basis for all three types of models (CGE, E4, and vehicle choice/usage models). Derivations are provided that yield a theory--based Approach for modifying E4 models that can be used without altering the basic software and modeling infrastructure widely used by many researchers. The approach is illustrated using an empirical application in which the behavioral assumptions from a nested multinomial choice model in an existing modeling system (MA3T) are incorporated into a TIMES/MARKAL model.

**Subject Area:** model; energy system; E4

# Interactive Online Machine Learning Approach for Activity-Travel Survey

*Takahiko Kusakabe, Toru Seo, Hiroto Gotoh, & Yasuo Asakura*

**Abstract:** Activity-travel survey methods with tracking devices have been developed since the late 1990s as effective methods to collect behavioural data (e.g. Asakura and Hato, 2004, and Draijer et al., 2000). In these surveys, trajectories of survey participants are automatically collected by mobile instruments such as Global Positioning System (GPS). Internet Web-based diaries synchronized with the data from mobile instruments are used for complementing the detailed information on trips and activities. Comparing with traditional surveys such as Person Trip surveys and paper-based diary surveys, the mobile instruments improve observation period and resolutions in both space and time dimensions. However, even if such mobile instruments are applied to a survey, survey participants are required to manually input the detailed activity-travel information because the information obtained from the instruments does not directly contain activity-travel attributes and contexts such as a trip purpose and travel mode. It means that a lot of time and efforts are required for the participants as the survey period becomes longer. As a consequence, number of participants in the most of tracking surveys remains less than a thousand, and survey duration is less than a few months in previous studies (e.g. Asakura and Hato, 2004, and Draijer et al., 2000). It is still difficult to collect day-to-day data for continuous long-term periods via these surveys because of cost, processing load, accuracy, and privacy protection of respondents.

**Subject Area:** activity travel survey; behavioral data; mobile tracking device

# Planning and Policy Applications of the 2009 National Household Travel Survey *Diane Davidson, Richard Goeltz and Tim Reuscher*

**Abstract:** This paper presents the numerous applications of the 2009 National Household Travel Survey (NHTS) data and categorizes these purposes for the benefit of the planning community. Energy, air quality, non-motorized travel, traffic model inputs and transit planning are some of the principal uses of the data. The paper fills a gap in the literature by compiling the myriad of ways that NHTS data has been used. This should provide participating states and MPOs, as well as other public and private users, with a better understanding of how to apply the valuable travel behavior data in the NHTS for improved planning and policy making purposes. With the 2015 NHTS available in the next year, this categorization of NHTS subject and application areas is timely and should be of value to the communities of practice.

**Subject Area:** National Household Travel Survey, travel behavior, planning and applications

**Stochastic Modeling of Plug-in Electric Vehicles Load Demand in Residential Grids Considering Nonlinear Battery Charge Characteristic** *Ali Ahmadian, Mahdi Sedghi & Masoud Aliakbar-Golkar*

**Abstract:** In order to investigate the impact of Plug-in Electric Vehicles (PEVs) in distribution network studies, realistic modeling of PEVs load demand is important. One of the most important characteristics of the PEVs is the nonlinear behavior of their batteries in charging periods that should be considered in PEVs demand modeling. An accurate stochastic modeling of PEVs load demand proposed in this paper. The charging characteristic of batteries has been considered in linear and nonlinear charge profiles, separately, and the results of them are compared with each other as well. The results show that the nonlinear modeling of batteries has a significant effect on the load of the fleet, and it should be considered in relevant studies.

## Using household travel surveys to adjust ITE trip generation rates *Kristina M. Currans & Kelly Clifton*

**Abstract:** The Institute of Transportation Engineers (ITE) Trip Generation Handbook has become the predominant method for estimating vehicle trips generated by development. The handbook is often criticized for its inability to account for multimodal behavior in urban contexts, often overestimating vehicle traffic. The purpose of this research is to develop and test a ready-to-use method for adjusting the ITE handbook vehicle trip generation estimates for urban context. This method was created using household travel surveys from Oregon, Washington, and Maryland, as well as nationally available built environment data. Three adjustments were estimated for eight general land-use categories, including a "pooled" category considering all travel survey data. The performance of three adjustments were tested using 195 establishment-level vehicle trip generation datasets compiled from three independent sources. Using this data, the performances of four land-use categories were tested. The overall findings suggest that the simplest of the three adjustments developed provided similar results to the more complex adjustment methods. Moreover, adjustments applied using the "pooled" land-uses category also provided similar results to the more detailed segmentation of travel survey data. Both of these findings punctuate the need for a simple, urban adjustment for trip generation estimates.

**Subject Area:** Trip generation handbook; urban adjustment for trip generation

**Interview with Alan Pisarski, January 2015** *Conducted by Nicholas Tulach, Edited by Robert B. Noland*

**Abstract:** n/a

**Subject Area:** Alan Pisarski

**Availability:** Noland, R., Pisarski, A., & Tulach, N.Interview with Alan Pisarski, January 2015, 2015 Retrieved from http://dx.doi.org/doi:10.7282/T3J67JNX

**Trip generation: Introduction to the special section** *Susan L Handy*

**Abstract:** This paper introduces a set of articles about how transportation planners need better tools for estimating trip generation, and to develop better tools we need more data collection, especially methods that capture passenger trips by personal vehicles, transit, walking, and bicycling, as well as freight trips. With such data in hand, researchers would be able to develop models that both produce more accurate estimates of vehicle trips and generate trip estimates for other passenger modes and for freight. Such estimates would help to ensure adequate provision for these modes and not just for cars.

**Subject Area:** Travel data collection

# Generation of Mandatory Activities and Formation of Mandatory Tours: Application to the Activity-Based Model for Phoenix, AZ *Binny M. Paul, Peter Vovsha, James E. Hicks, Gaurav Vyas, Vladimir Livshits, & Kyunghwi Jeon*

**Abstract:** Most activity based models (ABMs) in practice generate tours first and then predict details of intermediate stops. However, the basic unit of travel analysis in ABM system is an activity. This central idea is somewhat lost in many ABM designs in both research and practice. This paper outlines an approach to model daily travel in ABMs by generating activities first and then forming tours. This approach is based on the idea that higher priority activities are scheduled first and other activities are built around these prioritized activities. There are four steps to this approach – formation of mandatory tour skeletons, participation in shared non-mandatory activities, allocation of individual non-mandatory activities to day segments, and lastly activity sequencing and tour formation. This paper focuses on the first step.

Traditionally, a person with a mandatory daily activity pattern was assumed to have a single commuting tour to the usual workplace. However, in reality a significant number of workers pursue multiple work-related activities, including non-workplace (business) activities. Some previously developed ABMs tackled this issue by incorporating a mandatory tour frequency model. This approach distinguishes business activities from the regular workplace activities. First the frequency and chronological ordering of workplace/business activities is modeled, and then the location of business activities, and finally the tour breakdown decision. These models make the ABM system behaviorally more realistic and more useful in practice since they address certain travel markets like "midday business circulation" in urban business districts that are largely missing in most travel models.

**Subject Area:** Activity based models, tour formation, mandatory activity, mandatory tour skeleton

# Imputing trip purposes for long-distance travel *Yijing Lu, & Lei Zhang*

**Abstract:** Planning and policy analysis at the national, state and inter-regional corridor levels depends on reliable information and forecasts about long-distance travel. Emerging passive data collection technologies such as GPS, smartphones, and social media provide the opportunity for researchers and practitioners to potentially supplement or replace traditional long-distance travel surveys. However, certain important trip information, such as trip purpose, travel mode, and travelers' socio-demographic characteristics, is missing from passively collected travel data. One promising solution to this data issue is to impute the missing information based on supplementary data (e.g., land use) and advanced statistical or data mining algorithms. This paper develops machine learning methods, including decision tree and meta-learning, to estimate trip purposes for long-distance passenger travel. A passively collected long-distance trip dataset is simulated from the 1995 American Travel Survey for the development and validation of the machine learning methods. The predictive accuracy of the proposed methods is evaluated for several scenarios varying with trip purposes and the extent of data availability as inputs. This research design will provide not only a practically useful approach for long-distance trip purpose imputation, but also generate valuable insights for future long-distance travel surveys. Results show that the accuracy of the trip purpose imputation methods based on all available data decreases from 95 % with two purposes (business and non-business) to 77 % with four purposes (business, personal business, social visit, and leisure). Based on a two-purpose scheme, the predictive accuracy of the imputation algorithms decreases from 95 % when all input data is used (a full-information model), to 72 % with a minimum information model that only utilizes the passively collected data. If traveler's socio-demographic characteristics are available (possibly through other imputation models), the predictive accuracy only decreases from 95 to 91 %.

# Data Verification and Misbehavior Detection in Vehicular Ad-hoc Networks

*Ghaleb, Fuad A., Anazida Zainal, and Murad A. Rassam*

**Abstract:** n/a

**Subject Area:** Engineering design , Modeling , Network analysis , Vehicles

## A Data-Driven Network Analysis Approach to Predicting Customer Choice Sets for Choice Modeling in Engineering Design *Mingxian Wang and Wei Chen*

**Abstract:** In this paper, we propose a data-driven network analysis based approach to predict individual choice set for customer choice modeling. Taking into account product associations and customer heterogeneity, we apply data analytics to mine existing data of customer choice set, which is then used to predict choice set for individual customers in a new choice modeling scenario. Product association network is constructed first to identify product communities based on existing data of customer choice sets, where links between products reflect the proximity or similarity of two products in customers' perceptual space. To account for customer heterogeneity, customers are classified into clusters (segments) based on their profile attributes and for each cluster the product consideration frequency is computed. For predicting choice sets, a probabilistic sampling approach is proposed integrating product associations, customer segments, and the link strengths in the product association network. In case studies, we first implement the approach using an example with simulated choice set data. The quality of predicted choice sets is examined by assessing the estimation bias of the developed choice model. We then demonstrate the proposed approach using actual survey data of vehicle choice, illustrating the impact of choice sets on the customer utility representation and the agreement between choice model and reality. From both examples, improved choice modeling results are consistently observed using the predicted choice sets, demonstrating the benefits of the proposed method for choice modeling.

**Subject Area:** Engineering design , Modeling , Network analysis , Vehicles

**Analyzing Cell Phone Location Data For Urban Travel: Current Methods, Limitations And Opportunities** *Serder Çolak, Lauren Alexander, Bernardo Alvim, Shomik Mehndiretta, & Marta González*

**Abstract:** Travelers today utilize technology, which generates vast amounts of data at low costs. In essence, these data have the potential to supplement most of the outputs from regional travel demand models. Creating new analysis tools may shift the paradigm of how we approach data and modeling when assessing travel demand. Recent work has shown how processed origin-destination trips, as developed by trip data providers, supports travel analysis. Much less is reported on how raw data from telecommunication providers can be processed to support such analysis or to what extent the raw data can be treated to extract travel behavior. This work discusses how cell phone data can be processed to inform a four-step transportation model, focusing specifically on the limitations and opportunities of such data. We show a data treatment pipeline that uses only phone data and population density to generate trip matrices in two Metropolitan areas: Boston and Rio de Janeiro. We detail how to label zones as home and work based on frequency and the time of day. Based on the labels (home, work, or other) of consecutive stays we can assign purposes to trips such as home-based-work. The resulting number of trips pairs are expanded using the total population from census data. We show comparable results with existing information reported in local surveys in Boston and existing origin-destination matrices in Rio de Janeiro. Our results detail a method to use passively generated cellular data as a low cost option for transportation planning.

**Subject Area:** Mobile phone data, data mining, human mobility, trip production and attraction, trip distribution, travel surveys.

# Panel, Continuous, and Cross-Sectional Travel Surveys – Germany's Experience *Martin Kagerbauer & Stacey Bricka, Ph.D.*

**Abstract:** There is recurring interest in the U.S. in moving to a stronger travel survey design that would enable the identification of changes in travel patterns over time. There are multiple reasons supporting this desire, but the two main reasons have to do with cost and data. With respect to cost, household travel surveys conducted on an infrequent basis tend to be large budget items, while smaller surveys conducted continuously or on a more regular basis have the potential to be shown as regular budget items with a lower dollar amount per year. On the data side, significant advancements in travel demand modeling techniques and tools have paved the way to the desire to understand travel more from a behavioral perspective. To understand variations in travel patterns, panel surveys and multi-day cross-sectional surveys are discussed more frequently as possible solutions. The purpose of this paper is to further the discussion of alternative survey types through documenting the design and administrative elements of continuous and panel surveys conducted in Germany. The goal is both document the German approach to answering behavioral questions and to identify where and how the German surveys might inform an advanced survey type in the United States.

**Subject Area:** travel surveys, panel, multi-day cross-sectional

**Exploring Origin-Destination Passenger Travel Flow Patterns in Traffic Analysis District Clusters of Small/Medium Size Regions** *Ho-Ling Hwang, Shih-Miao Chin, Daniel Wilson, Tim Reuscher and Angel Canales*

**Abstract:** Information on Origin-Destination (OD) based daily travel flows is a vital, but rather challenging to obtain, part of the regional transportation planning process. OD data specifies traffic flow volumes between specified geographic zones or specific points of locations. Traditionally, this data has been difficult to gather due to the expense of manual data collection and entry through license plate surveys and/or traveler interviews. This data is crucial for the calibration of travel demand models, which without OD data, are mainly based on known land use patterns and existing road networks, providing only generalized travel information. The major goal of this case study is to investigate how data as gathered under the 2009 National Household Travel Survey (NHTS) can be used to produce Traffic Analysis District (TAD)-based regional travel flow information critical to support transportation planners in two small/medium size Metropolitan Planning Organizations (MPO) in New York State. The research team works closely with transportation analysts from Syracuse Metropolitan Planning Council (SMPC) and Binghamton Metropolitan Transportation Study (BMTS) to identify TAD clusters in their respected MPOs that are most feasible for performing travel flow analysis at a disaggregated sub-county level. The process involves the use of Geographic Information System (GIS) and examinations of detail geospatial data on business establishment locations, population size in the region, and considers the degree of travel activities (e.g., sufficient household trips originated from the given area) using data from the 2009 NHTS. Specifically, this process defines eight TAD-based zones for the SMPC region and five TAD-based zones for the smaller BMTS. The decision of dividing each MPO into specific TAD-based zones is made based on the considerations of not only having sufficient household travel data to support necessary analyses, but also ensuring that meaningful and useful results can be generated to support each MPO's planning needs through this study effort. Analyses of travel flow patterns among TAD-based zones within each MPO, as well as between these zones and outside MPO regions, are conducted separately. This allows region-specific analyses to be performed so that any uniqueness in regional characteristics and their travel patterns can be revealed.

**Subject Area:** TAD-based travel flows; OD data

## Efficient Storage of Big-Data for Real-Time GPS Applications *Akulakrishna, Pavan Kumar; J, Lakshmi; & K, Nandy S*

**Abstract:** GPS applications need real-time responsiveness and are location-sensitive. GPS data is time-variant, dynamic and large. Current methods of centralized or distributed storage with static data impose constraints on addressing the real-time requirement of such applications. In this project we explore the need for real-timeliness of location based applications and evolve a methodology of storage mechanism for the GPS application's data. So far, the data is distributed based on zones and it also has limited redundancy leading to non-availability in case of failures. In our approach, data is partitioned into cells giving priority to Geo-spatial location. The geography of an area like a district, state, country or for that matter the whole world is divided into data cells. The size of the data cells is decided based on the previously observed location specific queries on the area. The cell size is so selected that a majority of the queries are addressed within the cell itself. This enables computation to happen closer to data location. As a result, data communication overheads are eliminated. We also build some data redundancy, which is used not only to enable failover mechanisms but also to target performance. This is done by nine-cell approach wherein each cell stores data of eight of its neighbours along with its own data. Cells that have an overload of queries, can easily pass-off some of their workload to their near neighbours and ensure timeliness in response. Further, effective load balancing of data ensures better utilization of resources. Experimental results show that our approach improves query response times, yields better throughput and reduces average query waiting time apart from enabling real-time updates on data.

**Subject Area:** Big data storage of GPS applications; Data layout of GPS applications; Data storage of GPS applications

**Alternative Approaches for Estimating Annual Mileage Budgets for a Multiple Discrete-Continuous Choice Model of Household Vehicle Ownership and Utilization: An Empirical Assessment** *Bertho Augustin; Abdul R. Pinjari; Naveen Eluru & Ram M. Pendyala*

**Abstract:** This paper presents an empirical comparison of the following approaches to estimate annual mileage budgets for multiple discrete-continuous extreme value (MDCEV) models of household vehicle ownership and utilization: (1) The log-linear regression approach to model observed total annual household vehicle miles traveled (AH-VMT), (2) The stochastic frontier regression approach to model latent annual vehicle mileage frontier (AH-VMF), and (3) Other approaches used in the literature to assume annual household vehicle mileage budgets. For the stochastic regression approach, both MDCEV and multiple discrete-continuous heteroscedastic extreme value (MDCHEV) models were estimated and examined. When model predictions were compared with observed distributions of vehicle ownership and utilization in a validation data sample, the log-linear regression approach performed better than other approaches. However, policy simulations demonstrate that the log-linear regression approach does not allow for AH VMT to increase or decrease due to changes in vehicle-specific attributes such as changes in fuel economy. The stochastic frontier approach overcomes this limitation. Policy simulation results with the stochastic frontier approach suggest that increasing fuel economy of a category of vehicles increases the ownership and usage of those vehicles. But this doesn't necessarily translate into an equal decrease in usage of other household vehicles confirming previous findings in literature that improvements in fuel economy tend to induce additional travel. In view of policy responsiveness and prediction accuracy, we recommend using the stochastic frontier regression (for estimating mileage budgets) in conjunction with the MDCHEV model for discrete-continuous choice analysis of household vehicle ownership and utilization.

**Subject Area:** MDCEV; annual miles; household vehicle ownership and utilization; stochastic frontier regression; discrete-continuous choice

# Associations Between Television Watching and Car Riding Behaviors and Development of Depressive Symptoms: A Prospective Study

*Xuemei Sui, MD, MPH, PhD; Wendy J. Brown, PhD, Carl J. Lavie, MD, Delia S. West, PhD, Russel R. Pate, PhD, Jonathan P.W. Payne, MS, Steven N. Blair, PED*

**Abstract:** Objective: To examine the longitudinal association between sedentary behaviors and risk of development of depressive symptoms. Patients and Methods: The study population consisted of 4802 participants in the Aerobics Center Longitudinal Study (1012 women and 3790 men) aged 18 to 80 years who did not report depressive moods when they completed a health survey during 1982 in which they reported their time spent watching television (TV) and riding in a car each week. All participants completed a follow-up health survey when they responded to the 10-item Center for Epidemiologic Studies Depression Scale. Those who scored 8 or more on the Center for Epidemiologic Studies Depression Scale were considered to have depressive symptoms. Results: Among the 4802 participants, 568 reported depressive symptoms during a mean follow-up of 9.3 years. After multivariate adjustment including moderate- and vigorous-intensity physical activity, time riding in a car, time watching TV, and combined time spent in the 2 sedentary behaviors were positively associated with depressive symptoms (each P<.05 for trend). Individuals who reported 9 h/wk or more riding in a car, more than 10 h/wk watching TV, or 19 h/wk or more of combined sedentary behavior had 28%, 52%, and 74% greater risk of development of depressive symptoms than those who reported less than 5 h/wk, less than 5 h/wk, or less than 12 h/wk, respectively, after adjusting for baseline covariates and moderate- and vigorous-intensity physical activity. The positive association between time riding in a car or time watching TV and depressive symptoms was only observed among individuals who did not meet the current physical activity guidelines. Conclusion: More time reported in these 2 sedentary behaviors was positively associated with depressive symptoms. However, the direct associations between time spent in car riding and TV viewing and depressive symptoms were only significant among those who did not meet the current physical activity recommendations.

