

Bibliography and Technical Appendices to Intercity Passenger Rail in the Context of Dynamic Travel Markets

DETAILS

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List of Abbreviations

CBC	Choice-Based Conjoint
DOT	Department of Transportation
FRA	Federal Railroad Administration
GIS	Geographic information systems
HH	Household
HOV	High-occupancy vehicle
HSR	High-speed rail
ICLV	Integrated Choice/Latent Variable
ICT	Information communication technology
IVT	In-vehicle time
LCC	Latent Class Cluster
NEC	Northeast Corridor
NHTS	National Household Travel Survey
OD	Origin-destination
SEM	Structural equation modeling
SOV	Single-occupancy vehicle
SP	Stated preference
STE	Standardized total effect
TPB	Theory of Planned Behavior
VFR	Visiting friends and relatives
VMT	Vehicle miles traveled
VTT	Value of travel time
WTP	Willingness to Pay

1. Trends and Differences by Generation

THE PROJECT BIBLIOGRAPHY

Bibliography Theme 1: Trends and Differences by Generation

APTA (2013). "**Millennials and Mobility: Understanding the Millennial Mindset.**"

<http://www.apta.com/resources/reportsandpublications/Documents/APTA-Millennials-and-Mobility.pdf>

The Millennial Generation, those born between 1982 and 2003, is the largest and most diverse generation in American history. According to *Millennial Makeover*, a seminal volume on generational change, 40% of Millennials are African American, Latino, Asian or racially-mixed compared to only 25% of the next two older generations. Millennials are also living through times of economic dislocation and technological change. History shows that the combination of technological change, such as the advent of smartphone technology, television, or radio; combined with macro forces that shape behaviors, such as the Great Recession, the Great Depression, or World War II can lead to societal change that can last generations. It is in this context that Millennials, with their relative propensity for urban lifestyle components (whether they live in cities or in suburbs), dexterity with technology, while starting careers during economically constrained times can leave a lasting impact on society. In fact, they are already driving trends. As has been noted in a number of reports, including US PIRG's report, "A New Direction: Our Changing Relationship With Driving and the Implications for America's Future", rates of driving is down in the US, and Millennials are leading the trend. This APTA/TCRP report seeks to further understand the mindsets behind the trends and understand their implications for public transportation in the United States. This study utilizes a mixture of in-depth interviews in five cities and a survey of 1,000 people in six cities that are representative of the types of cities Millennials find attractive. Millennials are multimodal, they choose the best transportation mode (driving, transit, bike, or walk) based on the trip they are planning to take. Communities that attract Millennials have a multitude of transportation choices, as proven by Millennial hotspots, popular zip codes where residents have self-selected into a multi-modal lifestyle. Public transportation options are considered the best for digital socializing and among the most likely to connect the user with their communities. Transit also allows Millennials to work as they travel, a trend noted by 40% of those polled. These benefits of public transit need to be fully leveraged by the industry, as they provide a clear competitive advantage. Reasons and motivations for transportation choices are pragmatic, with 46% stating that a need to save money drives their choices; 46% also note convenience, 44% want exercise, and 35% say they live in a community where it just makes more sense to use transit. Millennials would like to see in the next ten years: 1) 61% more reliable systems, 2) 55% real-time updates, 3) 55% Wi-Fi or 3G/4G wherever they go, 4) 44% a more user-friendly and intuitive travel experience. Fully leveraging technology, through real-time transit applications that connect users with community amenities, through smartphone fare payment, and the provision of WiFi and 3G/4G, will allow transit users to be more spontaneous, thus addressing the key competitive advantage of the car.

Belden Russonello & Stewart (2011). "**The 2011 Community Preference Survey What Americans are looking for when deciding where to live. Analysis of a survey of 2,071 American adults nationally**" Conducted for the National Association of Realtors®

The National Association of Realtors® asked Belden Russonello & Stewart LLC to update research done in 2004 on Americans' preferences regarding the communities in which they live. There have been major changes in the economy and the housing market since the 2004 Community Preference Survey was conducted. Property values have dropped significantly in many areas, foreclosures are at record highs, and fluctuating gas prices have made long commutes more costly. This research explores how Americans' preferences regarding communities and housing have changed over the last seven years. The research covers characteristics consumers are looking for in a community, the reality of their current communities, and what policies they would support to improve their communities in the future. The 2011 BRS/NAR Community Preference Survey is a web-enabled survey of adults nationwide using the Knowledge Networks panel. Knowledge Networks uses probability methods to recruit its panel, allowing results to be generalized to the population of adults in the U.S. A total of 2,071 questionnaires were completed from February 15 to 24, 2011. The data have been weighted by gender, age, race, region, metropolitan status, and Internet

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access. The margin of sampling error for the sample of 2,071 is plus or minus 2.2 percentage points at the 95% level of confidence. A detailed methodology can be found in Appendix A.

Blumenberg, E, B Taylor, M Smart, K Ralph, M Wander and S Brumbagh (2012). "What's Youth Got to Do with It? Exploring the Travel Behavior of Teens and Young Adults

Today's teens are members of the first generation to have never known a world without instantaneous and nearly ubiquitous mobile phone access. They also must surmount greater hurdles to driver's licensing than any previous generation faced. And they are struggling to transition into the most unwelcoming job market since the Great Depression. These tectonic happenings surely augur equally dramatic changes in the travel choices and patterns of young adults in the years ahead. Or will they? This report examines this question. While scholars have studied the travel choices and patterns of adults extensively over the years, our knowledge of youth travel behavior is surprisingly limited and uneven. There is a growing body of research on how children travel to school and a second body of research on youth and travel safety, in particular, the high rates of crashes and driving fatalities among teenagers. Beyond these two rather focused lines of inquiry, however, studies of travel by children, teens, and young adults are rare. Researchers have posited several factors to explain differences in the travel behavior of youth and adults, and to support the argument that such differences may persist as today's youth move into adulthood. First, the rapid profusion and adoption of new communication technologies influences how people use their time and may affect how much they travel (Kwan, 2002), and young people tend to be early and frequent adopters of these technologies (Mans et al., forthcoming; Lenhart et al., 2005; Pew Research Center, 2010b). Second, all 50 states have now adopted graduated driver's licensing programs, making teen licensing more difficult and restrictive (with respect to time, trip purpose, and passengers) than in previous eras (Insurance Institute for Highway Safety, 2012). Third, unemployment rates during the current recession are highest for youth, thereby reducing journey-to-work and work-related travel and limiting the resources teens and young adults have to pay for non-work activities (and associated travel) of all types. This prolonged economic downturn may also influence youth travel patterns indirectly; fragmentary evidence suggests that young adults struggling to find work increasingly "boomerang" back home to live with parents (Kaplan, 2009; Pew Research Center, 2010b; Wiemers, 2011), drawn by a free or steeply discounted bedroom, groceries, and, perhaps, access to parents' cars.