**Subject Area:** Sedentary behavior; depression;

## U.S. National And Inter-Regional Travel Demand Analysis: Person-Level Microsimulation Model And Application To High-Speed Rail Demand Forecasting *Lei Zhang & Yijing Lu*

**Abstract:** The objective of this proposed research project is to develop a prototype microsimulation-based national and inter-regional passenger travel demand model for High Speed Rail demand forecasting and other national-level travel analysis. The proposed research represents the first attempt to develop a microsimulation-based national long-distance travel demand for high speed rail and national travel analysis. All major behavioral dimensions of long-distance travel will be considered, except for route choice and network loading that require significant new network data collection/coding efforts and cannot be achieved with the limited budgeted of this project. Compare to the traditional four-step approach, microsimulation-based techniques offer several advantages: (1) It is easier to consider tours, multi-day and multi-stop trips, and intermodal access/egress transfers that are important for long-distance travel modeling; (2) Households and persons are the basic units of analysis, which enables detailed behavioral representations and interactions; and (3) It provides a rich framework in which travel is analyzed as a multi-day, monthly, quarterly, or yearly pattern of behavior, derived from activity participation. There are also significant differences between long-distance trips considered in the proposed microsimulation-based model and trips on a daily/weekly basis represented in metropolitan/state-level tour/activity-based models developed in previous research. For instance, it is often the case that households first choose travel modes for long-distance vacation trips based on travel budget before selecting destinations. Categorization of trip purposes is also different for long-distance trips. Cost of travel for long-distance trips is not just travel disutility, but also includes lodging, food, etc., and the same with the total travel time for long-distance which usually covers not only in-vehicle travel time but also the ingress/egress time, transfer time, and lodge time. The much lower frequency of long-distance travel may also imply a different decision-making process. This research is exploratory in nature, and it is hoped that the final product, the prototype microsimulation-based model, will be able to predict high speed rail travel demand among various OD pairs at the national level.

**Subject Area:** microsimulation; travel demand model; High speed rail

## Demand and Capacity Problems in the Next Generation Air Transportation System *Davide Pu*

**Abstract:** This thesis investigates two main aspects of air transportation system, demand and capacity. The first study aims to estimate the potential market for Zip Vehicles, an advanced commuter type of aircraft equipped with automation and electric propulsion technologies. A Multinomial Logit Model was developed to estimate the mode choice behavior of commuters between Zip vehicle, auto and transit in seven metropolitan areas in the United States. The results showed that the Out-of-Vehicle travel time plays an important role in the decision process of commuters. Zip Vehicle is predicted to achieve residual demand with the current technologies and could become more competitive if it was equipped with Vertical Take-Off Technology. The second study developed a hybrid airport runway capacity model that blends both deterministic and simulation techniques. The model includes a graphic user interface that allows high degree of freedom to modify input parameters, such as airport information, weather conditions, minimum separation distances and aircraft grouping system. The model is widely validated and it appears to be a consistent solution for estimating airport capacity at different levels and with various degree of extensibility

**Subject Area:** airport capacity model aviation aircraft runway mode choice model zip vehicle simulation

**Optimizing Distribution of Pandemic Influenza Antiviral Drugs** *Bismark Singh, Hsin-Chan Huang, David P. Morton, Gregory P. Johnson, Alexander Gutfraind, Alison P. Galvani, Bruce Clements, Lauren A. Meyers*

**Abstract:** We provide a data-driven method for optimizing pharmacy based distribution of antiviral drugs during an influenza pandemic in terms of overall access for a target population and apply it to the state of Texas, USA. We found that during the 2009 influenza pandemic, the Texas Department of State Health Services achieved an estimated statewide access of 88% (proportion of population willing to travel to the nearest dispensing point). However, access reached only 34.5% of US postal code (ZIP code) areas containing <1,000 underinsured persons. Optimized distribution networks increased expected access to 91% overall and 60% in hard-to-reach regions, and 2 or 3 major pharmacy chains achieved near maximal coverage in well-populated areas. Independent pharmacies were essential for reaching ZIP code areas containing <1,000 underinsured persons. This model was developed during a collaboration between academic researchers and public health officials and is available as a decision support tool for Texas Department of State Health Services at a Web-based interface.

**Subject Area:** influenza pandemic drug distribution;

**Availability:** Singh, Bismark, et al. "Optimizing Distribution of Pandemic Influenza Antiviral Drugs." http://wwwnc.cdc.gov/eid/article/21/2/pdfs/14-1024.pdf

# Phantom Trips Overestimating the Traffic Impacts of New Development *Adam Millard-Ball*

**Abstract:** Trip Generation is the standard reference for assessing the impacts of new development on traffic congestion and the environment in the U.S. However, a comparison to household surveys suggests that Trip Generation overestimates trips by 55% – likely because its data represent a biased sample of development in the U.S. Moreover, the data in Trip Generation are ill-suited to many analyses of traffic impacts, development impact fees, and greenhouse gas emissions, because they do not account for substitution effects. Most trips "generated" by new developments are not new, but involve households reshuffling trips from other destinations. These twin problems – theoretical and practical – are likely to lead to the construction of excessive roadway infrastructure, and the overestimation of the congestion, fiscal and environmental impacts of new development.

**Subject Area:** Trip Generation; phantom trips; development impact fees; GHG

# 8. Traffic Safety

**Least Educated At Higher Risk of Auto-Related Death**  *David A. Wood*

**Abstract:** Study says the less education you have, the more likely you are to die in an auto-related accident.

**Subject Area:** death rate; crash

**Availability:** David A. Wood. "Least Educated at Higher Risk of Auto-Related Death". December 6, 2015; http://www.carcomplaints.com/news/2015/least-educated-higher-risk-auto-death.shtml

# Road users with fewer qualifications more likely to die in collisions *Craig Thomas*

**Abstract:** Road users who are educationally disadvantaged are more likely to die in traffic collisions than those with better qualifications, according to a new study

**Subject Area:** traffic fatalities; education

**Availability:** Express UK October 14, 2015; "Road users with fewer qualifications more likely to die in collisions" Thomas, Craig; http://www.express.co.uk/life-style/cars/612027/Cars-accidents-fewer-qualifications

## Trends in Socioeconomic Inequalities in Motor Vehicle Accident Deaths in the United States, 1995–2010 *Sam Harper, Thomas J. Charters and Erin C. Strumpf*

**Abstract:** Motor vehicle accident (MVA) mortality has been declining overall, but little is known about trends by socioeconomic position. We examined trends in education-related inequalities in US MVA death rates from 1995 to 2010. We used mortality data from the National Center for Health Statistics and population estimates from the Current Population Survey, and we calculated vehicle- and person-miles traveled using data from the National Household Travel Survey. We used negative binomial regression to estimate crude and age-, sex-, and race-adjusted mortality rates among adults aged 25 years or more. We found larger mortality decreases among the more highly educated and some evidence of mortality increases among the least educated. Adjusted death rates were 15.3 per 100,000 population (95% confidence interval (CI): 10.7, 19.9) higher at the bottom of the education distribution than at the top of the education distribution in 1995, increasing to 17.9 per 100,000 population (95% CI: 14.8, 21.0) by 2010. In relative terms, adjusted death rates were 2.4 (95% CI: 1.7, 3.0) times higher at the bottom of the education distribution than at the top in 1995, increasing to 4.3 times higher (95% CI: 3.4, 5.3) by 2010. Inequality increases were larger in terms of vehicle-miles traveled. Although overall MVA death rates declined during this period, socioeconomic differences in MVA mortality have persisted or worsened over time.

# Context Aware Driver Behavior Detection System in Intelligent Transportation Systems (ITS) *V. Rama Krishna Reddy, & Pattipaka Swarna Latha*

**Abstract:** Vehicle Ad hoc Networks (VANET) emerged as an application of Mobile Ad hoc Networks (MANET), which use Dedicated Short Range Communication (DSRC) to allow vehicles in close proximity to communicate with each other, or to communicate with roadside equipment. Applying wireless access technology in vehicular environments has led to the improvement of road safety and a reduction in the number of fatalities caused by road accidents, through the development of road safety applications and facilitating information sharing between moving vehicles regarding the road. This paper focuses on developing a novel and non-intrusive driver behavior detection system using a context-aware system in VANET to detect abnormal behaviors exhibited by drivers, and to warn other vehicles on the road so as to prevent accidents from happening. A five-layer context aware architecture is proposed which is able to collect contextual information about the driving environment, perform reasoning about certain and uncertain contextual information and react upon that information. A probabilistic model based on Dynamic Bayesian Networks (DBN) for real time inferring four types of driving behavior (normal, drunk, reckless and fatigue) by combining contextual information about the driver, vehicle and the environment is presented. The dynamic behavior model can capture the static and the temporal aspects related to the behavior of the driver, thus, leading to robust and accurate behavior detection. The evaluation of behavior detection using synthetic data proves the validity of our model and the importance of including contextual information about the driver, the vehicle and the environment.

**Subject Area:** Context-Aware System, VANET, Dynamic Bayesian Networks, Driver Behavior, Safety Application.

**Motor Vehicle Occupant Fatality Risk Based on Person-Time Exposed: Age, Sex, and Period of Week** *C. Craig Morris, Ph.D.*

**Abstract:** During the 5 years from 2008 through 2012, motor vehicle crashes killed 34,091 people each year in the United States, on average, 23,783 (69.8) percent of whom were motor vehicle occupants. This study analyzes motor vehicle occupant fatality risk in terms of person-time exposed as a function of age, sex, period of week, and interactions of these factors. Results reveal strong circadian periodicities of occupant fatalities and fatality risk, with greater risk during late evening-early morning hours every day of the week and the greatest risk during Friday–Saturday and Saturday–Sunday evening-to-morning hours. But these circadian trends interact with age and sex whereby young male occupants exhibit the most fatalities and risk. The circadian variation in occupant fatality risk—across demographic age-sex populations, days of the week, and drunk- and nondrunk-driver-related fatal crashes – suggests a drowsiness component acting alone, and sometimes synergistically with alcohol, to impair the judgment and performance of motor vehicle occupants.

**Subject Area:** Motor vehicle crash; fatalities; fatality risk;

**Weather, Traffic Accidents, and Climate Change** *Benjamin Leard and Kevin Roth*

**Abstract:** We exploit random daily variation in weather to document the relationship of temperature, rainfall, and snowfall with traffic accidents and travel demand. Using information on 46.5 million accidents from the State Data System of police reported accidents for 20 states and travel demand for 207,455 households included in the National Household Transportation Survey, we find unanticipated effects of weather on accidents and their severity. Our estimates suggest that while warmer temperatures and reduced snowfall are associated with a moderate decline in non-fatal accidents, they are also associated with a significant increase in fatal accidents. This increase in fatalities is due to a robust positive relationship between fatalities and temperature. Half of the estimated effect of temperature on fatalities is due to changes in the exposure to pedestrians, bicyclists, and motorcyclists as temperatures increase. The application of these results to middle-of-the-road climate predictions suggests that weather patterns for the end of the century would lead to 603 additional fatalities per year. Between 2010-2099, the present value social cost of all types of accidents caused by climate change is $58 billion.

**Subject Area:** Traffic Accidents, Traffic Fatalities, Climate Change

**Young Drivers and Their Passengers: A Systematic Review of Epidemiological Studies on Crash Risk**  *Marie Claude Ouimet, Ph.D., Anuj K. Pradhan, Ph.D., Ashley Brooks-Russell, Ph.D., Johnathon P. Ehsani, Ph.D., Djamal Berbiche, Ph.D., & Bruce G. Simons-Morton, Ed.D., M.P.H.*

**Abstract:** Purpose: A systematic review of the literature was conducted to appraise the evidence from epidemiological studies of crash risk in young drivers accompanied by passengers, compared with solo driving. Methods: Databases searched were the Cochrane Library, Embase, Scopus, Transportation Research Information Services, and Web of Science for studies published between January 1, 1989 and August 1, 2013. Epidemiological studies were selected for review if they focused on crashes of young drivers (≤24 years old) and included both a no-passenger comparison group and some measure of exposure to enable calculation of estimates. Results: Fifteen articles (17 studies) were selected; seven studies reported on fatal crashes and 10 on nonfatal or combined fatal/nonfatal crashes. Studies on fatal crashes showed increased risk, compared with solo driving, for young drivers with at least one passenger (significant estimates ranging from 1.24 to 1.89) and two or more passengers versus solo driving (1.70–2.92). Increased risk was also found for fatal crashes and for combined or nonfatal crashes with male versus female passengers (1.53–2.66) and for younger versus older drivers (1.42–3.14). Conclusions: Results more clearly indicated an increased risk for passenger presence in fatal crashes than that in nonfatal or combined fatal/nonfatal crashes. Findings of this review, based on correlational studies, support licensing policies that limit the presence and number of young passengers for young drivers.

**Subject Area:** Systematic review; Traffic accident; Driver; Passenger; Adolescent; Young adult

## Did the Great Recession Keep Bad Drivers Off the Road? *Vikram Maheshri & Clifford Winston*

**Abstract:** Motorists' fatalities and the fatality rate (roadway deaths per vehicle-mile traveled (VMT)) tend to decrease during recessions. Using a novel dataset of individual drivers, we establish that recessions have differential impacts on driving behavior by decreasing the VMT of observably risky drivers, such as those over age 60, and by increasing the VMT of observably safer drivers.

**Subject Area:** fatality rate; recession, vmt, risky drivers

# Temporal trends in motor vehicle fatalities in the United States, 1968 to 2010 - a joinpoint regression analysis *Priti Bandi, Diana Silver, Tod Mijanovich, & James Macinko*

**Abstract:** Background: In the past 40 years, a variety of factors might have impacted motor vehicle (MV) fatality trends in the US, including public health policies, engineering innovations, trauma care improvements, etc. These factors varied in their timing across states/localities, and many were targeted at particular population subgroups. In order to identify and quantify differential rates of change over time and differences in trend patterns between population subgroups, this study employed a novel analytic method to assess temporal trends in MV fatalities between 1968 and 2010, by age group and sex. Methods: Cause-specific MV fatality data from traffic injuries between 1968 and 2010, based on death certificates filed in the 50 states, and DC were obtained from Centers for Disease Control and Prevention Wide-ranging Online Data for Epidemiologic Research (CDC WONDER). Long-term (1968 to 2010) and short-term (log-linear piecewise segments) trends in fatality rates were compared for males and females overall and in four separate age groups using joinpoint regression. Results: MV fatalities declined on average by 2.4% per year in males and 2.2% per year in females between 1968 and 2010, with significant declines observed in all age groups and in both sexes. In males overall and those 25 to 64 years, sharp declines between 1968 and mid-to-late 1990s were followed by a stalling until the mid-2000s, but rates in females experienced a long-term steady decline of a lesser magnitude than males during this time. Trends in those aged <1 to 14 years and 15 to 24 years were mostly steady over time, but males had a larger decline than females in the latter age group between 1968 and the mid-2000s. In ages 65+, short-term trends were similar between sexes. Conclusions: Despite significant long-term declines in MV fatalities, the application of Joinpoint Regression found that progress in young adult and middle-aged adult males stalled in recent decades and rates in males declined relatively more than in females in certain age groups. Future research is needed to establish the causes of these observed trends, including the potential role of contemporaneous MV-related policies and their repeal. Such research is needed in order to better inform the design and evaluation of future population interventions addressing MV fatalities nationally.

**Subject Area:** motor vehicle fatality trends;

**Automobile Safety During Adulthood** *Douglas M. Wiegand, Jeffrey S. Hickman, & E. Scott Geller*

**Abstract:** Injuries and fatalities from motor vehicle crashes constitute one of the most significant public health threats in the USA and abroad. This entry provides a summary of current traffic surveillance statistics in the USA, defines key terms and methodologies in traffic safety research, and discusses the application of behavior-based safety (BBS) in preventing motor vehicle injuries and fatalities. A critical analysis of interventions designed to prevent injuries and deaths from motor vehicle crashes is offered in terms of their relative effectiveness, and future directions in traffic safety research are discussed in terms of embracing positive psychology.

**Subject Area:** traffic surveillance; behavior-based safety

**An assessment of driving fitness in patients with visual impairment to understand the elevated risk of motor vehicle accidents** *Shiho Kunimatsu-Ianuki, Aiko Iwase, Makoto Araie, Yuki Aoki, Takeshi Hara Toru Nakazawa, Takuhiro Yamaguchi, Hiroshi Ono, Tomoyuki Sanuki, & Makoto Itoh*

**Abstract:** Objective To assess the driving fitness of patients with glaucoma by identifying specific areas and degrees of visual field impairment that threaten safe driving. Design Case–control study. Setting, and participants This prospective study included 36 patients with advanced glaucoma, defined as Humphrey field analyzer (HFA; 24-2 SITA standard program) measurements of mean deviation in both eyes of worse than −12 dB, and 36 age-matched and driving exposure time-matched normal subjects. All participants underwent testing in a novel driving simulator (DS) system. Participants were recruited between September 2010 and January 2012. Main outcome measures The number of collisions with simulated hazards and braking response time in 14 DS scenarios was recorded. Monocular HFA 24-2 test results from both eyes were merged to calculate the binocular integrated visual field (IVF). The position of the IVF subfields in which the collision-involved patients had lower sensitivity than the collision-uninvolved patients was compared with the track of the hazard. The cut-off value to predict an elevated risk of collisions was determined, as were its sensitivity and specificity, with the area under the receiver operating characteristic (AUROC) curve. Results Patients with advanced glaucoma were involved in a significantly higher number of collisions in the DS than the age-matched and driving exposure time-matched normal subjects (119 vs 40, respectively, p<0.0001), especially in four specific DS scenarios. In these four scenarios, IVF sensitivity was significantly lower in the collision-involved patients than in the collision-uninvolved patients in subfields on or near the track of the simulated hazard (p<0.05). The subfields with the largest AUROC curve had values ranging from 0.72 to 0.91 and were located in the paracentral visual field just below the horizontal. Conclusions Our novel DS system effectively assessed visual impairment, showing that simulators may have future potential in educating patients.

**Subject Area:** visual impairment; glaucoma; safe driving;

# Driver Demographics, Built Environment, and Car Crashes: Implications for Urban Planning *Dongkwan Lee*

**Abstract:** This study investigates the effects of the surrounding environment on crashes, with a focus on crash severity and at-fault drivers characterized by gender and age. Crashes where a vehicle is the guilty party are investigated. The study adopts two approaches: aggregate and disaggregate. In the aggregate approach, the numbers of crashes, classified in terms of severity (fatalities, injuries, property damages only), and gender and age of the driver (with several age groups covering the 15-100 age span), represent the variables to be investigated, and have been derived for the Central Ohio Region from the multiple files of the crash database of the Ohio Department of Public Safety, over the period 2006-2011. These data are aggregated at the level of Traffic Analysis Zones (TAZ). OLS models are first estimated, but spatial autocorrelation tests point the existence of spatial autocorrelation (SA). Spatial econometrics models are then used to eliminate the SA bias: the Spatial Autoregressive Model (SAR) and the Spatial Error Model (SEM). Subsequent analyses are conducted using the SEM estimates, as the SEM model is successful in completely eliminating spatial autocorrelation. The aggregate approach uses a large set of explanatory variables classified into six groups: Regional and Locational, Socio-Economic, Land-Use, Public Transit and Traffic Flow, Circulation and Network, and Physical Characteristics. The results show that variables in all these groups have significant impacts on crash severity and frequencies. The disaggregate approach accounts for more variables that influence crash severity, but cannot be captured in the aggregate approach, such as weather conditions, light conditions, road conditions, type of intersection, and type of vehicle. All these variables are directly related to an individual crash. The logit model is used to explain the probability of a Bodily Injury (BI) crash at the crash scene, where the alternative is Property Damage Only (PDO) crash. Because the age of the at-fault driver is a continuous independent variable, it is possible to precisely assess the impact of age, for both male and female drivers. The results of the logit model estimation show that there is a significant relationship between the probability of a BI crash and drivers' behavior, built environment, driving conditions, and driving situation.