Blumenberg, E, M Wander, B Taylor and M Smart (2013). The Times Are They A-Changin'? Youth, Travel Mode, and the Journey to Work. Presented at 92nd Annual Meeting of the Transportation Research Board, Washington, D.C.

Today's youth live in a far different world than the youth of previous generations. They are struggling to transition into the most unwelcoming job market since the Great Depression, they are the first generation to have never known a world without the Internet, and they must surmount greater hurdles to driver's licensing than teens of any previous generation. In this paper, the authors examine the effect of these momentous societal changes on the travel behavior of youth. In particular, the authors use data from the 1990, 2001, and 2009 National Personal/Household Travel Surveys (NP/HTS) to model the commute mode choices of young workers over time. The analysis suggests that both the economy and changes in licensing regulations have influenced youth commute mode choice. While youth in 2009 commute by solo driving at slightly higher rates than in 2001, the authors' analysis suggests that these rates would have been even higher in the absence of both the deep recession and changes in driver's licensing regulations. Whether the observed effects on youth travel will be short-lived (a period effect) or more enduring (a cohort effect) remains to be seen.

Canberra Department of Infrastructure and Transport, Australia (2012). "**Traffic Growth: Modelling a Global Phenomenon**"

This report examines the trends in the growth of road traffic (vehicle kilometres travelled or vkt) in 25 countries around the world. Much of the report is technical in nature, dealing with the sources of data, and details of variable construction and modelling. For example, data back to at least 1963 has been assembled for 25 countries on vehicle kilometres travelled by vehicle type, numbers of vehicles by vehicle type, population, petrol prices, consumer prices and unemployment. The main result of all this data preparation has been the ability to document the consistent and yet varied patterns over time in vehicle kilometres per person in many countries around the globe. After rapid growth in the sixties and seventies, growth in traffic

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(all vehicle types) per capita has consistently slowed, with many countries approaching saturation. The main results of the study are models of vkt per capita as a function of real petrol prices, fluctuations in the economy and of a saturating effect of time. Each country is different, but the patterns of the models are amazingly similar. The models explain the common finding around the developed world of a fairly linear trend in total vkt over the past four decades – slowing growth in population has been matched by a declining rate of growth in traffic per person. Lately, there has been a significant effect of the global financial crisis in lowering traffic levels per capital around the world. The models can be used to provide base-case and scenario forecasts of future trends in traffic growth in the 25 countries. These are useful in a variety of contexts, for instance, in forecasting road fatalities from fatality rates, forecasting traffic growth in cities and needs for infrastructure investment.

Delbosc, Alexa and Graham Currie (2013). "***Causes of youth licensing decline: a synthesis of evidence.***" Transport Reviews **33**(3): 271-290.

In recent decades, young adults in many developed nations have become increasingly less likely to acquire a driving licence. If this trend continues it could have significant impacts on transport futures. Licensing reductions have only recently been identified and causes are only just being explored. This paper presents a first synthesis of available evidence including an assessment of more influential causal factors. It begins by documenting the declining trend evident in 9 of 14 documented countries; the average rate of decline is 0.6% per annum, with highest declines documented in Australia. A range of causal factors are documented from cross-sectional and longitudinal studies. Changes in life stage and living arrangements, changes in motoring affordability, location and transport, graduated driver licensing schemes, attitudinal influences and the role of e-communication are all explored. Evidence is in general weak and preliminary but suggests multiple causes rather than any single influence. However, of the evidence available life stage factors and affordability influences have stronger links to licence decline but are only likely to have a low affect size.

Delbosc, Alexa and Graham Currie (2013). Innovative Online Research Tools Investigating Attitudes Toward Cars Among Young People. TRB 92nd Annual Meeting Compendium of Papers, Transportation Research Board of the National Academies, Washington, D.C.

Young people are becoming increasingly less likely to acquire a car licence in North America, Australia and much of Europe. Emerging research is beginning to explore the structural and demographic explanations for these trends. However little research explains how attitudes are shaping these trends. Popular hypotheses are the (i) changing social status of the car, (ii) growing role of electronic communications and (iii) growing environmental awareness, but little academic research has directly explored these issues. This paper uses innovative online research tools to explore these issues with young people. Three 8 discussion forums were run with participants from across the state of Victoria, Australia. Thirty-three people aged 17 to 23 contributed across the course of one week's discussion. Discussions suggest that the car may be changing from a symbol of status and luxury to a symbol of adulthood and maturity. Electronic communications were seen as a supplement to face-to-face contact, not a replacement for car travel. Not one person in the sample spontaneously mentioned that environmental concerns shaped their travel choices; even when prompted these concerns were far removed from travel decisions. The paper follows with a commentary on the use of discussion forums for qualitative research. It closes with a discussion of the new hypotheses that these findings generate and uncovers many areas for future research.

Dutzik, Tony and Phineas Baxandall (2013). "***A New direction: Our Changing Relationship with Driving and the Implications for America's Future***" US PIRG, The Phoenix Institute

The Driving Boom—a six decade long period of steady increases in per-capita driving in the United States—is over. Americans drive fewer total miles today than we did eight years ago, and fewer per person than we did at the end of Bill Clinton's first term. The unique combination of conditions that fueled the Driving Boom—from cheap gas prices to the rapid expansion of the workforce during the Baby Boom generation—no longer exists. Meanwhile, a new generation—the Millennials—is demanding a new American Dream less dependent on driving. Transportation policy in the United States, however, remains stuck in the past. Official forecasts of future vehicle travel continue to assume steady increases in driving, despite the experience of the past decade. Those forecasts are used to justify spending vast sums on new and expanded highways, even as existing roads and bridges are neglected. Elements of a more balanced transportation system—from

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transit systems to bike lanes—lack crucial investment as powerful interests battle to maintain their piece of a shrinking transportation funding pie.

Dutzik, Tony, Jeff Inglis and Phineas Baxandall (2014). "***Millennials in Motion: Changing Travel Habits of Young Americans and the Implications for Public Policy***" U.S. PIRG Education Fund

Frontier Group

Over the last decade—after 60-plus years of steady increases—the number of miles driven by the average American has been falling. Young Americans have experienced the greatest changes: driving less; taking transit, biking and walking more; and seeking out places to live in cities and walkable communities where driving is an option, not a necessity. Academic research, survey results and government data point to a multitude of factors at play in the recent decline in driving among young people: socioeconomic shifts, changes in consumer preferences, technological changes, efforts by state governments and colleges to limit youth driving, and more. Millennials (those born between 1983 and 2000) are the nation's largest generation, making their transportation needs particularly important. They have the most to gain or lose from the transportation investment decisions we make today, as they will be affected by those investments for decades to come. If Millennials drive fewer miles than previous generations as they age—and if future generations of young people follow suit—America will have an opportunity to reap the benefits of slower growth in driving. These include reduced traffic congestion, fewer deaths and injuries on the roads, reduced expenditures for highway construction and repair, and less pollution of our air and climate. Several indicators—including continued decreases in per-capita driving across the whole U.S. population, the continued shift away from the use of cars for commuting by Millennials, and the consistency of Millennials' stated preferences for housing and transportation—suggest that it is unlikely that the trend toward less driving among Millennials during the 2000s has reversed thus far in the current decade. Moreover, many of the factors that have contributed to the recent decline in driving among young Americans appear likely to last. Now is the time for the nation's transportation policies to acknowledge, accommodate and support Millennials' demands for a greater array of transportation choices. Millennials are less car-focused than older Americans and previous 2 Millennials in Motion generations of young people, and their transportation behaviors continue to change in ways that reduce driving.

Dutzik, Tony, Travis Madsen and Phineas Baxandall (2013). "***A New Way to Go The Transportation Apps and Vehicle-Sharing Tools that Are Giving More Americans the Freedom to Drive Less***" U.S. PIRG Education Fund

Frontier Group

The rapid advance of the Internet, mobile communications technologies and social networking - and the technology-enabled transportation services they are spawning has the potential to expand the share of American households with the freedom to live without a car, or to live with fewer cars than they own today. These new tools give Americans a broader array of convenient, flexible transportation choices - enabling them to drive when and where they need to, share rides where they can, and take full advantage of the particular benefits of public transportation, bicycling and walking. Many of these new services are still in their infancy, while others are well on their way to becoming important fixtures of the nation's transportation system. Local, state and federal officials should take immediate steps to facilitate the growth of these services, while integrating emerging transportation technologies and tools into planning and decision-making for the future. This report looks at some of these emerging technologies and their impact on transportation choices. Topics covered include: social networking, carsharing, bikesharing, transit apps, ridesharing, multi-modal apps, taxi hailing and transportation network services. Policy recommendations are also included.

Frändberg, Lotta and Bertil Vilhelmson (2011). "***More or less travel: personal mobility trends in the Swedish population focusing gender and cohort.***" *Journal of Transport Geography* **19**(6): 1235-1244.

<http://dx.doi.org/10.1016/j.jtrangeo.2011.06.004>

This study explores mainstream trends and countertrends in the development of spatial mobility in the Swedish population. Tracing incipient change in travel behaviour is important for understanding the preconditions for social and environmental sustainability. We use data from the Swedish national travel surveys, conducted intermittently over almost 30 years (1978–2006), covering both daily and long-distance mobility. International travel is included for the last decade. With respect to mainstream trends, the results

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primarily concern the continuation of the spatial extension of overall mobility and of the motorization and individualization of travel modes, as well as an upward convergence between women's and men's mobility. When it comes to countertrends, substantial reductions in daily mobility and long-distance domestic travel are observed among the young.

Gallagher, Leigh (2013). ***The End of the Suburbs: Where the American Dream is Moving*** Portfolio Penguin.

For nearly 70 years, the suburbs were as American as apple pie. As the middle class ballooned and single-family homes and cars became more affordable, we flocked to pre-fabricated communities in the suburbs, a place where open air and solitude offered a retreat from our dense, polluted cities. Before long, success became synonymous with a private home in a bedroom community complete with a yard, a two-car garage and a commute to the office, and subdivisions quickly blanketed our landscape. But in recent years things have started to change. An epic housing crisis revealed existing problems with this unique pattern of development, while the steady pull of long-simmering economic, societal and demographic forces has culminated in a Perfect Storm that has led to a profound shift in the way we desire to live. In *The End of the Suburbs* journalist Leigh Gallagher traces the rise and fall of American suburbia from the stately railroad suburbs that sprung up outside American cities in the 19th and early 20th centuries to current-day sprawling exurbs where residents spend as much as four hours each day commuting. Along the way she shows why suburbia was unsustainable from the start and explores the hundreds of new, alternative communities that are springing up around the country and promise to reshape our way of life for the better. Not all suburbs are going to vanish, of course, but Gallagher's research and reporting show the trends are undeniable. Consider some of the forces at work: The nuclear family is no more: Our marriage and birth rates are steadily declining, while the single-person households are on the rise. Thus, the good schools and family-friendly lifestyle the suburbs promised are increasingly unnecessary. We want out of our cars: As the price of oil continues to rise, the hours long commutes forced on us by sprawl have become unaffordable for many. Meanwhile, today's younger generation has expressed a perplexing indifference toward cars and driving. Both shifts have fueled demand for denser, pedestrian-friendly communities. Cities are booming. Once abandoned by the wealthy, cities are experiencing a renaissance, especially among younger generations and families with young children. At the same time, suburbs across the country have had to confront never-before-seen rates of poverty and crime. Blending powerful data with vivid on the ground reporting, Gallagher introduces us to a fascinating cast of characters, including the charismatic leader of the anti-sprawl movement; a mild-mannered Minnesotan who quit his job to convince the world that the suburbs are a financial Ponzi scheme; and the disaffected residents of suburbia, like the teacher whose punishing commute entailed leaving home at 4 a.m. and sleeping under her desk in her classroom. Along the way, she explains why understanding the shifts taking place is imperative to any discussion about the future of our housing landscape and of our society itself—and why that future will bring us stronger, healthier, happier and more diverse communities for everyone.