**Subject Area:** bodily injury crash, built environment, property damage only

# Tracking progress in teenage driver crash risk in the United States since the advent of graduated driver licensing programs *Anne T. McCartt, & Eric R. Teoh*

**Abstract:** Introduction: This study examined U.S. teenagers' crash rates since 1996, when the first graduated driver licensing (GDL) program in the United State was implemented. Methods: Passenger vehicle driver crash involvement rates for 16–19 and 30–59 (middle-aged) year-olds were examined, using data from the Fatality Analysis Reporting System, National Automotive Sampling System General Estimates System, Census Bureau, and National Household Travel Surveys. Results: Per capita fatal and police-reported crash rates in 2012 were lower for 16 year-olds than for middle-aged drivers but older teenagers' rates were higher. Mileage-based fatal and police-reported crash rates in 2008 were higher for teenagers than for middle-aged drivers and higher for 16–17 year-olds than for older teenagers. In 1996–2012, teenagers' per capita fatal and police-reported crash rates declined sharply, especially for 16–17 year-olds, and more so than for middle-aged drivers. Substantial declines also occurred in teenagers' mileage-based fatal and police-reported crash rates from 1995–96 to 2008, generally more so than for middle-aged drivers. Regarding factors in fatal crashes in 1996 and 2012, proportions of young teenagers' crashes occurring at night and with multiple teenage passengers declined, more so than among older teenagers and middle-aged drivers. The proportion of fatally injured drivers who had been drinking declined for teenagers but changed little for middle-aged drivers. Improvements were not apparent in rates of driver errors or speeding among teenage drivers in fatal crashes. Conclusions: Teenage drivers' crash risk dropped during the period of implementation of GDL laws, especially fatal crash types targeted by GDL. However, teenagers' crash risk remains high, and important crash factors remain unaddressed by GDL. Practical applications: Although this study was not designed to examine the role of GDL, the results are consistent with the increased presence of such laws. More gains are achievable if states strengthen their laws.

**Subject Area:** Teenage drivers; Teenage driver crash risk; Graduated driver licensing

# Driver distraction detection and recognition using RGB-D sensor  *Céline Craye and Fakhri Karray*

**Abstract:** Driver inattention assessment has become a very active field in intelligent transportation systems. Based on active sensor Kinect and computer vision tools, we have built an efficient module for detecting driver distraction and recognizing the type of distraction. Based on color and depth map data from the Kinect, our system is composed of four sub-modules. We call them eye behavior (detecting gaze and blinking), arm position (is the right arm up, down, right of forward), head orientation, and facial expressions. Each module produces relevant information for assessing driver inattention. They are merged together later on using two different classification strategies: AdaBoost classifier and Hidden Markov Model. Evaluation is done using a driving simulator and 8 drivers of different gender, age and nationality for a total of more than 8 hours of recording. Qualitative and quantitative results show strong and accurate detection and recognition capacity (85% accuracy for the type of distraction and 90% for distraction detection). Moreover, each module is obtained independently and could be used for other types of inference, such as fatigue detection, and could be implemented for real cars systems.

**Subject Area:** distracted driving; ITS;

# 9. Transit Planning

**The demand for reliable transit service: New evidence using stop level data from the Los Angeles Metro bus system** *Sandip Chakrabarti*

**Abstract:** This study explores the role of service reliability in determining bus transit ridership. Using stop level service supply, demand, and performance data from the Los Angeles Metro bus system, I investigate whether reliability of a directional line serving a stop influences the number of passengers boarding the line at that stop, controlling for various other established factors affecting demand. This cross-sectional analysis of the variation in line boardings across about 1300 sample schedule time point bus stops served by about 300 directional bus lines over a six-month period uses a historical archive of real-time geo-referenced vehicle location data, and focuses on five different time periods, peaks and off-peaks, of a typical weekday. By evaluating two measures that capture different dimensions of bus service reliability, and by estimating a series of regression models, I find systematic evidence that higher average service punctuality (or schedule adherence) and lower variation in schedule deviation over time are associated with greater ridership, all else equal, particularly during the peak periods. This study also provides first empirical evidence that the effect of reliability on peak-period ridership is moderated by headway. The demand for reliability seems to be higher for lines with relatively longer headways. The findings indicate that service reliability influences transit mode choice and/or line/route selection, and suggest that system-wide ridership gains can be expected from reliability improvements. From an urban planning perspective, this study provides more evidence that good service quality can effectively compliment transformations in the urban fabric brought about by coordinated land use — transit plans to promote transit use.

**Subject Area:** Public transit policy; Ridership; Scheduling; Service reliability; On-time performance

**Availability:** Chakrabarti, Sandip. "The demand for reliable transit service: New evidence using stop level data from the Los Angeles Metro bus system." Journal of Transport Geography 48 (2015): 154-164. http://www.sciencedirect.com/science/article/pii/S0966692315001696

# The Statistical And Geographical Analysis On The Impacts Of Socioeconomic Characteristics On Bus-Stop Daily Boarding In Richmond City *Yue Zhao*

**Abstract:** At present, Richmond, Virginia only has bus transit services provided by the Greater Richmond Transit Company (GRTC) and primarily concentrated within the boundary of Richmond City. GRTC is impacted by both supply-side and demand-side factors, notably socioeconomic characteristics of bus riders, bus ridership is unevenly distributed across different bus stops. This thesis will conduct statistical and geographical analysis on the impacts of socioeconomic characteristics on bus-stop daily boarding in Richmond City. The statistical analysis includes both correlation analysis and regression analysis, assuming one dependent variable (bus-stop daily boarding) and fourteen independent variables (most of which describe socioeconomic characteristics of bus riders) at aggregated census block group levels. The research concentrates on local bus routes and the block groups with local bus stops in Richmond. This empirical study aims to identify the significant factors impacting bus ridership and assess the bus service situation for affected block groups (under-served or over-served). The study outcomes, such as the number of bus lines as the most important factor impacting ridership, will have important implications for Richmond's local transit planning and decision-making.

**Subject Area:** Richmond; bus transit ridership

# Building a Framework for Transportation Resiliency and Evaluating the Resiliency Benefits of Light Rail Transit in Denver, Colorado *W. Marshall, A Henao, and R. Bronson*

**Abstract:** This report presents a three-part research program examining transportation resiliency and the ability for a transportation system to maintain or return to a previous level of service after a disruptive, black swan type event. With transportation as the second highest household expenditure, it is vital to understand the disproportionate impact that a drastic increase in gas price might have on a major city and region. We seek to increase our understanding of resiliency, vulnerability, and transportation affordability issues by asking what would happen if the cost of driving suddenly doubled or tripled. Who is better off and why? How much difference does being near downtown or jobs make? What matters in terms of transit infrastructure? How much of a role do current travel behaviors play? The results of this report illustrate that transportation choice helps create network redundancy and facilitates adaptability under extreme conditions. While alternative fuels and improvements to the fuel economy of vehicles would help reduce the long-term impacts, the most vulnerable households are already spending more than 30% of their income solely on transportation costs and would be the least likely to benefit from such technological improvements. The most resilient households will live in cities and regions that plan for and invest in diversifying and expanding transportation choice. Those living in cities and regions that continue to promote the automobile as the only viable mode of transportation might be not currently view themselves as at risk, but they will be the most vulnerable should a "black swan" event occur.

**Subject Area:** black swan event; transportation resiliency;

# Regulation of public bus services: The Israeli experience *Yoram Ida & Gal Talit*

**Abstract:** The present research discusses structural reforms in the regulation of public bus services in Israel. In 2000, the market underwent a significant change; as a result, some of the bus services on fixed routes that were previously provided by two monopolistic operators are currently provided by means of competitive tendering. The research examined the reasons for this change, the measures taken in order to implement it, and the outcomes from the perspective of time. The findings indicated that, as in other countries, competitive tenders in Israel have succeeded in reducing costs, compared with the past, and this has led to a reduction in the related subsidies required of the government. At the same time, there was a general rise in the level of service provided to the public and a decline in fares. It seems that the government succeeded in improving its degree of control over the provision of bus services, but frequent changes in the structure of the tenders and their characteristics might reflect difficulties in the implementation of competition in the bus services in Israel.

**Subject Area:** Competitive tendering; Bus services; Regulation; Contract type; Contract period; Bus operators; Supervision and control

# Characterizing Bus Passenger Demand along Epifanio de los Santos Avenue (EDSA), Metro Manila
*Kervin Joshua C. Lucas, Sean Johnlee Q. Ting, Alexis M. Fillone*

**Abstract:** Bus passenger demand characteristics includes the boarding and alighting behavior of passengers along bus routes both occurring in the morning and afternoon, the location of major stops and transfer stations, as well as the socio-economic characteristics of the passengers using the bus. Understanding the bus passenger demand along EDSA and its tributaries can help in policy and project recommendation on how to improve bus service.

**Subject Area:** EDSA, bus ridership, demand characteristics

# A Study of Metro Manila's Public Transportation Sector By Implementing A Multimodal Public Transportation Route Planner *Chelcie Narboneta, & Kardi Teknomo*

**Abstract:** Public transportation provides commuters a convenient way to reach their destination faster and cheaper, as compare to using private vehicles. This however is not always the case for Metro Manila as many Filipinos have a negative perception of using public transportation. This paper would first discuss the researchers' study regarding the travel behavior of Metro Manila commuters and the status of its public transportation sector, as concluded from their "Metro Manila Public Transport Travel Survey." Information from the said study was used to implement a multimodal public transportation route planner for Metro Manila. The said system's goal is to provide commuters actual facts about public transportation, so as to change its negative image and to entice more people to utilize it. Then, the researchers' analysis of the publicly distributed GTFS data provided by the government would be discussed. All these support the researchers' end-goal of upping Metro Manila's public transportation.

**Subject Area:** Public Transport, Multimodal, Route Planner, Metro Manila Commuters, Travel Survey, OpenTripPlanner

## Understanding the effects of complex seasonality on suburban daily transit ridership *Kashfi, Syeed Anta, Jonathan M. Bunker, and Tan Yigitcanlar*

**Abstract:** Fluctuations in transit ridership pattern over the year have always concerned transport planners, operators and researchers. Predominantly, metrological elements have been specified to explain variability in ridership volume. However, the outcome of this research points to new direction to explain ridership fluctuation in Brisbane. It explored the relationship between daily bus ridership, seasonality and weather variables for a one-year period, 2012. Rather than segregating the entire year's ridership into the four calendar seasons (summer, autumn, spring, and winter), this analysis distributed the yearly ridership into nine complex seasonality blocks. These represent calendar season, school/university (academic) period and their corresponding holidays, as well as other observant holidays such as Christmas. The dominance of complex seasonality over typical calendar season was established through analysis and using Multiple Linear Regression (MLR). This research identified a very strong association between complex seasonality and bus ridership. Furthermore, an expectation that Brisbane's subtropical summer is unfavourable to transit usage was not supported by the findings of this study. A nil association of precipitation and temperature was observed in this region. Finally, this research developed a ridership estimation model, capable of predicting daily ridership within very limited error range. Following the application of this developed model, the estimated annual time series data of each suburb was analysed using Fourier Transformation to appreciate whether any cyclical effects remained, compared with the original data.

## An Industrial Design Proposal Responding to Unmet Transportation Needs in the United States *Y. Wang*

**Abstract:** n/a

**Subject Area:** transportation needs

**Availability:** Wang, Yifan. An Industrial Design Proposal Responding to Unmet Transportation Needs in the United States. Diss. University of Notre Dame, 2015.
https://curate.nd.edu/concern/etds/xw42n586h2n

**The cost of equity: Assessing transit accessibility and social disparity using total travel cost** *El-Geneidy, Ahmed, David Levinson, Ehab Diab, Genevieve Boisjoly, David Verbich, and Charis Loong*

**Abstract:** Social equity is increasingly incorporated as a long-term objective into urban transportation plans. Researchers used accessibility measures to assess equity issues, such as determining the amount of jobs reachable by marginalized groups within a defined travel time threshold and compare these measures across socioeconomic categories. However, allocating public transit resources in an equitable manner is not only related to travel time, but also related to the out-of pocket cost of transit fares, which can represent a major barrier to accessibility for many disadvantaged groups. Therefore, this research proposes a set of new accessibility measures that incorporates both travel time and transit fares. It then applies those measures to determine whether people residing in socially disadvantaged neighborhoods in Montreal, Canada experience the same levels of transit accessibility as those living in other neighborhoods. Results are presented in terms of regional accessibility and trends by social indicator decile. Travel time accessibility measures estimate a higher number of jobs that can be reached compared to combined travel time and cost measures. However, the degree and impact of these measures varies across the social deciles. Compared to other groups in the region, residents of socially disadvantaged areas have more equitable accessibility to jobs using transit; this is reflected in smaller decreases in accessibility when fare costs are included. Generating new measures of accessibility combining travel time and transit fares provides more accurate measures that can be easily communicated by transportation planners and engineers to policy makers and the public since it translates accessibility measures to a dollar value.

**Subject Area:**  Equity, Job accessibility, Transit fare, Travel time. Cost

# "Transit Makes you Short": On Health Impact Assessment of Transportation and the Built Environment *Ermagun, Alireza, and David Levinson*

**Abstract:** The current research provides a test framework to understand whether and to what extent increasing public transit use and accessibility by transit affect health. To this end, the effect of transit mode share and accessibility by transit on general health, body mass index, and height are investigated, while controlling for socioeconomic, demographic, and physical activity factors. The coefficient-p-value-sample-size chart is created and effect size analysis are conducted to explore whether the transit use is practically significant. Building on the results of the analysis, we found that the transit mode share and accessibility by transit are not practically significant, and the power of large-sample misrepresents the effect of transit on public health. The results, also, highlight the importance of data and variable selection by portraying a significant correlation between transit use and height in a multivariate regression analysis. What becomes clear from this study is that in spite of the mushrooming interdisciplinary studies in the nexus of transportation and health arena, researchers often propose short and long-term policies blindly, while failing to report the inherent explanatory power of variables. We show that there is a thin line between false positive and true negative results. From the weakness of p-values perspective, further, we strove to alert both researchers and practitioners to the dangerous pitfall deriving from the power of large samples. Building the results on just significance and sign of the parameter of interest is worthless, unless the magnitude of effect size is carefully quantified post analysis.

**Subject Area:** Public transit; BRFSS data; ACS data; Accessibility to jobs; p-hacking

# Regional Sky Transit *Brian A. Seeley MD*

**Abstract:** Future, on-demand, electrically-powered "Sky Taxi" aircraft must be able to deliver both people and packages at high proximity "pocket airparks" that minimize the length of 'last mile' surface travel for the short-range trips that people most often make. These are sub-100 mile trips that stay within metropolitan 'mega-regions'. Such a regional "Sky Transit" system would serve a vastly larger user base than that for trips that exceed 160 km (100 miles) in length. Sky Transit would necessarily operate with a very different type of aircraft than the conventional take-off and landing (CTOL) type used on longer range, higher speed general aviation (GA) flights. Ultra-quiet, V/ESTOL Sky Taxis, by having a much higher duty cycle than GA, would also be much more affordable. Fortunately, electrically-powered aircraft whose range is somewhat limited by present day battery technology could still fulfill the Sky Transit mission requirements if designed for robotic battery swap. A prospective business model for such regional Sky Transit using various cost scenarios and market penetrations shows its potential for strong profitability as well as numerous societal benefits. The San Francisco metropolitan region is analyzed with respect to its inter-county and major corridor surface traffic volumes in order to project realistic ridership for a fully implemented regional Sky Transit system. The analysis includes actual trip distances that account for direct flight path versus tortuous surface road path lengths. The subjective aspect of 'crowding of the skies' is examined by projections of a sky image simulated during peak operations. Partitioning of the region's airspace by assignment of altitudes is used as a means to estimate such projections and the attendant separation distances. Fast tempo take-off and landing operations are examined for their effect upon profitability and system capacity. Peak capacity at locations with the greatest number of daily travelers is examined in terms of operational intervals and safe aircraft separations. The relationship between land parcel size and availability with high proximity for the most popular traveler destinations is examined as a means to define the limiting case of short runway operations. Trip fares and their effect upon ridership and profitability are explored relative to alternative modes of surface travel and on a cost per km basis. The total regional electrical energy demand that would attend a full-fledged, electrically-powered Sky Transit System is estimated. The effect of Sky Transit in easing surface gridlock is estimated, along with its effect in reducing GHG emissions.

**Designing Shuttle Connections To Commuter Rail Using Census Origin And Destination Data** *Gretchen Johnson, Hazel Scher & Thomas Wittmann*

**Abstract:** Designing shuttles that help transit riders complete the "last mile" of their trip (from a transit station/stop to their destination) plays an important role in leveraging rail capacity and growing a regional transit market. Unavailable or imprecise data have made effective shuttle route design based on a defined potential market difficult. This paper presents a methodology to determine the size and location of the untapped market of commuters who drive long distances for work but could make the same tr ip using commuter rail and last mile shuttle service. The authors conducted the analysis using U.S. Census Longitudinal Employer-Household Dynamics (LEHD) data, a relatively new public dataset of statewide workplace and residence pairs at the Census block level. As a case study, the authors determined the potential for last mile shuttle connections between employment and 14 FrontRunner commuter rail stations outside of downtown Salt Lake City. To capture the shuttle market, the workplace and residence pairs in this methodology were selected based on three criteria: 1) a residence within the FrontRunner park-and-ride shed, 2) a workplace within two miles of a FrontRunner station, and 3) an overall trip distance of 15 miles or greater. The authors identified stations with the highest number of trips that met all three criteria and designed shuttle routes based on the associated employment locations. While this analysis focused on non-traditional commuting patterns, the same methodology is useful for many different analyses of commuter markets.

**Subject Area:** shuttles;  last mile

**The Impacts Of Socio-Economic And Demographic Shifts In Transit Served Neighborhoods On Mode Choice And Equity** *Steven Apell*

**Abstract:** Today the use of transit-oriented development (TOD) is a common strategy for metropolitan areas endeavoring to advance the sustainable communities strategy. At the same time, urban areas in America are experiencing rising energy prices and new geographies of employment, poverty, and wealth. Furthermore, the Millennial generation, and some Baby boomers are changing their residential preference from the suburbs to the central city. These modifications in the urban economy and residential preferences are likely to intensify competition for housing in the central city. Increased demand for housing generates high rents, which often results in the displacement of low-income, transit-dependent population. Consequently, the effectiveness of transit-oriented development is compromised as new affluent households increase vehicle use for home-based trips. Using 1990 and 2010 census data, this research investigated the unintended consequences of TOD policy on mode choice and equitable accessibility in block groups within one mile radius of rail stations in six metropolitan statistical areas. The research employed geographic information systems (GIS) and multivariate regression to analyze the relationship between socio-economic and demographic change in transit-oriented development and associated effects on mode choice for work commute. The findings reveal that while driving declined between 1990 - 2010, transit use for work commute increased in most metropolitan areas in the study. In addition, transit-oriented developments are associated with a high number of affluent households, college graduates, and White-collar employees, when compared with block groups with no transit-oriented development. However, the percentage of foreign-born residents have increased in transit-oriented development, while the percentage of Black and White population have declined. In addition, block groups within one mile of transit stations show nearly similar levels of transit use and driving when compared block groups within the half mile radius. These findings have significant implications on the long term effectiveness of TOD policy.

**Subject Area:** TOD; sustainable communities;

# 10. Travel Behavior

**Exploration of the current state and directions of dynamic ridesharing** *Di Gianni, Joseph J.*

**Abstract:**  Dynamic ridesharing (DRS) is an emerging transportation service based on the traditional concept of shared rides. DRS makes use of web-based real-time technologies to match drivers with riders. Enabling technologies include software platforms that operate on mobile communication devices and contain location-aware capabilities including Global Positioning Systems (Agatz, Erera, Savelsberg, & Wang, 2012). The platforms are designed to provide ride-matching services via smartphone applications differing from early systems that used non-real time services such as internet forums, or telecommunications, where responses were not immediate.