Garceau, T., C. Atkinson-Palombo and N. Garrick (2014). ***"Peak Travel and the Decoupling of Vehicle Travel from the Economy: A Synthesis of the Literature."*** *Transportation Research Record: Journal of the Transportation Research Board*, No. 2412. Transportation Research Board of the National Academies, Washington, D.C.

Decades of growth in overall and per capita automobile use led many to believe that driving-rate increases would occur indefinitely. In the mid-2000s, driving levels in the United States and other developed countries peaked and then began to decline. Referred to as "peak travel," this international phenomenon is occurring in places with urban layouts, densities, and demographics that are quite different from one another and suggests a fundamental shift in travel behavior. Simultaneously, after 70 years of concurrent growth, the complex relationship between the economy (as measured by gross domestic product) and personal vehicle travel appears to be changing, and this change suggests a weakening connection between the two. This paper reviews the literature about the current understanding and potential causes of these revolutionary trend reversals. Although causes such as saturation of demand, aging, decline of young drivers, preference shifts, and time budget constraints all contribute to reduced automobile travel at one time or another, or in one place or another, none of these factors can explain why peak travel is occurring on multiple scales in a diversity of places. The authors conclude that although the existing literature explains the recent trend reversal in specific cities or partially explains the global phenomenon, the fundamental reasons for peak

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travel are still not understood. Further, the authors challenge fellow researchers to explain these phenomena for more accurate and efficient planning of the transportation infrastructure.

Interrante, Erica (2014). ***The Next Generation of Travel: Research, Analysis and Scenario Development***. FHWA Office of Policy Studies.

It is well-known that on a national scale, there has been a significant drop in both vehicle miles traveled (VMT) and person miles traveled (PMT) in the past decade. Total PMT, which includes vehicle travel, has dropped most significantly among younger populations (ages 21–30), as shown in the graph above. Our research reveals that, compared with previous generations, youth travel has decreased. They are driving less, making fewer trips and traveling shorter distances. Younger commuters also appear to drive alone to work more frequently than similarly-aged workers from previous generations. Understanding these changes has policy implications for the future of transportation when considering how to best finance the system while continuing to make it affordable for the average user, as well as determine traveler needs based on mode shifts and an increase desire for multimodal systems and/or vehicles that are fuel efficient. Relative to these declines, there has been considerable research in the field of travel behavior and travel demand to explain what is occurring nationally and among younger populations. Explanations that have been presented concerning these changes include the following: Declines in miles traveled due to the most recent economic downturn, more stringent driver's licensing laws and fewer state-subsidized driver education programs, a growing urban population, the availability of other modes of transportation, environmental concerns related to driving, and the widespread adoption and use of Information Communication Technologies (ICT) and the impact they are having on travel behavior.

Kuhnimhof, Tobias, Jimmy Armoogum, Ralph Buehler, Joyce Dargay, Jon Martin Denstadli and Toshiyuki Yamamoto (2012). ***Men Shape a Downward Trend in Car Use among Young Adults—Evidence from Six Industrialized Countries.*** *Transport Reviews* 32(6): 761-779. 10.1080/01441647.2012.736426

This paper investigates trends in the travel behaviour of young adults in Germany, France, Great Britain, Japan, Norway, and the USA over the past few decades with a focus on car availability and car travel. The trend analysis relies on micro-data from over 20 National Travel Surveys from the study countries dating back to the mid-1970s. The analysis of the survey data is supplemented by official statistics on licence holding. On this basis, this paper compiles a body of evidence for changes in mobility patterns among young adults in industrialized countries over the past few decades. The findings indicate that since the turn of the millennium, access to cars, measured in terms of drivers' licences and household car ownership, has decreased in most study countries especially for men. Moreover, average daily car travel distance has decreased in most study countries, again especially for men. In France, Japan, and most significantly in the USA, the decrease in car travel has led to a reduction in total everyday travel by young travellers. In Great Britain, the decline in car travel was partly, and in Germany fully, compensated by an increased use of alternative modes of transport.

Kuhnimhof, Tobias, Ralph Buehler and Joyce Dargay (2011). A New Generation: Travel Trends among Young Germans and Britons. Presented at 90th Annual Meeting of the Transportation Research Board, Washington, D.C.

Like other industrialized countries, Germany and Great Britain have experienced increasing motorization over the past five decades. However, results from national travel surveys, vehicle registration statistics, and driver's licensing databases suggest that young Germans and Britons today are less automobile oriented than their parents' generation. The paper sheds light on this trend, with a focus on the group of 20- to 29-year-olds. The analysis finds decreasing car availability, a significant reduction of automobile mileage, increases in the use of other modes, and growing multimodal behavior of the young, with men reducing their automobile travel more than women. Even though the development is more pronounced in Germany, the similarity of the changes in young people's mobility patterns in the two countries is striking. This similarity suggests that the observed changes in travel behavior are not an idiosyncratic development in one country. Instead, the similarity may indicate a structural change in travel behavior that may be found in other Western countries. The paper substantiates findings of changes in trends in mobility patterns of young adults and identifies important storylines of this development on the basis of a harmonized international comparison. Finally, the paper intends to stimulate a discussion and research about reasons for these changes in mobility trend.

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Le Vine, S., Polak, J. (2014). "**Factors associated with young adults delaying and forgoing driving licences: Results from Britain.**" *Traffic Injury Prevention.*"

OBJECTIVE: To identify the reasons that young adults (age 17 to 29) in Britain delay or forgo driving licence acquisition. METHODS: Using year 2010 British National Travel Survey microdata, we first analyse self-reported reasons (including their prioritisation) for not holding a full car driving licence and then estimate a logistic regression model for licence-holding to investigate additional factors, several of which extend from previous studies. This study also employs a novel segmentation approach to analyse the sets of reasons that individual young adults cite for not driving. RESULTS: These results show that, despite the lack of a graduated driving licence system at present, many young adults indicate that issues associated with the driving-licence-acquisition process are the main reason they do not hold a full driving licence. About three in ten young adults can be interpreted as not viewing driving as a priority, whilst half of those without a licence are either learning to drive or are deterred principally by the cost of learning. We calculate that after their 17th birthday (the age of eligibility for a full driving licence) young adults spend a mean of 1.7 years learning to drive. Young adults citing the costs of insurance or car purchase are likely to cite them as secondary rather than the main reason for not driving, whereas those citing physical/health difficulties are very likely to cite this as the main reason they do not drive. Two distinct groups of young people are identified that both indicate that costs deter them from driving – one group that is less well-off financially and that indicates that costs alone are the primary deterrent, and one that reports that other reasons also apply and is better-off. Status as an international migrant was found to be an important factor, net of confounding variables, for identifying that a young adult in Britain does not hold a driving licence. Further research is needed to understand the relatively salience of plausible causal mechanisms for this finding. We also report that both personal income and household income are independently positively associated with licence-holding, but that [intuitively] the relationship of licence-holding with a young adult's own personal income is the much stronger of the two. CONCLUSIONS: On the basis of these findings, it can be concluded that a number of previously under-appreciated factors appear to be linked with young British adults not acquiring a driving licence.

Le Vine, S., Jones, P., Lee-Gosselin, M.E.H., Polak, J. (2014). "**Is Heightened Environmental-Sensitivity Responsible for Drop in Young Adults' Rates of Driver's Licence Acquisition**" *Transportation Research Record: Journal of the Transportation Research Board*, No. 2465. Transportation Research Board of the National Academies, Washington, D.C.

Across a range of developed societies, driving-licence acquisition rates amongst young adults have fallen from their historic peak levels (which in Britain were in the early 1990s). A widely-discussed hypothesis to explain this trend is that heightened environmental sensitivity amongst the current cohort of young adults could be responsible, either fully or, more plausibly, in part. The objective of this study was to establish whether empirical evidence provides support for this hypothesis. Public-opinion polling data from Britain and the United States and British National Travel Survey microdata were statistically analyzed. No evidence was found, either from the U.S. or Britain, of the populace becoming increasingly-inclined towards environmental protection. On the basis of longitudinal trends in public-opinion polling, the opposite seems to be true. Analysis of British National Travel Survey (n=2,820 unlicensed adults age 17-29) data shows that very few young British adults without driving licences report that sensitivity to the environment is either the main reason or a contributory reason that they have not acquired a driving license. Approximately 1% of British adults aged 17 to 29 cite environmental sensitivity as a reason (either main or contributory) for not having a driving licence. By contrast, more than half (59%) of not-fully-licensed young British adults reported that they are either learning to drive (27%), or are put off mainly by the license-acquisition testing requirements (2%) or by costs associated with motoring (30%). These findings are evidence contrary to the hypothesis that growing environmental sensitivity is responsible for falling rates of licensing amongst young adults, at least in Britain and the United States.

Le Vine, S., C Latinopoulos and J. Polak (2013). "**A tenuous result: re-analysis of the link between internet-usage and young adults' driving-licence holding. Comments on 'Recent changes in the age composition of drivers in 15 countries'**" *Traffic Injury Prevention*. DOI: 10.1080/15389588.2013.793583

In their influential 2012 paper, Sivak and Schoettle of the University of Michigan Transportation Research Institute report that the main implication of their cross-national study into falling rates of licence-holding amongst young adults is that: Of particular note was the finding that a higher proportion of Internet users

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was associated with a lower licensure rate. Implications: The results of the analysis are consistent with the hypothesis that access to virtual contact reduces the need for actual contact among young people. This specific finding has been widely-cited, and referenced by the authors in multiple public interviews such as those reported in USA Today and the New York Times: The reasons behind the decline vary, officials say...Michael Sivak, a professor at the University of Michigan's Transportation Research Institute who provided the 2010 teen driving percentages, also pointed to teens' access to the Internet. (Yamiche Alcindor, USA Today, 3 March 2012) In a study of 15 countries, Michael Sivak, a professor at the University of Michigan's Transportation Research Institute (who also contributed to the D.M.V. research), found that when young people spent more time on the Internet, they delayed getting their driver's licences. "More time on Facebook probably means less time on the road," he said. (Todd G. Buccholz and Victoria Buccholz, NY Times, 10 March 2012) Policymakers could easily be left with the impression that this result is robust enough to form the basis for public-policy choices. The fact is that it is not known, on the basis of the available evidence, whether young people's online activity is causing them to acquire licences at a lower rate than in years past. In this short comment paper we show that the research-design of the aforementioned study cannot provide the evidence required to support the authors' assertion that such an effect has been identified. We present six distinct classes of methodological problems with the study. Sivak and Schoettle then replied to our analysis in a letter published concurrently in Traffic Injury Prevention. Readers can judge which set of arguments they find more persuasive.

Lomax, Brian 2011 ***What's in the Numbers? Public Roads***
<http://www.fhwa.dot.gov/publications/publicroads/11novdec/06.cfm>

Sample from the article: "VMT has increased continuously since 1980 but declined from 2008 to mid-2009, reflecting economic conditions," says Brad Gudzin, a transportation specialist in the FHWA Office of Highway Policy Information. "Since early 2010, VMT resumed increasing until March of this year [2011]." But despite a decline from 2007 to 2008, light-duty truck VMT (which includes travel in passenger and small commercial vehicles) showed a rebound in 2009. Light-duty truck VMT increased 0.8 percent to 2.7 trillion in 2009. Truck VMT declined for both single-unit and combination trucks in 2009. Light trucks, used primarily for personal transportation, track with automobile VMT. VMT for single-unit trucks, which includes commercial vehicles and some recreational vehicles, declined 5 percent to 121 billion in 2009. VMT for combination trucks, which includes tractor trailers and other large commercial vehicles, declined 9 percent to 168 billion in 2009. VMT of single-unit and combination trucks, which are mostly commercial vehicles, are greatly affected by the business cycle; in the current situation, commercial truck VMT is down significantly."