The study of DRS is important when considering its role as an emerging transportation demand management strategy. DRS reduces travel demand on single-occupancy vehicles (SOVs) by filling vehicle seats that are typically left vacant. The most recent statistics of vehicle occupancy rates were measured in 2009 by the National Household Travel Survey (NHTS), conducted by the U.S. Department of Transportation. According to the NHTS, the 2009 occupancy rate for all purposes was a meager 1.67 persons per vehicle (Federal Highway Administration, 2015). Vehicle occupancy rates examined against the total of all registered highway vehicles in the U.S. as of 2012, calculated at 253,639,386 (Bureau of Transportation Statistics, 2015), reveals the magnitude of the impact of SOVs. Left unattended, the ramifications for environmental outcomes is substantial. Among the major energy consuming sectors, transportation's share is largest in terms of total $CO_2$ emissions at 32.9% (Davis, Diegel, & Boundy, 2014, p. 11-15).

DRS offers promise to fill empty vehicle seats. Evidence indicates that specific demographic subgroups are inclined to use DRS services. For example, data suggest that the subgroup of 18 to 34-year-olds, the so-called "millennials", have negative attitudes towards private car ownership unlike previous age groups (Nelson, 2013). Data collected for this study revealed that the millennial subgroup represents half of all DRS users. Millennials also revealed they tended to use DRS more than other subgroups to replace a private vehicle. Further research is needed to determine if the trend towards DRS by 18 to 34-year-olds represents current economic factors or a fundamental cultural shift away from the SOV transportation model.

**Subject Area:** Environmental management; Information technology; Social structure; Transportation planning

**Availability:** Di Gianni, Joseph J. Exploration of the current state and directions of dynamic ridesharing. Diss. MONTCLAIR STATE UNIVERSITY, 2015.

http://gradworks.umi.com/37/21/3721711.html

**The effect of carsharing on vehicle holdings and travel behavior: A propensity score and causal mediation analysis of the San Francisco Bay Area** *Mishra, Gouri Shankar, Regina R. Clewlow, Patricia L. Mokhtarian, and Keith F. Widaman*

**Abstract:**  We examine the impacts of carsharing on travel behavior utilizing a San Francisco Area subsample of the 2010–2012 California Household Travel Survey. We control for self-selection bias due to differences in observed characteristics of the respondents using propensity-score based matching. We find that vehicle holdings of carsharing members are substantially and significantly lower than for non-members with similar characteristics in terms of individual and household demographics and built environment features of both residential and job location. These differences increase as the propensity to enroll in carsharing programs increases. A latent construct, which measures the propensity to own or utility from owning vehicles and rises with numbers of vehicles owned, is lower for members by 0.3–1.3 standard deviations relative to non-members. Members are also likely to walk, bike, and use transit more frequently than non-members. However, these differences are relatively minor and tend to be statistically non-significant. Future research should control for self-selection bias arising from differences in unobserved characteristics of respondents, as well as simultaneity bias whereby decisions concerning vehicle ownership both influence and are influenced by the decision to join carsharing programs.

**Subject Area:** Self-selection bias; Carsharing; Shared use mobility; Propensity score matching; Vehicle ownership; Alternative modes

# The impact of urban form and gasoline prices on vehicle usage: Evidence from the 2009 National Household Travel Survey *Harya S. Dillon, Jean-Daniel Saphores, & Marlon G. Boarnet*

**Abstract:**  This paper relies on generalized structural equation modeling (SEM) to tease out the relationship between land use, gasoline prices and travel behavior. We analyze data from a Southern California subsample of the 2009 National Household Travel Survey (NHTS), which has a quasi-experimental nature thanks to large exogenous variations in gasoline prices during the administration of the NHTS (March 2008–April 2009). Our joint models of residential urban form, vehicle efficiency choice, and vehicle use account for residential self-selection and endogeneity of vehicle preferences in order to explain vehicle miles traveled (VMT) for both work and non-work trips. Residential urban form is treated as a latent construct that reflects observed variables such as population density, land use diversity and distance to employment centers. We find that in the short run, households drive 0.171% less for non-work trips when gas prices increase by 1%, while work trips are not responsive to gasoline price changes. Moreover, owners of more fuel efficient vehicles tend to be more educated and Asian. In addition, households in lower density neighborhoods are more likely to have a higher income, to be older than 65 and White; these households tend to own more vehicles per driver. Overall, our results underscore the importance of accounting for the nature of trips when estimating the short-term price elasticity of travel.

**Subject Area:** Land use; Travel behavior; Structural equation modeling; Gasoline prices

# Enhancement of Estimation of Internal Trip Capture Rates for Mixed-Use Developments *Pei-Sung Lin and Aldo Fabregas*

**Abstract:** Land use of a development plays an important role in efficient city and regional transportation planning. Mixed-use developments can considerably reduce the number of external trips than those from a single land use development. This paper presents the results of an internal trip capture study performed on four Mixed-Use Developments (MXDs). The study aimed at gaining further insights on internal trip capture behavior in MXDs and how it influences traffic impacts on public roadway systems. The results obtained confirmed that traditional methods significantly overestimate the trips generated by MXDs. In addition, the study served as a confirmation and enhancement of a recently proposed methodology to improve the traditional trip estimation method for MXDs.

**Subject Area:** land use; mixed development

# A Behavioral Analysis Of Shopping Trip Chaining In United States *Sun, Ting*

**Abstract:**  This thesis studies travelers' tendency to chain a shopping trip into daily travel tour. A comprehensive analysis of personal shopping trip-chaining probability and its relation to sociodemographic characteristics, household status and land use information is conducted both nationally and area wide in United States. Using the 2009 National Household Travel Survey (NHTS) data, a binary logit model is chosen to analyze the probability of trip chaining, and a negative binomial regression model is used to model individuals daily shopping frequency. Results show that gender, household life cycle, family income, driver status, rural living environment and weekend have significant impact on people's chaining propensity, while influences of age, education, and worker status is insignificant. The same studying method and models are applied to all US census divisions as well. Area behavior, as expected, is consistent with national behavior.

**Subject Area:** trip chaining, shopping, daily travel tour

**Development Of A Vehicle Fleet Composition Model System: Results From An Operational Prototype** *You, Daehyun, Venu Garikapati, Ram Pendyala, Chandra Bhat, Subodh Dubey, Kyunghwi Jeon, and Vladimir Livshits*

**Abstract:** This paper presents the estimation and validation results of a vehicle fleet composition simulator that can be integrated with a larger activity-based microsimulation model system. The motivation behind the development of this fleet composition simulator is two-fold. First, it is desirable to predict the vehicle fleet mix to accurately quantify the emission profile in a region as vehicle technologies and fuel types evolve. This will provide planners the ability to evaluate the potential impacts of a host of emission control strategies. Second, knowledge of household vehicle fleet mix will enable modeling the 'type' of vehicle at the trip/tour level in existing activity based models (ABMs). This will not only add to the behavioral representation of travel in ABMs but also facilitate an accurate assessment of emission hotspots, and emissions along specific travel sheds. A heuristic algorithm is applied together with other model components to accurately predict the fleet mix of individual households where vehicle types are defined by body type and age. The model system performs well in replicating the base year fleet mix patterns for the Greater Phoenix metropolitan region, for which the model was developed.

# On the Impacts of Telecommuting over Daily Activity/Travel Behavior: A Comprehensive Investigation through Different Telecommuting Patterns
*Hamidreza Asgari*

**Abstract:** The interest in telecommuting stems from the potential benefits in alleviating traffic congestion, decreasing vehicle miles traveled (VMT), and improving air quality by reducing the necessity for travel between home and the workplace. Despite the potential economic, environmental, and social benefits, telecommuting has not been widely adopted, and there is little consensus on the actual impacts of telecommuting. One of the major hurdles is lack of a sound instrument to quantify the impacts of telecommuting on individuals' travel behavior. As a result, the telecommuting phenomenon has not received proper attention in most transportation planning and investment decisions, if not completely ignored. This dissertation addresses the knowledge gap in telecommuting studies by examining several factors. First, it proposes a comprehensive outline to reveal and represent the complexity in telecommuting patterns. There are various types of telecommuting engagement, with different impacts on travel outcomes. It is necessary to identify and distinguish between those people for whom telecommuting involves a substitution of work travel and those for whom telecommuting is an ancillary activity. Secondly, it enhances the current modeling framework by supplementing the choice/frequency approach with daily telework dimensions, since the traditional approach fails to recognize the randomness of telecommuting engagement in a daily context. A multi-stage modeling structure is developed, which incorporates choice, frequency, engagement, and commute, as the fundamental dimensions of telecommuting activity. One pioneering perspective of this methodology is that it identifies non-regular telecommuters, who represent a significant share of daily telecommuters. Lastly, advanced statistical modeling techniques are employed to measure the actual impacts of each telecommuting arrangement on travelers' daily activity-travel behavior, focusing on time use analysis and work trip departure times. This research provides a systematic and sound instrument that advances the understanding of the benefits and potentials of telecommuting and impacts on travel outcomes. It is expected to facilitate policy and decision makers with higher accuracy and contribute to the better design and analysis of transportation investment decisions.

**Subject Area:** telework; congestion, air quality

**Heterogeneity in the relationship between the built environment and driving: Focus on neighborhood type and travel purpose** *Salon, Deborah*

**Abstract:** Global concern about fossil fuel use and associated environmental externalities has led many governments to consider actions that encourage their residents to drive less. This research uses empirical analysis of travel survey data to estimate the relationship between built environment characteristics and vehicle miles traveled (VMT) in California. The work improves upon past research in two key ways. First, it employs a novel approach to control for residential self-selection, categorizing neighborhoods into types and using these as the alternatives in a predictive model of neighborhood type choice. Second, it focuses on exploring and understanding heterogeneity in the relationship between the built environment and VMT across two dimensions – neighborhood type and travel purpose.

The results show that VMT sensitivity to built environment characteristics does depend on both neighborhood type and the purpose of travel, in ways that are intuitive but had not previously been estimated. This calls into question the usefulness of prior research that provides only single point estimates of the relationships between travel choices and the built environment. Though these relationships may be small on average, this work shows that for certain trip types and in certain neighborhood types, the built environment is strongly related to travel choices.

# Determinants of private vehicle use intensity in China: Evidence from aggregate macroeconomic and disaggregate household data *Zhao Zhang, & Hai Jiang*

**Abstract:** We investigate determinants of private vehicle use intensity (annual kilometers travelled per vehicle, or annual VKT per vehicle) in China, a problem that has not been thoroughly studied in the literature. Unlike existing approaches that rely on either aggregate macroeconomic data such as GDP per-capita or disaggregate household data such as household income to build use intensity models, we propose to include both types of data as independent variables, which allows us to understand the impacts of macroeconomic indicators on private vehicle use and explain residents' vehicle usage behavior at the household level. Based on data from the 2012 China Household Finance Survey (CHFS), we find that: (1) Vehicle use intensity is positively related to GDP per capita and real estate increment, which is consistent with existing literature; (2) The average vehicle use expense for a household is about 2.17 to 2.5 Chinese Yuan (CNY) per kilometer; (3) Households with light duty passenger vehicles drive 12,000 km less than those with trucks; (4) Geographic location and commuting behaviors have significant impact on household vehicle use. For example, households whose members commute by transit drive about 4,000 km less than those whose members commute by car. In addition, those who commute between cities drive about 10,000 to 11,000 km more than those who live and work in a same city.

**Subject Area:** vehicle use intensity, regression models, aggregate data, disaggregate data

## Sustainable Transportation and Social Demographics at Uptown Waterloo
*Chase, Geoffrey*

**Abstract:** This thesis investigates how the use of a mid-size city's core is related to the transportation preferences and socioeconomic status of its residents.

**Subject Area:** sustainable transportation

**Availability:** Chase, Geoffrey. "Sustainable Transportation and Social Demographics at Uptown Waterloo." (2015). https://uwspace.uwaterloo.ca/handle/10012/9773

## A study on possibility of commuting trip using private motorized modes in cities around the world: Application of multilevel model *Hyunsu Choi & Yoongho Ahn*

**Abstract:** The focus of the current research was to evaluate how the individual's social characteristics and urban infrastructure impacts the usage of Private Motorized Modes (PMM). Based on individual and urban characteristics a multilevel analysis was conducted on the possibility of commuting trip by private motorized modes on the rush time of 78 cities around the world. Also the selected cities were classified through a principal component analysis, and based on the classification the impact of and urban variables on the possibility of commuting trips made by private motorized modes (PCTP) was verified. Results showed a diverse range of variables related to the usage of PMM, as well as the urban structure and railway lengths being an important variable in travel behavior.

# Income, Location Efficiency, and VMT: Affordable Housing as a Climate Strategy *Gregory L. Newmark Ph.D and Peter M. Haas Ph.D*

**Abstract:**  A dominant concern of planning research over the last three decades has been the effect of the built environment on automobile travel. This question is particularly pertinent for political jurisdictions, such as the state of California, whose climate change policies emphasize land use planning as a strategy for reducing vehicle-miles traveled (VMT). Such policies, combined with growing market demand, have led to increased development interest in location-efficient neighborhoods – i.e., those places associated with the lowest transportation costs. Location-efficient places are characterized by high levels of accessibility to jobs and services that enable residents to drive less either by making shorter trips or by shifting to transit, walking, and bicycling. This increased development interest, typically focused on residences for higher-income populations, but in neighborhoods historically home to lower-income populations, has raised questions about the best use of the scarce, location-efficient space for achieving VMT reduction targets. Specifically, how can the VMT consequences of different policies be assessed and is there a role for location-efficient affordable housing in meeting greenhouse gas emission goals? This research addresses these questions by estimating a statistical model of VMT for the entire state of California and then using that model to explore detailed data on residents of the state's most location-efficient areas. The statistical model is designed as both a predictive tool for estimating any household's expected VMT and as a planning tool for identifying factors associated with reduced VMT to guide policy formation. A final section illustrates this policy application in reference to California's current regulations promoting location-efficient affordable housing. The research finds strong justification for location-efficient affordable housing programs as a climate change mitigation strategy. This justification is not that location efficiency results in deeper absolute reductions in VMT for lower income populations than for wealthier populations – no statistically significant differences were found; rather, lower-income populations favor location-efficient living, use those scarce spaces more efficiently (enabling the social benefits to be most widely shared), generate the least amount of VMT due to both household composition and income, and demonstrate the largest relative VMT reductions with location efficiency. Taken together, these findings suggest that allocating land and monies for location-efficient development affordable to lower-income households is expected to yield greater VMT benefits than the same allocation for higher-income households.

**Subject Area:** built environment; vmt; income; housing

## Commuting Patterns of Workers in a Village of Barddhaman District, West Bengal *Bhaswati Mondal*

**Abstract:** Commuting helps to keep balance between residence and workplace of workers. With growing accessibility and connectivity, the importance of commuting is increasing all over the world. It is becoming a major substitute to migration. In commute-studies, commute-pattern is an important chapter. It highlights commuters' directions of movement, distance they cover, modes of transport they use, the time they take to commute, etc. Unlike the urban-based commute pattern, commute pattern in rural areas are relatively an under-researched issue. In fact, traditionally rural people are thought to carry a sedentary lifestyle. Using primary data, this study aims to explore the commute patterns of rural workers located in the village of Gandharbapur of Barddhaman district of West Bengal, India. All the commuters were found to be engaged in non-farm work. Commuters stem from two major groups. One group of commuters is accumulated farm-income induced. They possess sufficient agricultural land. Investing their surplus farm-income, they have established non-farm works. The second group of commuters is poverty-driven. They are landless poor or are marginal farmers and to escape poverty, they have slipped into these works. Located beyond the suburban area (Memari being the nearest town), most commuters commute to nearby rural areas. Due to non-availability of public transport, women commute less than men do. Regular-paid government employees commute longer than other workers commute. The article concludes with a summary of findings and recommendations for further research.

**Subject Area:** Commuting, Working Commuters, Commuting Patterns, Rural area, Barddhaman District, West Bengal, India

# Impact Of Ride-Sourcing Services On Travel Habits And Transportation Planning *Zhen Chen*

**Abstract:** The use of app-based, on-demand ride-sourcing services has spread rapidly and become more and more important in urban transport. Companies such as Uber and Lyft may provide better service with less waiting time and higher vehicle occupancy when compared to traditional transportation services such as private auto, public transit and taxis. This new type of transportation service is defined as ride-sourcing. This increase in the ride-sourcing availability, due to the introduction of Uber and Lyft, may impact travel habits and change the local, regional and national travel demand. The research compared the users' differences in travel characteristics between traditional transportation services and new ride-sourcing services. This comparison was be done by conducting a survey in the Pittsburgh region to determine users' attitude and travel habits when using ride-sourcing services. The results of the survey were used to compare to the travel characteristics of ride-source users to established travel behavior data and then determine how the impact of ride-sourcing on travel habits may be incorporated into the transportation planning process. The findings indicate that ride-sourcing users are generally younger than the typical traveler, the service is used by a higher percentage of males and females. Social and recreational trips are the predominant type of trips used for ride-sourcing followed by work trips, trip lengths are shorter for all types of trips when compared to typical trip makers and vehicle occupancy rates are generally higher for ride-sourcing trips. Ride sourcing users generate more trips than typical traveler's in the Pittsburgh region and the use of taxis and private autos are most impacted by ride sourcing where users' shift away from these modes. Currently, ride-sourcing is still a relatively small number of daily trips in an urban area. However as populations increase in urban areas and the demand for transportation facilities increases the new type of travel could increase to significant levels. It could be considered as a new transportation mode or categorized in as an auto mode in travel demand models.

**Subject Area:** ride-sourcing, tr

## Impact of Neighborhood Walkability on Trip Generation and Trip Chaining: Case of Los Angeles *Lee, Jeongwoo*

**Abstract:** The purpose of this study was to test whether a compact neighborhood design is associated with trip-chaining behavior. Trip chaining is regarded as a growing phenomenon in travel and activity behavior because people seek to minimize the travel time and cost required to accomplish their daily activities based on the available time budget and other needs. In this study, trip-chaining patterns were examined over a survey day, giving insight into the association between land use and the planning of the trip and its distance, as well as the preferred mode of transportation. A tour consists of a combination of individual trips, including all of the stops that are made along the way. A series of multivariate models was used separately for different types of tours segmented into simple (one destination) and complex (more than one destination), and into work and nonwork tours. The results confirmed the idea that trip chaining diminishes the likelihood of using nonmotorized modes of transportation. In addition, local land use and walkability have a limited effect on work-related tours, but these factors are significantly related to nonwork tours. A resident who lives in a more walkable neighborhood is likely to take simple, albeit more frequent nonwork tours and conduct their nonwork activities on foot or by public transport, which reduces their use of vehicles during the day. These findings lead to the conclusion that there is more opportunity to use urban design policies to influence nonwork tours than work tours.

## Understanding the Effect of Online Shopping Behavior on Shopping Travel Demand through Structural Equation Modeling *Muhammad Zudhy Irawan & Elfira Wirza*

**Abstract:** This paper provides more insights into the relationships between online searching, e-shopping and shopping trip in Indonesia. It becomes attractive since nearly a fifth of total population use internet for searching product information and online shopping. An online survey was used to collect the data. Out of 312 respondents participating, only 281 respondents were selected residing in thirteen provinces in Indonesia. A Structural equation modeling was used to understand the complex variable relationships. The result shows that online shopping can replace the shopping travel demand. However, in-store shopping has no effect on the demand of online shopping. Meanwhile, online searching is not only increasing the frequency of e-shopping, but also generating a more often shopping trips. This study also found that both e-shopping and in-store shopping are influenced by exogenous factors such as shoppers' demographic features, household socio-economy, shopping characteristic and shopping attitude.