Mans, Janine, Erica Interrante, Lewison Lem, Judy Mueller and Michael Lawrence (2012). "Next Generation of Travel Behavior: Potential Impacts Related to Household Use of Information and Communication Technology." *Transportation Research Record: Journal of the Transportation Research Board*, No. 2323, Transportation Research Board of the National Academies, Washington, D.C., pp. 90-98.

Transportation behavior appears to have shifted in recent years. Between the 2001 and 2009 National Household Travel Surveys, the average annual vehicle miles traveled for all age brackets fell. This reduction in driving is likely to be related to a number of factors, one of which may be the rapid introduction and adoption of information and communication technologies (ICTs) over this period. This paper builds a framework that analyzes the extent to which recent studies and reports have been able to establish a link between the use of new technologies and changes in transportation behavior. The paper also attempts to establish whether there is a difference in the intensity and manner of technology use between age cohorts and in the manner in which technology use affects transportation behavior. Finally, the paper assesses major gaps in the current understanding of how ICTs may affect travel behavior.

McCahill, Chris (2014). "***Per capita VMT drops for ninth straight year; DOTs taking notice SSTI.***" State Smart Transportation Initiative

Estimates released by FHWA on Friday suggest that per capita vehicle miles of travel dropped again in 2013, making it the ninth consecutive year of decline (Figure 1). Total VMT in the United States increased by 0.6 percent from 2012, hovering just below 3 trillion, and per capita VMT dropped to 9,402 (the prior year's initial estimate was revised to 9,412). Unlike other past dips in driving, this recent downward shift has had no clear, lasting connection to economic trends or gas prices. Evidence suggests that the decline is likely due to

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changing demographics, saturated highways, and a rising preference for compact, mixed-use neighborhoods, which reduce the need for driving. Some key factors that pushed VMT upward for decades – including a growing workforce and rising automobile ownership – have also slowed considerably. SSTI released a report last September outlining the many contributing factors, with references to supporting literature. By now, some DOTs have acknowledged the downward trends in their states and begun to question what it means for their agencies—particularly when it translates into falling revenues, as in Oregon. It appears this has not affected investment priorities significantly in most states, but it has changed the way some DOTs now view future travel needs. Several recently updated long-range transportation plans reflect this shift.

McDonald, Noreen C (2015). **"Are Millennials Really the "Go-Nowhere" Generation?"** Journal of the American Planning Association. 10.1080/01944363.2015.1057196 <http://dx.doi.org/10.1080/01944363.2015.1057196>

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.

Millard-Ball, Adam and Lee Schipper (2011). **"Are we reaching peak travel? Trends in passenger transport in eight industrialized countries."** Transport Reviews 31(3): 357-378.

Projections of energy use and greenhouse gas emissions for industrialized countries typically show continued growth in vehicle ownership, vehicle use and overall travel demand. This represents a continuation of trends from the 1970s through the early 2000s. This paper presents a descriptive analysis of cross-national passenger transport trends in eight industrialized countries, providing evidence to suggest that these trends may have halted. Through decomposing passenger transport energy use into activity, modal structure and modal energy intensity, we show that increases in total activity (passenger travel) have been the driving force behind increased energy use, offset somewhat by declining energy intensity. We show that total activity growth has halted relative to GDP in recent years in the eight countries examined. If these trends continue, it is possible that accelerated decline in the energy intensity of car travel; stagnation in total travel per capita; some shifts back to rail and bus modes; and at least somewhat less carbon per unit of energy could leave the absolute levels of emissions in 2020 or 2030 lower than today.

Noble, B. (2005). **"Why are some young people choosing not to drive?"**.

After steady growth for many years, the proportion of young people in Great Britain with full licences started falling in the early 1990s. Over the last decade, the proportion of people aged 17-20 with a licence has fallen from 48% to 30%, and the effect is also clear for people in their 20s, and recently, in their early 30s. There is evidence of similar decreases in Scandinavia and the USA, but in some other European countries, the proportion of licensed young drivers continues to grow. Until these trends are investigated fully, there is concern that there may be an increase in young people driving without a licence. Fewer young drivers could have important policy and planning implications, especially if there is a new cohort of younger people who choose never to learn to drive, rather than just delaying the acquisition of a licence. In particular, it could mean that current models need to be revised. Traffic may not grow as quickly in the future. Young people

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may get used to using alternatives to the car, including cycling, walking and taking a bus, and either never choose to drive, or delay driving until the demands of a young family make other alternatives less practical. This paper will consider a number of explanatory factors using detailed cross sectional and trend data from the Great Britain National Travel Survey and other data sources. It will discuss some of the likely reasons for the fall in licence holding, and include analysis of new attitudinal questions asked on the Office for National Statistics' Omnibus Survey in spring 2005, asking non-drivers for the reasons why they choose not to drive.

OECD/ITF **Long-run Trends in Car Use**, OECD Publishing/ITF.

The growth of car use in several advanced economies has slowed down, stopped, or turned negative. The change cannot be attributed to adverse economic conditions alone. Socio-demographic factors, including population ageing and changing patterns of education, working, and household composition matter. Rising urbanization and less car-oriented policies in some cities also reduce the growth of car use, perhaps combined with changing attitudes towards mobility. Some groups choose to use cars less, others are forced to. This report summarizes insights into the drivers of change in car use. It shows that explanations are place-specific, and that projections of future car use are increasingly uncertain. The task for policy-makers is to identify mobility strategies that are robust under an increasingly wide range of plausible scenarios.

Polzin, S. E. , X. Chu and J. Godfrey (2014). "***The impact of Millennials' travel behavior on future personal vehicle travel.***" *Energy Strategy Reviews* **5**, : 59-65. . doi:10.1016/j.esr.2014.10.003

The millennial generation, born between 1980 and 2000, is exhibiting different travel behavior trends than previous generations, which are shaped by several different yet correlated characteristics such as; place of residence, race/ethnicity, labor force participation, education level, income, living arrangements, lifecycle status, licensure status, vehicle ownership/availability, values, and propensity to substitute technology for travel. Many millennials are living with their parents longer, obtaining drivers licenses at older ages, postponing marriage and procreation, and substituting travel for work and socializing with telecommuting and social media. Millennials are currently shaping the nation's changing demographics, which in turn directly affect future travel behavior trends and their consequences on energy consumption and the environment.