**Subject Area:** Online Searching, E-Shopping, In-store shopping, SEM, Indonesia

**Does rush hour see a rush of emotions? Driver mood in conditions likely to exhibit congestion** *Eric A. Morris & Jana A. Hirsch*

**Abstract:** Polls show that a large portion of the public considers traffic congestion to be a problem and believes a number of policy interventions would ameliorate it. However, most of the public rejects new taxes and fees to fund transportation system improvements or raise the cost of travel. This may be because of a disconnect between the public's stated antipathy towards congestion and the recalled emotional costs congestion imposes. To explore this, we use a large and representative sample drawn from the American Time Use Survey to examine how drivers experience four emotions (happiness, sadness, stress, and fatigue), plus a constructed composite mood variable, when they travel in peak periods, in large metropolitan areas, in city centers, and in combinations of these. We also explore the interactions between these indicators and trip duration. We find evidence that drivers in the largest cities at the very peak of rush hour (5:00 pm–6:00 pm) on non-holiday weekdays are in a less positive mood, presumably because of congestion. However, this effect, though significant, is small, and we find no significant results using broader definitions of the peak period. In all, our findings suggest that congestion's impact on drivers as a group is quite limited. This may help explain why the public's attitude toward painful financial trade-offs to address congestion is lukewarm.

**Subject Area:** Well-being; Happiness; Traffic congestion; Emotions; Mood

## The interactions between online shopping and personal activity travel behavior: an analysis with a GPS-based activity travel diary *Yu Ding & Huapu Lu*

**Abstract:** Accompanying the widespread use of the Internet, the popularity of e-commerce is growing in developing countries such as China. Online shopping has significant effects on in-store shopping and on other personal activity travel behavior such as leisure activities and trip chaining behavior. Using data collected from a GPS-based activity travel diary in the Shangdi area of Beijing, this paper investigates the relationships between online shopping, in-store shopping and other dimensions of activity travel behavior using a structural equation modelling framework. Our results show that online buying frequency has positive effects on the frequencies of both in-store shopping and online searching, and in-store shopping frequency positively affects the frequency of online searching. Frequent online purchasers tend to shop in stores on weekends rather than weekdays. We also found a negative effect of online buying on the frequency of leisure activities, indicating that online shopping may reduce out-of-home leisure trips.

# Transport mode choice in South East Asia: Investigating the relationship between transport users' perception and travel behaviour in Johor Bahru, Malaysia

*Leanne Yong Le Loo, Jonathan Corcoran, Derlie Mateo-Babiano, &Renee Zahnow*

**Abstract:** The worldwide increase in private car dependency poses a set of significant environmental, economic and social sustainability challenges that continue to undermine the urban quality of life. Rapid motorisation, particularly in South East Asia (SEA), has emerged as a global concern given the region's cumulative population, rate of industrialisation, and large-scale urbanisation. Thus, there is a compelling need to enhance our understanding of the underlying dynamics of how people perceive and use transportation such that transport planning is better placed to address the current, unsustainable travel patterns in SEA. Despite this need, there has been relatively limited SEA-based research that has endeavoured to examine travel perceptions and transport mode choice from a non-instrumental perspective. This research redresses this deficit by investigating the relationship between transport users' perceptions and travel behaviours within SEA, with a particular focus on psychosocial drivers of transport mode choice interfaced with more traditional instrumental measures. Spatially stratified survey data have been collected in a case study area, Johor Bahru, Malaysia, comprising users from different transport user groups. Employing regression modelling, drivers of individual's travel behaviour are examined. Results highlight the merit in recognising the role of non-instrumental motives alongside instrumental motives to explain transport mode choice. We conclude by highlighting that transport mode choices are motivated by a range of locational, socio-demographic, psychological and cultural determinants. The current research has contributed to a better understanding of transport mode choice in Johor Bahru and provides a foundation for future SEA-based travel behaviour research. Studies in this area can inform more sustainable travel behaviour in the SEA region.

# Analysis of Route Choice and Activity Scheduling Dynamics in Multi-Agent Transport Simulation Environment for Efficient Network Demand Estimation
*Enock Thomas Mtoi*

**Abstract:** The study of user-behavior and decision-making dynamics in transportation network are vital in modeling and simulation of user interactions. Different users access transportation network in order to accomplish different activities. Such activities can be regular commuting, transit services, commercial taxicabs, deliveries, long distance trips, logistics or fleet services, etc. While the world is becoming increasingly urbanized reliable and cost effective movement of people and goods is important for the productivity and economic growth at large. Urbanization and population growth have created the shift in how travel activities are tied to the economy. In today's economy, businesses and individuals are looking for ways of making their fiscal resources and workforce more efficient. However, traffic congestion dampens the efficiency and prosperity by imposing additional operating costs, slowing mobility and causing wastage of time and by hindering efficient metropolitan services such as deliveries, public safety and maintenance. Traffic congestion in the United States in 2011 for instance, caused urban commuters to travel 5.5 billion hours more and to purchase an extra 2.9 billion gallons of fuel (enough to fill Superdome in New Orleans, two times) for a congestion cost of $121 billion. In larger cities and in busy expressways, traffic infrastructures are already operating at near or full capacity. With today's shrinking budgets, often no funding is available to rebuild or expand an aging public transportation infrastructure, making it crucial to devise ways to optimize the performance of existing transportation assets. Since the recurring congestions in large metropolitan areas are mainly due to predictable behavioral activity scheduling, traffic management efforts should be geared towards behavior analysis and modeling. Modeling behavior and decisions, pertinent to route choice and activity scheduling dynamics are crucial for capturing microscopic and mesoscopic nature of traffic flow patterns. In this research, the focus is placed on the development of multi-agent transportation demand estimation and simulation framework to be used by the public entities for performance optimization of existing transportation network and scenario evaluation of new investments. The framework employs several mathematical and statistical methods for the derivation of sampling distributions of users' (i.e., agents') behavior and travel characteristics for the initial network demand generation. The processes of deriving sampling distributions of agents' behavior and travel characteristics largely rely on the quantity, quality and resolution of the available data of the region under study. Travel characteristics/travel surveys data from South East Florida Regional Planning Model (SERPM) region and the National Household Travel Survey (NHTS) data contained individuals' travel characteristics such as origin, destination, departure and arrival time, chain of activities and tours within the trip. These are micro-information needed for the derivation of household and individual agent's travel behavior. The data was processed to develop probability distributions for groups of agents with similar travel behavior, given the agents' household characteristics. In a similar fashion, with agents' household characteristics given, the logit models for agents' activity and locations choices were developed. Besides behavior simulation and demand estimation, the developed framework included an ad-on module for lane choice and pricing approaches applicable to dynamic high occupancy toll (HOT) lanes pricing. The reinforcement learning (RL) approach was used for updating the optimal

pricing strategy in a given traffic condition. The pricing controller was configured to start with a predefined base price at a given traffic level, and then in the process of learning, it varies the price in accordance with the acceptable price levels at a given level of service (LOS). In this way, the pricing controller learns the states in which a higher price is more beneficial and those in which a lower price is more beneficial, and then adjusts the parameters of the pricing function to minimize the difference between the current computed price and the posted price. The framework was tested and validated for the scenario based on the data from SERPM region. The scenario was simulated in Multi-Agent Transport Simulation (MATSim). In MATSim, the simulation is constructed around the notion of agents that make independent decisions about their actions. Each traveler of the real system is modeled as an individual agent. Generally, the observation of network traffic evolution from the simulation showed the expected traffic patterns for both morning peak and afternoon peak traffic. One of the most important aspects of travel behavior is the characterization of travel activities by trip duration. The distribution of travel activities by trip duration is the reflection of user behavior in the study area. This determines the expected users departing, en-route, stuck, and arriving to their destinations at a particular time interval. In this research, the simulation results show that network users in our case consist mainly of regular commuters (≥ 20%) whose trips take about 15 minutes. As any other research study, there are some limitations with this work. Due to lack of relevant data, transit use and other modes other than personal vehicle were not considered. Future directions for this research include the inclusion of other data sources and optimization of the demand estimation framework in order to scale-down the computation cost. In addition to the reduction of computation cost, focus will be on development and implementation of modules for simulating dynamic toll pricing on high occupancy toll lanes and assessing the effects of social media information exchange among the agents on mobility.

**Subject Area:** Route choice; MATSim; SERPM; decision making

**Availability:** Mtoi, Enock Thomas, "Analysis of Route Choice and Activity Scheduling Dynamics in Multi-Agent Transport Simulation Environment for Efficient Network Demand Estimation" (2015). Electronic Theses, Treatises and Dissertations. Paper 9419.

http://diginole.lib.fsu.edu/etd/9419

## Should we all just stay home? Travel, out-of-home activities, and life satisfaction *Morris, Eric A*

**Abstract:** How and why travel contributes to our life satisfaction is of considerable import for transportation policy and planning. This paper empirically examines this relationship using data from the American Time Use Survey. It finds that, controlling for relevant demographic, geographic, and temporal covariates, travel time per day is significantly and positively associated with life satisfaction. This relationship is attenuated, but still significant, when the amount of time spent participating in out-of-home activities is controlled for. Time spent bicycling is strongly associated with higher life satisfaction, though it attains significance only in some models; time spent walking is also quite positive, though it is not significant. However, both walking and bicycling are positively and significantly associated with life satisfaction when time spent on purely recreational walking and bicycling is included. Life satisfaction is positively and significantly associated with time spent traveling for the purposes of eating and drinking, religious activities, volunteering, and playing and watching sports. Travel time exhibits a strong positive relationship with life satisfaction in smaller towns and cities, but in large cities the association weakens, and for very large cities travel time may actually not be associated with life satisfaction at all. This may be due to the costs of traffic congestion, which disproportionately exists in large cities. In all, while the associations between travel and life satisfaction are clear, the causal story is complex, with the positive relationships potentially being explained by (1) travel allowing us to access destinations that make us happy, (2) the act of travel itself being fulfilling, and/or (3) intrinsically happier people being more likely to travel. In all likelihood, all three factors are at play.

**Subject Area:** Happiness; Life satisfaction; Well-being; Travel time; Activity participation

# Characterizing the spatial and temporal patterns of farmers' market visits

*James Mack, & Daoqin Tong*

**Abstract:** This research presents a study of visits to farmers' markets, a rapidly growing urban phenomenon in the U.S., from a geographic perspective. Although the social and economic impacts of farmers' markets have received considerable attention recently, examining farmers' market access in space-time is still lacking in the existing analytical frameworks. This study challenges conventional food access measures that have been primarily focused on the spatial separation between markets and consumers' homes and proposes a more realistic space-time based strategy. A survey was conducted on twelve markets in Tucson, Arizona. Analysis results show that majority of market patrons went to a market that was different from the one nearest to their homes, and the market choice, including the geographic location and the associated market operating time, was highly affected by patrons' other daily activities. The particular types of activities combined with farmers' market trips were found to vary temporally and fluctuate based on patron's employment characteristics. Our study suggests that conventional food access measures should be used in caution to assess farmers' market access as these measures can lead to an overestimate of the travel consumers are willing or even able to incur.

**Subject Area:** Farmers' markets; Food access; Space-time; Trip-chaining

# Neo-Traditional Town Centers and Residential Travel Behavior: Effect of Retail Composition *Sung Won Han*

**Abstract:** Neo-traditional developments are often comprised of mix-use neighborhoods with a town center that acts as the central commercial district that is easily accessible to the surrounding residents without a car. This paper investigates the reality of walking and biking in two such neo-traditional developments in Colorado. I compared frequency and purpose of non-car trips in two neighborhoods whose local town centers differ in retail composition. The first town center, Belmar, has a higher composition of comparison goods and services such as clothing, apparel, and other comparison goods. The second, East 29th Avenue Town Center, has a higher composition of convenient goods and services such as the library, dry cleaners, and dog wash store. An analysis of travel behavior surveys from fifty residents of each site reveals no significant difference in the travel behavior between residents of the two neighborhoods. While having a higher percentage of convenience goods was not shown to increase the residents' perception of driving less, my evidence suggests that only specific convenience goods, such as grocery stores and dry cleaners, increases the residents' perception of making less car trips. While the absence of significant findings may have resulted from a small sample size, and the absence of travel diaries, this research can serve as an exploratory study for further research on the relationship between retail composition and travel behavior.

**Subject Area:** mixed development; retail composition; non-motorized vehicles

# A Fair Assignment of Drivers to Parking Lots *Nicole Taheri, Jia Yuan Yu, & Robert Shorten*

**Abstract:** Searching for a parking spot can waste time and gasoline. This waste can be reduced by assigning drivers to parking lots based on their destination and arrival time. In such a system, drivers could request a parking spot in advance and be alerted (e.g., via their phone or vehicle) of their assignment to a specific parking lot or available spot. In this paper, a parking assignment system is described to allocate parking spaces in a fair and equitable manner. Heuristics are developed to solve the underlying large scale optimization problem. The efficacy of the system is demonstrated by applying our algorithms to real data sets.

**Subject Area:** parking spots assignment

**Analysis of plug-in hybrid electric vehicles' utility factors using GPS-based longitudinal travel data** *Wu, Xing, Md Aviquzzaman, and Zhenhong Lin*

**Abstract:** The benefit of using a PHEV comes from its ability to substitute gasoline with electricity in operation. Defined as the proportion of distance traveled in the electric mode, the utility factor (UF) depends mostly on the battery capacity, but also on many other factors, such as travel pattern and recharging pattern. Conventionally, the UFs are calculated based on the daily vehicle miles traveled (DVMT) by assuming motorists leave home in the morning with a full battery, and no charge occurs before returning home in the evening. Such an assumption, however, ignores the impact of the heterogeneity in both travel and charging behavior, such as going back home more than once in a day, the impact of available charging time, and the price of gasoline and electricity. Moreover, the conventional UFs are based on the National Household Travel Survey (NHTS) data, which are one-day travel data of each sample vehicle. A motorist's daily travel distance variation is ignored. This paper employs the GPS-based longitudinal travel data (covering 3–18 months) collected from 403 vehicles in the Seattle metropolitan area to investigate how such travel and charging behavior affects UFs. To do this, for each vehicle, we organized trips to a series of home and work related tours. The UFs based on the DVMT are found close to those based on home-to-home tours. On the other hand, it is seen that the workplace charge opportunities significantly increase UFs if the CD range is no more than 40 miles.

**Subject Area:** Utility factor, PHEV, Longitudinal travel data

# Households with more vehicles Travel More  *EIA Trisha Hutchins*

**Abstract:** Based on data from the National Household Travel Survey, households with more vehicles not only travel more, but often put more miles on their most-used vehicle compared to households with fewer vehicles. Households with just one vehicle drove an average of 10,600 miles per year, while households with six or more vehicles traveled a total of 57,700 miles. Sixty-eight percent of households have either one or two cars

**Subject Area:** household vehicles, VMT

**Availability:** Today in Energy: EIA April 16, 2015
http://www.eia.gov/todayinenergy/detail.cfm?id=20832

## American Driving Survey: Methodology and Year One Results, May 2013 – May 2014 *Triplett, Tim; Santos, Robert; Rosenbloom, Sandra*

**Abstract:** This report documents the methodology of the American Driving Survey (ADS) as well as the results of the first full year of data collection, which occurred between May 21, 2013 and May 31, 2014. Interviews were conducted with 3,319 drivers sampled from among 4,287 households that were initially contacted and screened. The first year data show that all drivers 16 and older drive, on average, 29.2 miles per day or 10,658 miles a year. Men reported driving more miles than women; Caucasians reported driving more miles than respondents of other races; Hispanic respondents reported driving the least. Teenagers and drivers ages 75+ also drive significantly fewer miles on average. About one-third of all drivers did not drive at all on the day about which they were interviewed. About 50% of all miles driven are in a car, and another 40% in a sports utility vehicle (SUV) or pickup truck. People drive, on average, more on weekdays and less on weekends. There is a significant mileage gap between rural and urban drivers, but the gap is smaller on the weekends than on weekdays. People drive, on average, less during the winter months and more during the summer months. To investigate the extent to which data from the ADS was similar to or different from other data from other well-accepted sources, data from the ADS was compared to data from the Federal Highway Administration's 2009 National Household Travel Survey (NHTS).

**Subject Area:** Age groups; Drivers; Gender; Methodology; Persons by race and ethnicity; Statistics; Time duration; Travel by vehicle type; Travel surveys; Trip length

**Availability:** Triplett, Tim, Robert Santos, and Sandra Rosenbloom. "American Driving Survey: Methodology and Year One Results, May 2013–May 2014." (2015).
https://www.aaafoundation.org/sites/default/files/2015AmericanDrivingSurveyRerport.pdf

**Vehicle Miles (Not) Traveled: Why Fuel Economy Requirements Don't Increase Household Driving** *Jeremy West, Mark Hoekstra, Jonathan Meer & Steven L. Puller*

**Abstract:** A major concern with addressing the negative externalities of gasoline consumption by regulating fuel economy, rather than increasing fuel taxes, is that households respond by driving more. This paper exploits a discrete threshold in the eligibility for Cash for Clunkers to show that fuel economy restrictions lead households to purchase vehicles that have lower cost-per-mile, but are also smaller and lower-performance. Whereas the former effect can increase driving, the latter effect can reduce it. Results indicate these households do not drive more, suggesting that behavioral responses do not necessarily undermine the effectiveness of fuel economy restrictions at reducing gasoline consumption.

**Subject Area:** CAFÉ; fuel economy, fuel taxes, VMT

**Measuring the impacts of weather variability on home-based trip chaining behaviour: a focus on spatial heterogeneity** *Chengxi Liu, Yusak O. Susilo, & Anders Karlström*

**Abstract:** Using the 2011 Swedish national travel survey data, this paper explores the influence of weather characteristics on individuals' home-based trip chaining complexity. A series of panel mixed ordered Probit models are estimated to examine the influence of individual/household social demographics, land use characteristics, and weather characteristics on individuals' home-based trip chaining complexity. A thermal index, the universal thermal climate index (UTCI), is used in this study instead of using directly measured weather variables in order to better approximate the effects of the thermal environment. The effects of UTCI are segmented into different seasons to account for the seasonal difference of UTCI effects. Moreover, a spatial expansion method is applied to allow the impacts of UTCI to vary across geographical locations, as individuals in different regions have different weather/climate adaptions. The effects of weather are examined in subsistence, routine, and discretionary trip chains. The results reveal that the 'ground covered with snow' condition is the most influential factor on the number of trips chained per trip chain among all other weather factors. The variation of UTCI significantly influences trip chaining complexity in autumn but not in spring and winter. The routine trip chains are found to be most elastic towards the variation of UTCI. The marginal effects of UTCI on the expected number of trips per routine trip chain have considerable spatial variations, while these spatial trends of UTCI effects are found to be not consistent over seasons

**Subject Area:** Trip chaining complexity, Weather impact, Thermal index, Spatial heterogeneity

# Sensitivity of location-sharing services data: evidence from American travel pattern *Zhenhua Chen & Laurie A. Schintler*

**Abstract:**  This paper investigates sensitivity of location-sharing services (LSS) data with a focus on understanding American daily travel pattern using three LSS datasets: Brightkite, Gowalla and Foursquare. Through a systematic data refining process, person miles of travel and daily person trip are created and compared both among themselves and with the US National Household Travel Survey (NHTS) of 2009. The results suggest that LSS data provides a better estimation of person miles of travel than daily person trip on average. In addition, the comparison with the NHTS reveals that LSS data tends to have a better reflection of daily travel behavior among metro areas with high population density.

# Concentration of Travel Demand in Space and Time *John C. Falcocchio, & Herbert S. Levinson*

**Abstract:** The concentrations of people and their activities (density) in space and in time are a natural consequence of human behavior in urban areas. If all travel demand were evenly distributed throughout the day, and among the various parts of the urban area, the urban traffic congestion problem would be greatly reduced. But travel demand patterns reflect where and when people live, work, and play. Therefore they are concentrated in space and time. It is these spatial and temporal concentrations that contribute to the urban traffic congestion problem.

# No Rest for the Weary: Commuting, Hours Worked, and Sleep *James M. Bishop*

**Abstract:** This paper is the first to combine data from large nationwide surveys to investigate how commuting and work hours affect sleep. I estimate that 11-21% of the marginal unit of time spent working and 22-30% of the marginal unit of time spent commuting replaces sleep. Controlling for these effects, commuting before 5 a.m. and after 9 a.m. each increase the likelihood of short sleep. I also find that time spent commuting and working and the prevalence of these strange commute times each contribute to unintentionally falling asleep at some time during the day, while early commuting in particular increases the likelihood of falling asleep while driving. Little of these effects are explained by reduced time spent sleeping, indicating that there are multiple biological channels through which commuting duration and timing impact road safety. None of these effects appear for non-workers as opposed to the employed, supporting the validity of the results. Overall, most of the effects are stronger for women than for men, though the prevalence of early commutes is particularly associated with less sleep among men.

**Subject Area:** Commuting; Sleep; Time Allocation; Gender

## Why Dual-Earner Households in Seoul Live Closer to the Wife's Workplace than the Husband's? *Myung-Jin Jun & Ki-Hyun Kwon*

**Abstract:** This study analyses the determinants of residential location patterns of dual-worker households in the Seoul Metropolitan area (SMA) using the 2006 Household Travel Survey (HTS) data. To achieve this we employ two statistical methods: (1) a multinomial logit (MNL) model for analysing the residential location patterns of dual-worker households given the couples' predetermined joint workplaces; and (2) standard regression models to identify the determinants of couples' spatial separation (or proximity) between their homes and workplaces. Our major findings can be summarised as follows: (1) dual-worker households in the SMA are likely to choose a residence closer to the wife's workplace than the husband's; (2) the wife's commute length and duration are significantly shorter than the husband's; (3) the wife's family serving role is the most important factor in determining a location with greater proximity between the home and the wife's workplace; and (4) commute times better depict gender differences than commute distance.

# Measuring Commuting in the American Time Use Survey *Gray Kimbrough*

**Abstract:**  The journey between work and home plays an important role in daily time use, acting as both a fixed time cost of labor force participation and as a constraint on time for other activities. Data from the American Time Use Survey (ATUS) offer the opportunity to examine commuting behavior and its relationship to demographics, labor market characteristics, and the amount of time spent on other activities. Previous analyses have been complicated by the difficulties of obtaining commuting time measures from the ATUS. Travel information can be difficult to interpret in the ATUS, and many commuting trips are likely misclassified using stock measures of work-related travel. To address this shortcoming, I review the strategies of previous researchers to reclassify travel. After surveying possible methodologies, I focus on applying to the ATUS a methodology applied to the National Household Transportation Survey (NHTS). Detailed time information in the NHTS allows me to compare both aggregate commuting measures and the timing of commuting in the two surveys. I further extend the analysis to compare to journey-to-work information in another commonly used dataset, the American Community Survey. These comparisons and the methodology provided serve to enable and validate further analysis of commuting behavior using the ATUS, leveraging the advantages of this dataset.

## Variations in Americans' Day-to-Day Travel Patterns *Prateek Bansal, Daniel J. Fagnant, & Kara Kockelman*

**Abstract:** Travel patterns vary over space (from city to city, region to region, & state to state) & over time (day to day & month to month) due to region-specific events (e.g., local rainstorms), holidays, & various other factors. In order to optimally serve demand over time & space (e.g., transit, shared autonomous vehicle fleets, roadway supply), it is very valuable to understand these variations. NHTS 2009 data allow us to quantify these variations.

**Subject Area:** VMT, Trip lengths, Occupancy

**Availability:** TRB 2015 Poster Presentation; *Variations in Americans' Day-to-Day Travel Patterns* Bansal, P.; Fagnant, D. & Kockelman, K.

# Origin-destination trips by purpose and time of day inferred from mobile phone data
Lauren Alexander, Shan Jiang, Mikel Murga, and Marta C. Gonzalez

**Abstract:** In this work, we present methods to estimate average daily origin-destination trips from triangulated mobile phone records of millions of anonymized users. These records are first converted into clustered locations at which users engage in activities for an observed duration. These locations are inferred to be home, work, or other depending on observation frequency, day of week, and time of day, and represent a user's origins and destinations. Since the arrival time and duration at these locations reflect the observed (based on phone usage) rather than true arrival time and duration of a user, we probabilistically infer departure time using survey data on trips in major US cities. Trips are then constructed for each user between two consecutive observations in a day. These trips are multiplied by expansion factors based on the population of a user's home Census Tract and divided by the number of days on which we observed the user, distilling average daily trips. Aggregating individuals' daily trips by Census Tract pair, hour of the day, and trip purpose results in trip matrices that form the basis for much of the analysis and model-ing that inform transportation planning and investments. The applicability of the proposed methodology is supported by validation against the temporal and spatial distributions of trips reported in local and national surveys.

**Subject Area:** Mobile phone data, data mining, human mobility, trip production and attraction, trip distribution, travel surveys.

**Availability:** Alexander, Lauren, et al. "Origin-destination trips by purpose and time of day inferred from mobile phone data." http://humnetlab.mit.edu/wordpress/wp-content/uploads/2010/10/TRC_RevisedDraft_Jan2015.pdf

## Determinants of Per Capita Vehicle Miles Traveled (VMT): The Case of California *Mintesnot Woldeamanuel and Andrew Kent*

**Abstract:** This study uses multivariate regression to isolate determinants of per capita VMT in California from the National Household Travel Survey (NHTS), as well as a Chow Test to identify structural change between the 2001 and 2009 NHTS. Results across the 2001 and 2009 NHTS data sets indicate certain determinant variables have emerged over time and others have changed in strength of impact. Our findings support mixed methods VMT reduction strategies to achieve near- and long term GHG targets. This research intends to derive a comprehensive understanding of California specific per capita VMT determinants by isolating significant VMT variables from the National Household Travel Survey for the years 2001 and 2009. Comparing significant variables between both years will grant an understanding of how determinants have changed or remained constant. Through the analysis we will also determine what kinds of variables have the greatest relative impacts on annual per capita VMT in California. Our primary research questions include: (1) what are per capita VMT determinants in California? (2) how do per capita VMT determinants rank relatively? (3) how have per capita VMT determinants changed over the past decade? Through answering these questions, we hope to recommend which per capita VMT determinants the State of California and local MPOs should concentrate on to best reduce per capita VMT and achieve California's ambitious greenhouse gas reduction targets.

**Subject Area:** VMT determinants; GHG targets

## The Gender Gap in Non-Work Travel: The Relative Roles of Income Earning Potential and Land Use *Marlon G. Boarnet, & Hsin-Ping Hsu*

**Abstract:** We empirically test two hypotheses: (1) that gender differences in income earning potential play a role in the within-household division of non-work travel and (2) that compact land use development can reduce the within-household gender gap in non-work travel. Using the 2001 Southern California Household Travel Survey, we find that non-work travel patterns for men and women do not vary much by gender unless children are in the household. Households with children display a striking difference in chauffeuring trips and women bear most of the chauffeuring burden. Adjusting for sociodemographics, women in households with children take over 300% more chauffeuring trips than do men living alone. The difference in chauffeuring trips among females and males within the household, the "within-household, female-male chauffeuring gap", is larger for households with employed males and smaller in households with employed females. The chauffeuring gap is smaller when the woman's earning power is larger compared to the man in the same household. The chauffeuring gap is larger for households that have higher amounts of single family residential land use in the quarter-mile area around their residence, and the chauffeuring gap is larger for households that live farther than a half mile from the nearest bus stop. The magnitude of the effect of those two land use variables on the chauffeuring gap is similar to the magnitude of variables that measure within-household differences in income-earning potential or female and male employment status, suggesting that more dense land use and better transit service can help reduce disproportionate chauffeuring burdens of women.

**Subject Area:** Gender; Non-Work Travel; Chauffeuring; Income Earning Potential; Land Use

# 11. Trend Analysis and Market Segmentation

**Spatial Modeling of Electric Vehicle Ownership across Texas and A Simulation-based Framework to Predict Americans' Adoption of Autonomous Vehicle Technologies** *Prateek Bansal & Kara M. Kockelman*

**Abstract:** This thesis is divided into four parts. The first part investigates the impact of built-environment and demographic attributes on adoption rates of hybrid electric vehicles and more fuel-efficient vehicles. To allow for spatial autocorrelation (across census tracts) in unobserved components of tract-level vehicle counts, as well as cross-response correlation (both spatial and aspatial), vehicle counts by vehicle type and fuel economy levels were estimated using bivariate and trivariate Poisson-lognormal conditional autoregressive models. Fuel-efficient-vehicle ownership rates were found to rise with household income, resident's education levels, and the share of male residents, and fall in the presence of larger household sizes and higher job densities.

In the second part, a fleet evolution framework was designed to simulate Americans' long-term (year 2015 to 2045) adoption of connected and autonomous vehicle (CAV) technologies under eight different scenarios based on 5% and 10% annual drops in technology prices; 0%, 5%, and 10% annual increments in Americans' willingness to pay (WTP) for such technologies; and U.S. (federal) regulations regarding technology adoption. A survey was designed and disseminated to obtain 2,167 Americans' behavioral data and preferences; and those data were used for the various simulations. The survey results indicate that Americans' average WTP to add connectivity and Level 3 and Level 4 automation are $67, $2,438, and $5,857, respectively. The simulation results predict that 24.8% (assuming 5% annual drop in technology prices and constant WTP) to 87.2% (assuming 10% annual drop in technology prices and 10% annual rise in WTP) of the Americans' privately owned vehicles will be fully automated by 2045.

The final two parts of this multi-part thesis summarizes findings of two separate surveys, polling 1,088 Texans and 347 Austinites, respectively, to understand their opinions on CAV technologies and strategies. Ordered probit, interval regression, and other econometric models of human behavior were estimated to understand the impact of demographics, built environment features, and other attributes on Austinites' and Texans' WTP to add CAV technologies to their vehicles, as well as the adoption rates of shared AVs (SAVs) under different pricing scenarios, adoption-timing's dependence on friends' adoption rates, and home-location decisions after AVs and SAVs become common modes of transport. The Texas study's results indicate that those who support speed regulation strategies and have higher household income are estimated to pay more, on average, for all CAV technologies, but older and more experienced licensed drivers tend to place lower value on these technologies, everything else constant. The Austin study's results indicate that higher-income technology-savvy males, living in urban areas and those who have experienced more crashes, have a higher WTP for the new technologies. Moreover, Texans and Austinites share many common

perceptions and expect fewer crashes to be the primary benefit of AVs, with equipment failures being their top concern.

**Subject Area:** EV; Electric vehicle; CAV; connected and autonomous vehicles

**Availability:** Bansal, Prateek. Spatial modeling of electric vehicle ownership across Texas and a simulation-based framework to predict Americans' adoption of autonomous vehicle technologies. Diss. 2015. https://utexas-ir.tdl.org/handle/2152/31797

# Generalized Extreme Value models for count data: Application to worker telecommuting frequency choices *Rajesh Paleti*

**Abstract:** Count models are used for analyzing outcomes that can only take non-negative integer values with or without any pre-specified large upper limit. However, count models are typically considered to be different from random utility models such as the multinomial logit (MNL) model. In this paper, Generalized Extreme Value (GEV) models that are consistent with the Random Utility Maximization (RUM) framework and that subsume standard count models including Poisson, Geometric, Negative Binomial, Binomial, and Logarithmic models as special cases were developed. The ability of the Maximum Likelihood (ML) inference approach to retrieve the parameters of the resulting GEV count models was examined using synthetic data. The simulation results indicate that the ML estimation technique performs quite well in terms of recovering the true parameters of the proposed GEV count models. Also, the models developed were used to analyze the monthly telecommuting frequency decisions of workers. Overall, the empirical results demonstrate superior data fit and better predictive performance of the GEV models compared to standard count models.

**Monitoring travel behaviour in England A 50-year journey** *Delphine Robineau &*
*Matthew Tranter*

**Abstract:**  Longitudinal modelling of vehicle ownership is limited in the literature of ownership
models. Temporal variation of households' long-term vehicle ownership decisions can be
modelled by considering longitudinal information of the households. Utilizing households'
longitudinal vehicle history information, this thesis develops ownership state models, where
durations of the households' no-car ownership state and subsequent transient ownership
states are evaluated. Moreover, this thesis examines the vehicle type choice behaviour of a
household purchasing its first vehicle (i.e. first-time vehicle owner) by terminating the no-car
ownership state, and vehicle type choice behaviour of the transient vehicle owner households
at repeated vehicle ownership events. One of the unique features of this research is that it
examines the effects of life-cycle events on the vehicle ownership decisions. Finally, this
research evaluates future vehicle type choice behaviour using a comprehensive set of
alternative fuel vehicles by anticipating a future policy scenario of hypothetical gas price
increase.

**Subject Area:** Vehicle ownership models; gas price changes

**Availability:** Khan, Nazmul Arefin. "Longitudinal Modelling of Households' Vehicle Transaction
and Type Choice Decisions." (2015).
http://dalspace.library.dal.ca/bitstream/handle/10222/64670/Khan-Nazmul%20Arefin-MASc-
CIVL-December-2015.pdf?sequence=1&isAllowed=y

**Monitoring travel behaviour in England A 50-year journey** *Delphine Robineau & Matthew Tranter*

**Abstract:**  In 1965, Britain became the first country in the world to collect data on national patterns of travel behaviour through its National Travel Survey. As the survey reaches its 50th anniversary, it remains a key source of data on how and why we travel. Delphine Robineau and Matthew Tranter explore the trends

**Subject Area:** England Travel trends

# Accelerating the Global Adoption of Electric Vehicles: Barriers and Drivers

*Ghazale Haddadian, Mohammad Khodayar, & Mohammad Shahidehpour*

**Abstract:** For EVs to achieve a large-scale market presence, the regulatory framework needs to be designed in a way that incorporates both push and pull factors within its incentive schemes. These incentives can be aimed at dwindling the total cost of ownership compared to conventional vehicles, overcoming obstacles to EV usage and offering EV buyers benefits that offset EV liabilities, thus alleviating the risks of buying and using EVs early in their developmental stage.

**Subject Area:** electric vehicles; incentive schemes

## A Frequency Model of Home-Based Telecommuting: A Case Study of Washington-Baltimore Metropolitan Area *Taehyeong Kim*

**Abstract:** This study focused on research for a better understanding of home-based telecommuting behavior by analyzing factors affecting the individual frequency to home-based telecommuting in Washington-Baltimore Metropolitan Area. With an extensive review of literature, this study expands the existing body of home-based telecommuting research by using data from the 2009 National Household Travel Survey (NHTS) to consider a larger sample and to include characteristics unavailable in previous analysis. As factors that can affect the individual's frequency of home-based telecommuting, personal characteristics, household characteristics, accessibility to the workplace, and job-related characteristics are considered. Also, the frequency of home-based telecommuting is modeled as an ordered logit model. Regression result suggests that driver, number of drivers in household, number of workers in household, number of vehicles in household, annual household income-more than $75,000, one-way distance from home to work and full-time worker are significant determinants of telecommuting frequency in Washington-Baltimore Metropolitan Area.

**Travel Time Use Over Five Decades** *Chen Song & Chao Wei*

**Abstract:** In this paper, we use five decades of time use surveys, including the annual American Time Use Survey between 2003 and 2013, to document travel time uses in the aggregate and across demographic groups. We nd that total travel time features an inverted-U shape over time, registering a 20 percent increase from 1975 to 1993, but an 18 percent decline from 1993 to 2013. We find that demographic shifts explain around 45 percent of the increase in total travel time from 1975 to 1993. Increases in educational attainment alone contribute to around 28 percent of the increase. Demographic shifts play a much smaller role in the evolution of total travel time afterwards. From 2003 to 2013 the shift of time allocation from travel-intensive non-market work to travel-non-intensive leisure accounts for around 50 percent of the decline in total travel time.

# Sedentary Work-A Risk Factor for Diabetes with a Positive Family History *Jinu Merlin Koshy, W M S Johnson, & B Sathya Priya*

**Abstract:** The phrase "sedentary behaviour" comes from the Latin word "sedere" which means "to sit". Obesity and sedentary lifestyles are escalating national and global epidemics that warrant increased attention by physicians and other health care professionals. These intricately linked conditions are responsible for an enormous burden of chronic disease, impaired physical function and quality of life. Persons having sedentary work and lifestyle will be prone to type II diabetes. Sedentary work, which accelerates risk of diabetes, is least explored in the Indian population.

# Assessing the Impact of Real-time Ridesharing on Urban Traffic using Mobile Phone Data *Lauren P. Alexander & Marta C. González*

**Abstract:** Recently, smart-phone based technology has enabled ridesharing services to match customers making similar trips in real-time for a reduced rate and minimal inconvenience. But what are the impacts of such services on city-wide congestion? The answer lies in whether or not ridesharing adds to vehicle traffic by diverting non-driving trips like walking, transit, or cycling, or reduces vehicle traffic by diverting trips otherwise made in private, single occupancy cars or taxis. This research explores the impact of rideshare adoption on congestion using mobile phone data. We extract average daily origin-destination (OD) trips from mobile phone records and estimate the proportions of these trips made by auto and other non-auto travelers. Next, we match spatially and temporally similar trips, and assume a range of adoption rates for auto and non-auto users, in order to distill rideshare vehicle trips. Finally, for several adoption scenarios, we evaluate the impacts of congestion network-wide.

# Deliveries to residential units: A rising form of freight transportation in the U.S. *Xiaokun (Cara) Wang & Yiwei Zhou*

**Abstract:** As a result of the rapid growth of online shopping, more goods and services are delivered directly to residential units. The door-to-door deliveries improve residents' accessibility to retail sector, and at the same time create truck delivery trips. However, partially due to the data limitation, most existing freight research focuses on freight trips generated by business establishments. Little is known about freight trips generated by residential units. As a growing number of urban areas are pushing for dense and mixed development, it is necessary to understand the pattern of truck freight trips directly generated by residential units. This paper uses the U.S. National Household Travel Survey (NHTS) data to investigate the freight trips generated by residential units. The 2009 NHTS provides accurate, comprehensive and timely information on trips, land use, household characteristics and social economic factors. It is the first time that the NHTS data is used to estimate freight trips. A binary choice model and a right-censored negative binomial model are used to identify the impacts of person-related, household-related, and regional-specific variables on home delivery frequency. A case study for the New York State Capital District is then presented. The estimated freight trips generated by residential units are also compared to the freight trips generated by business establishments. Results, although still preliminary and subject to uncertainty, indicate that freight trips generated by residential units have comparable magnitude as the freight trips generated by businesses. Such a study will supplement city logistics studies that traditionally focus on business behavior, helping reconstruct a complete picture of the freight activities in urban areas.

**Subject Area**: Freight delivery; Online shopping; Residential units; NHTS

## Operations Of A Shared, Autonomous, Electric Vehicle Fleet: 2 Implications Of Vehicle & Charging Infrastructure Decisions *T. Donna Chen, Kara M. Kockelman, & Josiah P. Hanna*

**Abstract:** The nexus of autonomous vehicle (AV) and electric vehicle (EV) technologies has important potential impacts on our transportation systems, particularly in the case of shared-use vehicles. There are natural synergies between shared AV fleets and EV technology, since fleets of AVs resolve the practical limitations of today's non-autonomous EVs, including traveler range anxiety, access to charging infrastructure, and charging time management. Fleet-managed AVs relieve such concerns, managing range and charging activities based on real-time trip demand and established charging-station locations, as demonstrated in this paper. This work explores the management of a fleet of shared autonomous (battery-only) electric vehicles (SAEVs) in a regional discrete-time, agent-based model. The simulation examines the operation of SAEVs under various vehicle range and charging infrastructure scenarios in a gridded city modeled roughly after the densities of Austin, Texas. Results indicate that fleet size is sensitive to battery recharge time and vehicle range, with each 80-mile range SAEV replacing 3.7 privately owned vehicles and each 200-mile range SAEV replacing 5.5 privately owned vehicles, under Level II (240-volt AC) charging. With Level III 480-volt DC fast-charging infrastructure in place, these ratios rise to 5.4 vehicles for the 80-mile range SAEV and 6.8 vehicles for the 200-mile range SAEV. SAEVs can serve 96 to 98% of trip requests with average wait times between 7 and 10 minutes per trip. However, due to the need to travel while —empty for charging and passenger pick-up, SAEV fleets are predicted to generate an additional 7.1 to 14.0% of travel miles. Financial analysis suggests that the combined cost of charging infrastructure, vehicle capital and maintenance, electricity, insurance, and registration for a fleet of SAEVs ranges from $0.42 to $0.49 per occupied mile traveled, which implies SAEV service can be offered at the equivalent per-mile cost of private vehicle ownership for low mileage households, and thus be competitive with current manually-driven carsharing services and significantly cheaper than on-demand driver-operated transportation services. The availability of inductive (wireless) charging infrastructure allows SAEVs to be price-competitive with non-electric SAVs (when gasoline prices are between $2.18 and $3.50 per gallon). However, charging SAEVs at attendant-operated stations with traditional corded chargers incurs an additional $0.08 per mile compared to wireless charging, and as such would only be price competitive with SAVs when gasoline reaches $4.35 to $5.70 per gallon.