Ralph, Kelcie Mechelle (2015). "***Stalled On The Road To Adulthood? Analyzing the Nature of Recent Travel Changes for Young Adults in America, 1995 to 2009.***" *PhD thesis.*

Young people in the 2000s traveled fewer miles, owned fewer vehicles, and were less likely to hold a driver's license than young people in the 1990s. Scholars, policymakers, and journalists proffered a host of possible explanations for this trend: attitudes and preferences about travel fundamentally changed due in part to the increased availability of communication technologies; economic conditions limited activities (including employment) and constrained travel options; young adults became less likely to attain adult roles like marriage and child-birth; young people lead a back-to-the-city movement where the utility of non-automobile modes improved; and/or racial and ethnic minorities are less likely to drive and the population became more diverse. Whichever of these explanations is the principal cause, perhaps the American love affair with the car was over. I assess the evidence for these hypotheses using data from the 1995, 2001, and 2009 national travel surveys in the United States. I identify four distinct traveler types using latent profile analysis of travel patterns over a single day and an extended period. These types—Drivers, Long-distance Trekkers, Multimodals, and Car-less—serve as the dependent variable in the subsequent analysis, where I evaluate changes in the prevalence of each type over time for specific subgroups and use multinomial logistic regression to identify the independent relationship between traveler type and economic resources, adult roles, residential location, and race/ethnicity. I find that economic constraints, role deferment, and racial/ethnic compositional changes in the population primarily explain the travel trends during this period. The evidence in support of preferences and residential location explanations was substantially more limited. The concluding chapter contextualizes these findings, arguing that a large and growing share of young adults suffer from transportation disadvantage. The most important take-away from this work is that the decline in driving by young people in the 2000's deserves our attention—not as an unmitigated success story, but as an early indication of a problem.

Ruud, A and S Nordbakke (2005). "***Decreasing driving licence rates among young people - consequences for local***

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public transport." PROCEEDINGS OF ETC 2005, STRASBOURG, FRANCE 18-20 SEPTEMBER 2005 - TRANSPORT POLICY AND OPERATIONS - EUROPEAN POLICY AND RESEARCH - ACCESS TO TRANSPORT AND FUTURE ISSUES.

Driving licence and access to a car traditionally have been among the most significant determinants for mode choice. In the 1980s, driving licence rates among young people increased in Norway and Sweden. In the 1990s, trend changed. The driving licence rates among young people between 18 and 24 years decreased both in Norway and in Sweden. The same trend has appeared in the big cities in Finland and also in the UK. At the same time, there has been a decline in young people's access to a car (defined as access to a car whenever you need one) in Norway and Sweden. A review of existing literature and analyses of transport use and attitudes to transport modes among young people was undertaken. The objective is to identify the most important barriers and determinants connected to transport mode choice today and identify the main challenges for future travel behaviour among young people. In what way will the trends among youth affect the use of local public transport, and how can the public transport sector meet these challenges? The findings indicate that the car does not have the same symbolic value as before among young people in the city areas. The development in the population's travel patterns show that people travel more, and the pattern of travel is becoming ever more differentiated. When young people choose transport mode, they look for a convenient way to organize their everyday life. The everyday life of many young people as structured consists of a set of different travel destinations; University, part time job, training, meeting friends at a café etc. Public transport users are not a homogenous group. Public transport users belong to groups in all categories, in all layers of society, with different needs and requirements with regard to travel and with different levels of willingness and capability to pay. Thus, public transport presents a major challenge with regard to developing a service which will meet the demands of these different groups. Developing a standard service designed to satisfy the needs of all groups may result in a poor service for the majority. If young people experience an inflexible and uncomfortable public transport supply not adjusted to their needs they will acquire a driving licence and buy a car as soon as they feel that their everyday trips are too complicated with public transport. For the covering abstract please see ITRD E135207.

Sakaria, Neela and Natalie Stehfest (2013). *TCRP Web-Only Document 61: Millennials and Mobility: Understanding the Millennial Mindset and New Opportunities for Transit Providers*. Transportation Board of the National Academies, Washington, D.C., [http:// http://www.trb.org/Main/Blurbs/169527.aspx](http://www.trb.org/Main/Blurbs/169527.aspx).

TRB's Transit Cooperative Research Program (TCRP) *Web-Only Document 61: Millennials and Mobility: Understanding the Millennial Mindset and New Opportunities for Transit Providers* is designed to help public transit providers increase ridership by better understanding Millennials lifestyle and mobility decision-making processes. A quantitative survey was used in the development of *TCRP Web-Only Document 61*. The survey focused on quantifying Millennials' mobility motivations and behaviors. Understand Millennials' lifestyle and decision-making processes with an emphasis on mobility (daily travel). Identify specific factors affecting Millennials' lifestyle decisions, including post-recession attitudes about the economy, heightened environmental awareness, a renewed interest in local communities, shifting social values amongst peers, new information technologies, urban attraction, and so on. • Identify how Millennials make their mobility decisions in a holistic way (e.g., considering all means of transportation: driving personal vehicles, public transit, other mobility options such as biking, walking, car-sharing, etc.), taking into account the effect of major life decisions on mobility choices (e.g., where to live, where to work). Additionally, understand how these considerations may change as Millennials progress through life stages. • Identify key hurdles and benefits of various mobility options, including accessibility, convenience, time, community/belongingness, fluidity with other mobility options (e.g., multi-modal transit), etc. • Uncover potential opportunities for public transit providers to increase ridership—by improving messaging, information access, service offerings/accessibility, etc.

Santos, Adelia, Nancy McGuckin, Hikari Yukiko Nakamoto, Danielle Gray and Susan Liss (2011). "**Summary of travel trends: 2009 national household travel survey**"

The 2009 National Household Travel Survey (NHTS) provides data to characterize daily personal travel patterns across the country. The survey includes demographic data on households, vehicles, people, and detailed information on daily travel by all modes of transportation. NHTS survey data is collected from a sample of households and expanded to provide national estimates of trips and miles of travel by travel mode, trip purpose, and other household attributes. When combined with historical data from the 1969,

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1977, 1983, 1990, and 1995 NPTS and the 2001 NHTS, the 2009 NHTS serves as a rich source of detailed travel data over time for users. This document highlights travel trends and commuting patterns in eight key areas - summary of travel and demographics, household travel, person travel, private vehicle travel, vehicle availability and usage, commute travel patterns, temporal distribution, and special populations.