**Subject Area**: Agent-based modeling, carsharing, electric vehicles, autonomous vehicles

## Essays on Energy Efficiency and Pricing Behavior in the U.S. Automobile Market: Evidence from Hybrid Electric Vehicles  *Sangsoo Park*

**Abstract:** This dissertation consists of three essays on the energy efficiency and pricing behavior of firms in the U.S. automobile market with a focus on Hybrid Electric Vehicles (HEVs). The first essay analyzes the market share of HEVs and evaluates consumers' willingness to pay (WTP) for future fuel cost savings by purchasing fuel efficient HEVs. Estimates of consumers' WTP for future fuel cost savings and the finding of an implicit discount rate of 8.35%14.35% suggest that consumers undervalue future fuel cost savings from purchasing HEVs, and that consumers want a return on their investment on fuel cost saving HEV technology in 711 years. The second essay empirically investigates the existence of quality-based price discrimination in the U.S. automobile market. By estimating a structural model of demand and supply in the automobile market, I can recover marginal costs, markups and percentage markups for all vehicle models sold between 2000 and 2013. The extent of price discrimination is then examined by comparing markup and percentage markup differences between HEVs and gasoline vehicles. The results demonstrate that automobile manufactures charge both higher markups and higher percentage markups on their HEV models. On average, HEVs have higher markups by 11.1% compared to gasoline vehicles, and Toyota, a leader in the HEV market, charges higher markups on their HEV models compared to other manufacturers. The Toyota Prius, the top-selling hybrid car in the U.S. market, particularly enjoys a higher markup and percentage markup than other competitive vehicles.

**Subject Area**: energy efficiency, HEV, fuel cost, price discrimination, demand supply

# The Introduction of a Supermarket via Tax-Credits in a Low-Income Area: The Influence on Purchasing and Consumption

*Brian Elbel, PhD, MPH; Tod Mijanovich, PhD; Kamila Kiszko, MPH; Courtney Abrams, MA; Jonathan Cantor, MS; L. Beth Dixon, PhD, MPH*

**Abstract:**  Purpose.  Interest and funding continue to grow for bringing supermarkets to underserved areas, yet little is known about their impact.

Design.  A quasi-experimental study was used to determine the impact of a new supermarket opening as a result of tax and zoning incentives.

Setting.  The study took place in the South Bronx, New York City, New York.

Subjects:  Studied were residents of two South Bronx neighborhoods deemed high need.

Measures.  Food purchasing and consumption were examined via surveys and 24-hour dietary recalls before and at two points after the supermarket opened (1–5, 13–17 months).

Analysis.  Data were analyzed using difference-in-difference models controlling for gender, race and ethnicity, age, education, marital status, and self-reported income. Ordinary least squares and logistic regression models were estimated for continuous and binary outcomes, respectively.

Results.  At baseline, 94% to 97% of consumers shopped at a supermarket. There was a 2% increase in this behavior in the intervention community ($p < .05$) not seen in the comparison community. One year later there was a 7% net increase in eating at home ($p < .1$) and a 20% decrease in drinking sugary beverages ($p < .05$), but no appreciable change in fruit/vegetable consumption or overall dietary quality.

Conclusion.  The new supermarket did not result in substantial or broad changes in purchasing patterns or nutritional quality of food consumed, though smaller, positive changes were observed over a 1-year period. Future work should examine different contexts and a broader set of outcomes, including economic development.

**The Development of a Method to Assess the Effects of Traffic Situation and Time Pressure on Driver Information Preferences** *Eriksson, Alexander, Ignacio Solis Marcos, Katja Kircher, Daniel Västfjäll, and Neville A. Stanton*

**Abstract:** Contemporary Driving Automation (DA) is quickly approaching a level where partial autonomy will be available, relying on transferring control back to the driver when the operational limits of DA is reached. To explore what type of information drivers might prefer in control transitions an online test was constructed. The participants are faced with a set of still pictures of traffic situations of varying complexity levels and with different time constraints as situations and time available is likely to vary in real world scenarios. The choices drivers made were then assessed with regards to the contextual and temporal information available to participants. The results indicate that information preferences are dependent both on the complexity of the situation presented as well as the temporal constraints. The results also show that the different temporal and contextual conditions had an effect on decision-making time, where participants orient themselves quicker in the low complexity situations or when the available time is restricted. Furthermore, the method seem to identify changes in behaviour caused by varying the traffic situation and external time pressure. If the results can be validated against a more realistic setting, this particular method may prove to be a cost effective, easily disseminated tool which has potential to gather valuable insights about what information drivers prioritize when confronted with different situations

**Subject Area**: Adaptation to task demands, Driving automation, Online survey, & Decision making

**Long-term trends in domestic US passenger travel: the past 110 years and the next 90** *Schäfer, Andreas W.*

**Abstract:** Based upon a long-term historical data set of US passenger travel, a model is estimated to project aggregate transportation trends through 2100. One of the two model components projects total mobility (passenger-km traveled) per capita based on per person GDP and the expected utility of travel mode choices (logsum). The second model component has the functional form of a logit model, which assigns the projected travel demand to competing transportation modes. An iterative procedure ensures the average amount of travel time per person to remain at a pre-specified level through modifying the estimated value of time. The outputs from this model can be used as a first-order estimate of a future benchmark against which the effectiveness of various transportation policy measures or the impact of autonomous behavioral change can be assessed.

**Subject Area**: Passenger travel; Time series model; Mode choice; Travel time budget; Peak car; Scenario

**Management of a Shared, Autonomous, Electric Vehicle Fleet: Vehicle Choice, Charging Infrastructure & Pricing Strategies** *Chen, D. and Kockelman, K.M.*

**Abstract:** This study focused on research for a better understanding of home-based telecommuting behavior by analyzing factors affecting the individual frequency to home-based telecommuting in Washington-Baltimore Metropolitan Area. With an extensive review of literature, this study expands the existing body of home-based telecommuting research by using data from the 2009 National Household Travel Survey (NHTS) to consider a larger sample and to include characteristics unavailable in previous analysis. As factors that can affect the individual's frequency of home-based telecommuting, personal characteristics, household characteristics, accessibility to the workplace, and job-related characteristics are considered. Also, the frequency of home-based telecommuting is modeled as an ordered logit model. Regression result suggests that driver, number of drivers in household, number of workers in household, number of vehicles in household, annual household income-more than $75,000, one-way distance from home to work and full-time worker are significant determinants of telecommuting frequency in Washington-Baltimore Metropolitan Area.

**Subject Area:** Telecommuting, Frequency, Ordered logit model, Washington-Baltimore, NHTS

# Towards Context-Aware Mobile Crowdsensing in Vehicular Social Networks

*Xiping Hu & Leung, V.C.M.*

**Abstract:** Driving is an integral part of our everyday lives, and the average driving time of people globally is increasing to 84 minutes every day, which is a time when people are uniquely vulnerable. A number of research works have identified that mobile crowd sensing in vehicular social networks (VSNs) can be effectively used for many purposes and bring huge economic benefits, e.g., safety improvement and traffic management. This paper presents our effort that toward context-aware mobile crowd sensing in VSNs. First, we introduce a novel application-oriented service collaboration (ASCM) model which can automatically match multiple users with multiple mobile crowd sensing tasks in VSNs in an efficient manner. After that, for users' dynamic contexts of VSNs, we proposes a context information management model, that aims to enable the mobile crowd sensing applications to autonomously match appropriate service and information with different users (requesters and participants) in crowdsensing.

**Subject Area**: context-aware; mobile crowdsensing; vehicular social networks

# Close-Ups And The Scale Of Ecology: Land Uses And The Geography Of Social Context And Crime *Adam Boessen and John Hipp*

**Abstract:** Whereas one line of recent neighborhood research has placed an emphasis on zooming into smaller units of analysis such as street blocks, another line of research has suggested that even the meso-area of neighborhoods is too narrow and that the area surrounding the neighborhood is also important. Thus, there is a need to examine the scale at which the social ecology impacts crime. We use data from seven cities from around the year 2000 to test our research questions using multilevel negative binomial regression models (N = 73,010 blocks and 8,231 block groups). Our results suggest that although many neighborhood factors seem to operate on the microscale of blocks, others seem to have a much broader impact. In addition, we find that racially and ethnically homogenous blocks within heterogeneous block groups have the most crime. Our findings also show the strongest results for a multitude of land-use measures and that these measures sharpen some of the associations from social characteristics. Thus, we find that accounting for multiple scales simultaneously is important in ecological studies of crime.

**Subject Area**: neighborhoods; crime; aggregation; spatial effects

**Exploring the impact of shared autonomous vehicles on urban parking demand: An agent-based simulation approach** *Zhang, Wenwen, Subhrajit Guhathakurta, Jinqi Fang, and Ge Zhang*

**Abstract:** Although recent studies of Shared Autonomous Vehicles (SAVs) have explored the economic costs and environmental impacts of this technology, little is known about how SAVs can change urban forms, especially by reducing the demand for parking. This study estimates the potential impact of SAV system on urban parking demand under different system operation scenarios with the help of an agent-based simulation model. The simulation results indicate that we may be able to eliminate up to 90% of parking demand for clients who adopt the system, at a low market penetration rate of 2%. The results also suggest that different SAV operation strategies and client's preferences may lead to different spatial distribution of urban parking demand.

# Electric vehicles in multi-vehicle households *Michael A. Tamor & Miloš Milačić*

**Abstract:** The suitability of an electric vehicle of a given range to serve in place of a given conventional vehicle is not limited by the daily travel over distances within that that range, but rather by the occasional inconvenience of finding alternative transport for longer trips. While the frequency of this inconvenience can be computed from usage data, the willingness of individual users to accept that replacement depends on details of available transportation alternatives and their willingness to use them. The latter can be difficult to assess. Fortunately, 65% of US households have access to the most convenient alternative possible: a second car. In this paper we describe an analysis of prospective EV acceptance and travel electrification in two-car households in the Puget Sound region. We find that EVs with 60 miles of useful range could be acceptable (i.e. incur inconvenience no more than three days each year) to nearly 90% of two-car households and electrify nearly 55% of travel in those households (32% of all travel). This compares to 120 miles range required to achieve the same fraction of electrified travel via one-for-one replacement of individual vehicles. Even though only one third of personal vehicles in the US may be replaced in this paradigm, the 'EV as a second-car' concept is attractive in that a significant fraction of travel can be electrified by vehicles with modest electric range and virtually no dependence on public charging infrastructure.

# Young people are driving less than their parents. But why? *Joseph Stromberg*

**Abstract:** Recently, there has been a big change in US transportation: young people are driving fewer miles than their parents. For most of modern US history, Americans steadily drove more and more miles every year, particularly as suburbs expanded. But then, around 2007, driving went into decline, with young people driving significantly less.

**Subject Area**: millennials, VMT

**Availability:** Stromberg, J. "Young People are Driving Less than their Parents. But Why?" www.vox.com http://www.vox.com/2015/5/1/8524147/driving-young-people-millennials

## Driverless, Electric Taxis Could Reduce Emissions By 94% *Charlie Sorrel*

**Abstract:** Jeffery Greenblatt and Samveg Saxena from Lawrence Berkeley National Laboratory reported the financial and environmental benefits of autonomous taxis in the July 6, 2105, edition of the journal Nature Climate Change. A new study from Lawrence Berkeley National Laboratory would find that robot cars, powered from a central grid, could reduce taxi emissions by 94% compared to today's gas-powered, human-steered cabs.

**Subject Area**: autonomous taxi; hybrid

**Autonomous taxis could greatly reduce greenhouse-gas emissions of US light-duty vehicles** *Jeffery B. Greenblatt & Samveg Saxena*

**Abstract:** Autonomous vehicles (AVs) are conveyances to move passengers or freight without human intervention. AVs are potentially disruptive both technologically and socially, with claimed benefits including increased safety, road utilization, driver productivity and energy savings. Here we estimate 2014 and 2030 greenhouse-gas (GHG) emissions and costs of autonomous taxis (ATs), a class of fully autonomous shared AVs likely to gain rapid early market share, through three synergistic effects: (1) future decreases in electricity GHG emissions intensity, (2) smaller vehicle sizes resulting from trip-specific AT deployment, and (3) higher annual vehicle-miles travelled (VMT), increasing high-efficiency (especially battery-electric) vehicle cost-effectiveness. Combined, these factors could result in decreased US per-mile GHG emissions in 2030 per AT deployed of 87–94% below current conventionally driven vehicles (CDVs), and 63–82% below projected 2030 hybrid vehicles, without including other energy-saving benefits of AVs. With these substantial GHG savings, ATs could enable GHG reductions even if total VMT, average speed and vehicle size increased substantially. Oil consumption would also be reduced by nearly 100%.

# Berkeley Lab study predicts autonomous taxis by 2030 *Paul Hamaker*

**Abstract:** Jeffery Greenblatt and Samveg Saxena from Lawrence Berkeley National Laboratory reported the financial and environmental benefits of autonomous taxis in the July 6, 2105, edition of the journal Nature Climate Change. The researchers found that autonomous taxis presented several benefits that rivaled human driven taxis. The additional cost of an autonomous vehicle can be justified by the savings that autonomous cars can deliver.

**Subject Area**: autonomous taxi; hybrid

**Even As Batteries Age, Electric Cars Meet Commuter Needs: Study** *Bengt Halvorson*

**Abstract:** In the first study of its kind, scientists at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) quantitatively show that electric vehicles (EVs) will meet the daily travel needs of drivers longer than commonly assumed. Many drivers and much prior literature on the retirement of EV batteries have assumed that EV batteries will be retired after the battery has lost 20 percent of its energy storage or power delivery capability. This study shows that the daily travel needs of drivers continue to be met well beyond these levels of battery degradation. Samveg Saxena, who leads a vehicle powertrain research program at Berkeley Lab, analysed real-world driving patterns and found that batteries that have lost 20 per cent of their originally rated energy storage capacity can still meet the daily travel needs of more than 85 per cent of US drivers.

**Subject Area**: daily travel; electric vehicle; energy storage

# Aging Electric-Car Batteries Can Still Offer Useful Range: Report *Stephen Edelstein*

**Abstract:** In the first study of its kind, scientists at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) quantitatively show that electric vehicles (EVs) will meet the daily travel needs of drivers longer than commonly assumed. Many drivers and much prior literature on the retirement of EV batteries have assumed that EV batteries will be retired after the battery has lost 20 percent of its energy storage or power delivery capability. This study shows that the daily travel needs of drivers continue to be met well beyond these levels of battery degradation. Samveg Saxena, who leads a vehicle powertrain research program at Berkeley Lab, analysed real-world driving patterns and found that batteries that have lost 20 per cent of their originally rated energy storage capacity can still meet the daily travel needs of more than 85 per cent of US drivers.

**Subject Area**: daily travel; electric vehicle; energy storage

**Availability:** www.greencarreports.com *Aging Electric-Car Batteries Can Still Offer Useful Range: Report* April 9, 2015 DOE/Lawrence Berkeley National Laboratory."
http://www.greencarreports.com/news/1097701_aging-electric-car-batteries-can-still-offer-useful-range-report

# Electric Vehicles Can Last Longer, Says LBNL Scientist *indiawest.com*

**Abstract:** Putting speculation to rest, scientists at Lawrence Berkeley National Lab led by Indian American Samveg Saxena have quantitatively showed that electric vehicles can meet the daily travel needs of drivers longer than commonly assumed. The new study shows that the daily travel needs of drivers continue to be met well beyond these levels of battery degradation.

**Subject Area**: daily travel; electric vehicle; energy storage

**Availability:** www.indiawest.com *Electric Vehicles Can Last Longer, Says LBNL Scientist*  May 13, 2015 DOE/Lawrence Berkeley National Laboratory."
http://www.indiawest.com/news/global_indian/electric-vehicles-can-last-longer-says-lbnl-scientist/article_f196748e-f99e-11e4-b52c-132160f4dc87.html

# Is Range Anxiety Really That Big A Problem For EV Owners? *George Zack*

**Abstract:** Many drivers and much prior literature on the retirement of EV batteries have assumed that EV batteries will be retired after the battery has lost 20 percent of its energy storage or power delivery capability. However, research recently published in the journal of Power Sources - co-authored by researchers from the University of California at Berkeley and from the Lawrence Berkeley National Laboratory - suggests that range anxiety is overstated. Electric vehicles can still meet the daily needs of their owners, even after losing significant charge through degradation, say researchers at the US Department of Energy's Lawrence Berkeley National Laboratory. This study shows that the daily travel needs of drivers continue to be met well beyond these levels of battery degradation. Samveg Saxena, who leads a vehicle powertrain research program at Berkeley Lab, analysed real-world driving patterns and found that batteries that have lost 20 per cent of their originally rated energy storage capacity can still meet the daily travel needs of more than 85 per cent of US drivers.

**Subject Area**: daily travel; electric vehicle; energy storage

# Electric car battery degradation not as serious as feared *Ecomento.com*

**Abstract:** In the first study of its kind, scientists at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) quantitatively show that electric vehicles (EVs) will meet the daily travel needs of drivers longer than commonly assumed. Many drivers and much prior literature on the retirement of EV batteries have assumed that EV batteries will be retired after the battery has lost 20 percent of its energy storage or power delivery capability. This study shows that the daily travel needs of drivers continue to be met well beyond these levels of battery degradation. Samveg Saxena, who leads a vehicle powertrain research program at Berkeley Lab, analysed real-world driving patterns and found that batteries that have lost 20 per cent of their originally rated energy storage capacity can still meet the daily travel needs of more than 85 per cent of US drivers.

**Subject Area**: daily travel; electric vehicle; energy storage

**Electric cars more useful than thought: Study** *The Economic Times (India times)*

**Abstract:** In the first study of its kind, scientists at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) quantitatively show that electric vehicles (EVs) will meet the daily travel needs of drivers longer than commonly assumed. Many drivers and much prior literature on the retirement of EV batteries have assumed that EV batteries will be retired after the battery has lost 20 percent of its energy storage or power delivery capability. This study shows that the daily travel needs of drivers continue to be met well beyond these levels of battery degradation. Samveg Saxena, who leads a vehicle powertrain research program at Berkeley Lab, analysed real-world driving patterns and found that batteries that have lost 20 per cent of their originally rated energy storage capacity can still meet the daily travel needs of more than 85 per cent of US drivers.

**Subject Area**: daily travel; electric vehicle; energy storage

## Goodbye, range anxiety? Electric vehicles may be more useful than previously thought *DOE/Lawrence Berkeley National Laboratory*

**Abstract:** In the first study of its kind, scientists at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) quantitatively show that electric vehicles (EVs) will meet the daily travel needs of drivers longer than commonly assumed. Many drivers and much prior literature on the retirement of EV batteries have assumed that EV batteries will be retired after the battery has lost 20 percent of its energy storage or power delivery capability. This study shows that the daily travel needs of drivers continue to be met well beyond these levels of battery degradation.

**Subject Area**: daily travel; electric vehicle; energy storage

**Electric vehicles more useful: Indian American scientist** *zeenews.india.com*

**Abstract:** New York: Putting speculation to rest, scientists at the Berkeley Lab led by an Indian American have quantitatively showed that electric vehicles (EVs) can meet the daily travel needs of drivers longer than commonly assumed.

**Subject Area**: daily travel; electric vehicle; energy storage

**Availability:** zeenew.india.com *Electric vehicles more useful: Indian American scientist*  March 31, 2015 DOE/Lawrence Berkeley National Laboratory. http://zeenews.india.com/news/sci-tech/electric-vehicles-more-useful-indian-american-scientist_1570770.html

## More Miles, Less Cars *Andrea Wells*

**Abstract:**  Autonomous vehicles may reduce the number of vehicles a family needs, but may lead to an increase in total miles driven, say researchers at the University of Michigan Transportation Research Institute.

**Subject Area:** Technology Michigan Tesla Vehicle Technology Google Autonomous Vehicle

**Driverless Cars Impact: Fewer Cars, More Miles** *Claims Journal*

**Abstract:** Autonomous vehicles may reduce the number of vehicles a family needs, but may lead to an increase in total miles driven, say researchers at the University of Michigan Transportation Research Institute.

**Subject Area:** Technology Michigan Tesla Vehicle Technology Google Autonomous Vehicle

**Availability:** claimsjournal.com *Driverless Cars Impact: Fewer Cars, More Miles* March 26, 2015. http://www.claimsjournal.com/news/national/2015/03/26/262522.htm

# Driverless cars waste more energy! *Adel Murad*

**Abstract:** A world moving toward driverless cars is a world consuming more energy, according to several academic studies from the University of Michigan and other institutes. There are positive sides to using autonomous cars but the net result is more millage and that means more energy. This trend could reverse recent momentum of declining fuel consumption.

**Subject Area:** Technology Michigan Tesla Vehicle Technology Google Autonomous Vehicle

# Robot-driven cars may rack up more miles *Lloyd Alter*

**Abstract:** Whether you love the idea or hate it, the self-driving car is likely coming soon, and it's going to have a huge impact. I wrote about why the Google car could change everything, and noted that since cars were parked 90 percent of the time, it was likely that we might need 90 percent fewer of them and they would always be on the move doing something.

**Driver-less cars could severely hit multi-car households: Study** *domain-b.com*

**Abstract:** Another study warns that self-driving cars will eliminate many multicar households, reduce U.S. auto sales by 40% over the next 25 years and force General Motors and Ford to cut North American production by more than half. By analyzing data from the government's National Household Travel Survey, UMTRI researchers Brandon Schoettle and Michael Sivak found that families with three or more vehicles in their driveway rarely use more than one at a time.

**Subject Area:** autonomous vehicles, self-driving vehicles, driverless vehicles, vehicle sharing, vehicle demand, vehicle ownership, vehicle usage, National Household Travel Survey, NHTS

**Availability:** www.domain-b.com *Analyst: Driver-less cars could severely hit multi-car households: Study* May 21, 2015. http://www.domain-b.com/automotive/20150521_households.html

# Analyst: Driverless cars will cut U.S. sales by 40% *Greg Gardner*

**Abstract:**  Another study warns that self-driving cars will eliminate many multicar households, reduce U.S. auto sales by 40% over the next 25 years and force General Motors and Ford to cut North American production by more than half. By analyzing data from the government's National Household Travel Survey, UMTRI researchers Brandon Schoettle and Michael Sivak found that families with three or more vehicles in their driveway rarely use more than one at a time.

**Subject Area:** autonomous vehicles, self-driving vehicles, driverless vehicles, vehicle sharing, vehicle demand, vehicle ownership, vehicle usage, National Household Travel Survey, NHTS

**Availability:** Detroit Free Press *Analyst: Driverless cars will cut U.S. sales by 40%* May 20, 2015. http://www.freep.com/story/money/2015/05/20/general-motors-ford-fiat-chrysler-barclays-self-driving-cars/27635805/

# Research: mpg down for new vehicles and miles up for autonomous cars *Bryan Jonston*

**Abstract:**  Research Institute show a decline in the average mpg for new vehicles sales and that driverless cars in the future may cause more trips.  Average fuel economy (window-sticker values) of cars, light trucks, vans and SUVs purchased in February was 25.2 mpg, down from 25.4 mpg in January and now just 0.1 mpg higher than a year ago. Overall, vehicle fuel economy is up 5.1 mpg from October 2007*, the first full month of monitoring by researchers Michale Sivak and Brandon Schoettle.

**Subject Area:** Technology Michigan Tesla Vehicle Technology Google Autonomous Vehicle

**Availability:**  www.autoconnectedcar.com *Research: mpg down for new vehicles and miles up for autonomous cars* March 12, 2015. http://www.autoconnectedcar.com/2015/03/research-mpg-down-for-new-vehicles-and-miles-up-for-autonomous-cars/

# Dirty downside to driverless cars shown in university study *Isaac Arnsdorf*

**Abstract:** Driverless cars better be able to refuel themselves. They'll consume more energy than cars with drivers. That's the somewhat counterintuitive conclusion in a new study by researchers at the University of Michigan in Ann Arbor. They say that autonomous autos could reverse a years-long trend of declining fuel consumption

**Subject Area:** Technology Michigan Tesla Vehicle Technology Google Autonomous Vehicle

**Availability:** AutomotiveNews.com *Dirty downside to driverless cars shown in university study* March 12, 2015. http://www.autonews.com/article/20150312/OEM06/150319954/dirty-downside-to-driverless-cars-shown-in-university-study

Stuff.co.nz/motoring *Dirty downside to driverless cars shown in university study* March 12, 2015. http://www.stuff.co.nz/motoring/news/67395544/dirty-downside-to-driverless-cars-shown-in-university-study

Unionleader.com *Dirty downside to driverless cars shown in university study April 23, 2015.* http://www.unionleader.com/apps/pbcs.dll/article?AID=/20150424/NEWS24/150429484/1038/LOC

**Future Urban Transportation Technologies for Sustainability with an Emphasis on Growing Mega Cities: A Strategic Proposal on Introducing a New Micro Electric Vehicle Segment** *Emilio Honey, Hojin Lee, and In-Soo Suh*

**Abstract:** The current transportation regime is largely based on two alternatives: (1) fixed route public transit, and (2) private ownership of internal combustion engine (ICE) powered vehicles per households. This paper analyzes one possible transportation alternative, Micro Electric Vehicles or MEVs, and compares with the ICE vehicles in terms of social, economic and environmental benefits, especially emphasizing its environmental advantage over ICE vehicles for future sustainability. While some representative models of MEVs exist in a limited market capacity, but global technical standards are generally insufficient and non-homogenous across nations, which restricts the development of the proposed transportation sector. The focus of this paper is to analyze the characteristics and potential benefits of MEVs in economical and environmental perspectives, including development status and technical standards, with a particular focus in the E.U., the U.S., Japan, and Korea. Based on the data of analysis, this paper aims to derive and propose a cooperative and adaptive global policy framework designed to speed up adoption and expansion of the global MEV market, including passenger and utility vehicles. We propose MEV to be a new mobility segment in the global transportation market because of their advantage in environmental impact, sustainability, overall cost of ownership, and safety.

**Subject Area:** Micro Electric Vehicle, MEV, Quadricycle, Sustainability, Safety, Fuel Economy, CO2

# The Future Of Fully Automated Vehicles: Opportunities For Vehicle- And Ride-Sharing, With Cost And Emission Savings *Daniel James Fagnant*

**Abstract:** Fully automated or autonomous vehicles (AVs) hold great promise for the future of transportation, with Google and other auto manufacturers intending on introducing self-driving cars to the public by 2020. New automation functionalities will produce dramatic transportation system changes, in safety, mobility, travel behavior, and the built environment.

This work's results indicate that AVs may save the U.S. economy up to $37.7 billion from safety, mobility and parking improvements at the 10% market penetration level (in terms of system-wide vehicle-miles traveled [VMT]), and up to $447.1 billion with 90% market penetration. With only 10% market share, over 1,000 lives could be saved annually. However, realizing these potential benefits while avoiding pitfalls requires overcoming significant barriers including AV costs, liability, security, privacy, and missing research.

Additionally, once fully self-driving vehicles can safely and legally drive unoccupied, a new personal travel transportation mode looks set to arrive. This new mode is the shared automated vehicle (SAV), combining on-demand service features with self-driving capabilities. This work simulates a fleet of SAVs operating within Austin, Texas, first using an idealized grid-based representation, and next using Austin's actual transportation network and travel demand flows. This second model incorporates dynamic ride-sharing (DRS), allowing two or more travelers with similar origins, destinations and departure times to share a ride.

Model results indicate that each SAV could replace around 10 conventionally-owned household vehicles, with a fleet of 1715 SAVs serving over 56,000 person-trips. SAVs' ability to relocate unoccupied between serving one traveler and the next may cause an increase of 7-10% more travel; however, DRS can result in reduced overall VMT, given enough SAV-using travelers willing to ride-share. Furthermore, using DRS results in overall lower wait and service times for travelers, particularly from pooling rides during peak demand. SAVs should produce favorable emissions outcomes, with an estimated 16% less energy use and 48% lower volatile organic compound emissions, per person-trip compared to conventional vehicles. Finally, assuming SAVs cost $70,000 each, an SAV fleet in Austin could provide a 19% return on investment, when charging $1 per trip-mile served. In closing, this new paradigm holds much promise in helping to create a more efficient and sustainable transport system.

**Subject Area:** shared autonomous vehicles; dynamic ride-sharing

**Self-driving cars may cut household's vehicle count** *Greg Gardner*

**Abstract:** Self-driving cars could reduce the number of vehicles a household needs and open up new commuting options for Americans, according to a report released Monday by the University of Michigan Transportation Research Institute. By analyzing data from the government's National Household Travel Survey, UMTRI researchers Brandon Schoettle and Michael Sivak found that families with three or more vehicles in their driveway rarely use more than one at a time.

**Subject Area:** autonomous vehicles, self-driving vehicles, driverless vehicles, vehicle sharing, vehicle demand, vehicle ownership, vehicle usage, National Household Travel Survey, NHTS

**Availability:** Detroit Free Press *Self-driving cars may cut household's vehicle count* March 10, 2015. http://www.guampdn.com/article/20150310/LIFESTYLE/303100020/Self-driving-cars-may-cut-household-s-vehicle-count

# The Performance and Benefits of a Shared Autonomous Vehicles Based Dynamic Ridesharing System: An Agent-Based Simulation Approach *Zhang, Wenwen; Guhathakurta, Subhrajit; Fang, Jinqi; Zhang, Ge*

**Abstract:** The recently introduced concept of Shared Autonomous Vehicle (SAV) system, a taxi system without drivers or a short-term rental car-sharing program with autonomous vehicles, presents great potential to promote ridesharing travel behavior. Given the reliability and flexibility provided by the SAV system, some hurdles in the current ridesharing programs, such as lack of flexibility to handle near term travel schedule changes, can be overcome. However, the existing studies regarding SAV system are limited to non-ridesharing (NR) systems. To fulfill this research gap, this study designed and applied an agent-based model to simulate the performance and estimate the potential benefits of an SAV system with dynamic ridesharing (DR-SAV). The modeled DR-SAV system will assign SAVs to serve vehicle-trips, with similar travel profile as in 2009 National Household Travel Survey (NHTS), in a 10*10 mile grid based city, for each one-minute time step. Two vehicle-trips may voluntarily participate into the ridesharing service, if both of them are willing to share rides with strangers and the additional delay time cost triggered by ridesharing can be offset by travel cost reductions. Preliminary results show that a DR-SAV system can provide more satisfactory level of service compared with an NR-SAV system, in terms of shorter trip delays, more reliable services (especially during peak hours), less Vehicle Miles Travelled (VMT) generation, and less trip costs. Additionally, the results also indicate that a DR-SAV system can be more environment-friendly in the long run.

**Autonomous Cars: Fewer Vehicles, More Miles** *evworld.com*

**Abstract:** The University of Michigan's Transportation Research Institute projects that the advent of self-driving vehicles will cut car ownership by as much as 43 percent. UMTRI researchers Brandon Schoettle and Michael Sivak recently analyzed the revised edition of the 2009 U.S. National Household Travel Survey in the light of the advent of self-driving, autonomous vehicles and came to some interesting conclusions, one that is likely to trouble carmakers.

**Subject Area:** autonomous vehicles, self-driving vehicles, driverless vehicles, vehicle sharing, vehicle demand, vehicle ownership, vehicle usage, National Household Travel Survey, NHTS

**Availability:** EVWorld.com *Autonomous Cars: Fewer Vehicles, More Miles* Feb. 18, 2015.
http://evworld.com/news.cfm?newsid=34871

**Driverless cars could cut auto sales in half** *Richard Read*

**Abstract:**  Today's sky-high auto sales could plummet as driverless cars start hitting the streets, research suggests. The reason? Driverless cars would let people share a vehicle for separate trips. America's auto market is booming right now, but a study from the University of Michigan Transportation Research Institute suggests that today's sky-high sales figures could plummet in the next decade, as autonomous cars start hitting the streets.

**Subject Area:** autonomous vehicles, self-driving vehicles, driverless vehicles, vehicle sharing, vehicle demand, vehicle ownership, vehicle usage, National Household Travel Survey, NHTS

**Availability:** Read, Richard; www.csmonitor.com *Driverless cars could cut auto sales in half* Feb. 12, 2015. http://www.csmonitor.com/Business/In-Gear/2015/0212/Driverless-cars-could-cut-auto-sales-in-half

# Autonomous vehicles may lead to an increase in miles driven *Bernie Degroat*

**Abstract:** Autonomous vehicles may reduce the number of vehicles a family needs, but may lead to an increase in total miles driven, say researchers at the University of Michigan Transportation Research Institute. UMTRI researchers Brandon Schoettle and Michael Sivak examined U.S. National Household Travel Survey data that contained comprehensive information about each trip made by a person within a selected household, including the exact start and stop times of each trip.

**Subject Area:** autonomous vehicles, self-driving vehicles, driverless vehicles, vehicle sharing, vehicle demand, vehicle ownership, vehicle usage, National Household Travel Survey, NHTS

# Self-Driving Vehicles Could Cut Car Ownership Nearly in Half, Report Finds
*Megan Gannon*

**Abstract:** In the not-too-distant future, the typical picture of a big American household in the suburbs might include just one car in the driveway: A new report finds that self-driving cars have the potential to cut U.S. car ownership nearly in half. For the report, Brandon Schoettle and Michael Sivak of the University of Michigan Transportation Research Institute looked at 2009 data from the U.S. National Household Travel Survey, which found that 31.9 percent of households had one car, 41.6 percent had two cars and 26.5 percent had three or more vehicles.

**Self-driving cars may lead to fewer vehicles driven more** *Greg Gardner*

**Abstract:** Self-driving cars could cut the number of vehicles a household needs, but open up new commuting options for Americans and even lead to more total miles driven, according to a report released Monday by the University of Michigan Transportation Research Institute. By analyzing data from the government's National Household Travel Survey, UMTRI researchers Brandon Schoettle and Michael Sivak found that families with three or more vehicles in their driveway rarely use more than one at a time.

# Potential Impact of Self-Driving Vehicles on Household Vehicle Demand and Usage *Schoettle, Brandon, Michael Sivak, and Sustainable Worldwide Transportation*

**Abstract:** In this report we present an analysis of the potential for reduced vehicle ownership within households based on sharing of completely self-driving vehicles that employ a "return-to home" mode, acting as a form of shared family or household vehicle. An examination of the latest U.S. National Household Travel Survey (NHTS) data shows a general lack of trip overlap between drivers within a majority of households, opening up the possibility for a significant reduction in average vehicle ownership per household based on vehicle sharing. This reduction in ownership and an accompanying shift to vehicle sharing within each household, in the most extreme hypothetical scenario, could reduce average ownership rates by 43% (from 2.1 to 1.2 vehicles per household). Conversely, this shift would result in a 75% increase in individual vehicle usage (from 11,661 to 20,406 annual miles per vehicle). However, given the number of current unknowns regarding sufficient gaps between trips, future self-driving-vehicle implementation, self-driving-vehicle acceptance, and possible vehicle-sharing strategies within households, these results serve only as an upper-bound approximation of the potential for household sharing of completely self-driving vehicles.

**Subject Area:**  autonomous vehicles, self-driving vehicles, driverless vehicles, vehicle sharing, vehicle demand, vehicle ownership, vehicle usage, National Household Travel Survey, NHTS

## Governor Hogan thinks only 10% of Marylanders use transit. Actually, 25% or more do. *Jim Titus*

**Abstract:** Maryland Governor Larry Hogan says that Maryland should shift its focus away from transit toward building more roads because (he says) less than 10% of people use transit. But the real number is far more. Hogan's mistaken assertion comes from the Census Bureau's American Community Survey (ACS), which estimates that 9.1% of Maryland's 2.9 million workers over the age of 16 used transit as their primary mode for commuting in 2013. A comment on the article references NHTS: "What about the National household Travel Survey? The latest one was done in 2009, but it should show a statistically significant snapshot of all travel in Maryland."

**Subject Area:** Maryland Transit users; ACS; census

# Measuring & Mitigating Electric Vehicle Adoption Barriers *Tommy Carpenter*

**Abstract:** Transitioning our cars to run on renewable sources of energy is crucial to addressing concerns over energy security and climate change. Electric vehicles (EVs), vehicles that are fully or partially powered by batteries charged from the electrical grid, allow for such a transition. Specifically, if hydro, solar, and wind generation continues to be integrated into the global power system, we can power an EV-based transportation network cleanly and sustainably. To this end, major car manufacturers are now producing and marketing EVs. Unfortunately, at the time of this writing, drivers are slow to adopt EVs due to a number of concerns. The two greatest concerns are range anxiety—the fear of being stranded without power and the fear that necessary charging infrastructure does not exist—and the unknown return on investment of EVs over their lifetime. Towards measuring the barriers to adoption, we build a sentiment analysis system for programmatically mining detailed perceptions towards EVs from ownership forums. In addition, we design the most comprehensive electric bike trial to date, which allows us to study several aspects of electric vehicles, including range anxiety, at a much lower cost. Towards mitigation, we develop algorithms for managing a network of gasoline vehicles to be used by EV owners when a planned trip exceeds the range of their EV. Further, we design a model for taxi companies to compute whether it is profitable to transition a fraction of their fleet to EVs. To summarize our findings, we find that sentiments towards EVs are very positive, especially regarding performance and maintenance, but there are concerns over range anxiety and the higher initial price of EVs. Larger batteries cost more, so alleviating range anxiety with larger batteries leads to pricier vehicles. Conversely, EVs with low range capabilities can also induce costs, because drivers and fleets that own EVs may have to often acquire (or own as an additional vehicle) a gasoline vehicle to fully meet their mobility demands. As a result, EVs are best suited for drivers and fleets that are able to make long-term return on investment calculations, and whose mobility patterns do not include many very long trips. Fleets can greatly reduce their operating costs by adopting EVs because they have the capital to make upfront investments that are profitable long-term. We show that even under conservative assumptions about revenue loss due to battery depletion, EVs are already profitable (the company saves more than enough money to recoup all initial investments) for a large taxi company in San Francisco. Similarly, EVs can be profitable for two-car families (those who already have a gasoline car) and for those who can easily acquire a gasoline vehicle when needed, hence our work on sizing networks of gasoline-vehicle pools for EV owners. Finally, we find that not only are electric bikes and EVs operationally similar, the sentiments towards the two technologies are as well. Advancements made in the battery sector, especially those that reduce costs or weight, are likely to accelerate sales in both markets. The results presented in this thesis, as well as in prior work, suggest that EVs are suitable for many drivers and will hence serve a role in our eventual transition away from fossil fuels.