Schoettle, Brandon and Michael Sivak (2014). "***The reasons for the recent decline in young driver licensing in the United States.***" Traffic Injury Prevention **15**(1): 6-9.

Objective: This survey examined why a substantial percentage of young adults currently do not have a driver's license and the future plans of this group concerning obtaining a license. Method: A questionnaire was developed to examine several issues related to an individual's decision not to obtain a driver's license. An online survey was conducted, yielding useable responses from 618 persons aged 18 to 39 without a driver's license. Results: The top 8 reasons for not having a driver's license were as follows: (1) too busy or not enough time to get a driver's license (determined by personal priorities), (2) owning and maintaining a vehicle is too expensive, (3) able to get transportation from others, (4) prefer to bike or walk, (5) prefer to use public transportation, (6) concerned about how driving impacts the environment, (7) able to communicate and/or conduct business online instead, and (8) disability/medical/vision problems. Of the respondents, 22% indicated that they plan to never obtain a driver's license. On the other hand, 69% expect to get a driver's license within the next 5 years. Young adults without a driver's license—in comparison with the general population of the same age—tend to have less education and higher unemployment. However, the present study was not designed to investigate whether there is a causal relationship or the direction of the effect if there were such a relationship.

Sen, Bisakha, Nitish Patidar and Sheikilya Thomas (2013). "***A Silver Lining to Higher Prices at the Pump? Gasoline Prices and Teen Driving Behaviors.***" American Journal of Health Promotion.

Abstract Purpose . Existing literature shows negative relationships between gasoline price and motor vehicle crashes, particularly among teens. This paper extends that literature by evaluating the relationship between gasoline price and self-reported risky driving among teens. Design . Observational study using multivariate empirical analysis, using pooled data from the Youth Risk Behavior Survey, waves 2003-2009. Setting . Secondary data from survey administered in private and public high schools across the United States. Subjects . Students in grades 9 through 12, surveyed biennially from 2003 to 2009 (n = 58,749). Measures . Outcomes are (self-reported) driving without seatbelts, driving after consuming alcohol, and moderate physical activity (like walking or bicycling). State-level retail gasoline prices constitute the main predictor variable. Analysis . Multivariate logistic models are estimated for the full sample, as well as by gender, race/ethnicity, and age. Individual characteristics, state unemployment, and state driving policies are controlled for. Standard errors are clustered at the state level. Results are reported in form of risk differences. Results . Higher gasoline prices are negatively and significantly associated with driving without seatbelts. Associations are particularly strong for males and minorities. There are fewer statistical associations between gasoline prices and driving after drinking. Higher gasoline prices are positively associated with more moderate physical activity. Conclusion . Higher gasoline prices are associated with less risky driving behaviors among teens, and they may be associated with more active forms of transportation, like walking and bicycling. The study limitations are discussed.

Shults, Ruth A and Allan F Williams (2013). "***Trends in driver licensing status and driving among high school seniors in the United States, 1996–2010.***" Journal of safety research **46**: 167-170.

The evolution of graduated licensing systems in the past 25 years has resulted in dramatic growth in research on this topic. The most recent summary reports have covered the period up to 2007. In the present article more recent and ongoing research is categorized, summarized, and discussed.

Sivak, M., Schoettle, B. (2013). "***Recent changes in the age composition of drivers in 15 countries.***" Traffic Injury Prevention **13:125-132**. . DOI: 10.1080/15389588.2011.638016

Objective: This study examined the recent changes in the percentage of persons with a driver's license in 15 countries as a function of age. Method: The countries included were Canada, Finland, Germany, Great Britain, Israel, Japan, Latvia, The Netherlands, Norway, Poland, South Korea, Spain, Sweden, Switzerland, and the United States. Results: The results indicate 2 patterns of change over time. In one pattern (observed for 8

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countries), there was a decrease in the percentage of young people with a driver's license, and an increase in the percentage of older people with a driver's license. In the other pattern (observed for the other 7 countries), there was an increase in the percentage of people with a driver's license in all age categories. A regression analysis was performed on the data for young drivers in the 15 countries to explore the relationship between licensing and a variety of societal parameters. Of particular note was the finding that a higher proportion of Internet users was associated with a lower licensure rate. Implications: The results of the analysis are consistent with the hypothesis that access to virtual contact reduces the need for actual contact among young people.

Sundquist, Eric 2013 **Report: Lower VMT Trend is Here to Stay** State Smart Transportation Initiative
www.ssti.us/2013/05/report-lower-vmt-trend-is-here-to-stay/

From the text: FHWA today released its monthly travel-volume trend summary, showing that for the first quarter of 2013, aggregate national VMT was down 0.8 percent and per-capita VMT was down 1.5 percent compared to the same quarter of 2012. Rolling 12-month figures were also down in both categories. The summary is just the latest evidence that Americans are driving less on average than they were a decade ago, and that even with population increases, total VMT is flat to slightly declining. But, given the long historic trend of consistently increasing vehicle miles traveled through the early 2000s, the question remains: Are we in a period of aberration that will eventually end, or has something really changed?

Taylor, B, K Ralph, E Blumenberg and M Smart (2013). Who Knows About Kids These Days? Analyzing the Determinants of Youth and Adult Mobility Between 1990 and 2009. Presented at 92nd Annual Meeting of the Transportation Research Board, Washington, D.C.

We know a great deal about the travel behavior of adults, and more recently about travel by children and the elderly, but what about teens and young adults? This question is particularly pressing because youth in the late 2000s and early 2010s (a) face the harshest economic climate in decades, which has caused much higher unemployment rates than among middle-aged adults and forced many young adults to return ("boomerang") home, (b) use information and communication technologies (ICTs) extensively, and considerably more than their elders, and (c) subject to increasingly stringent graduated driver's licensing (GDL) regulations. All are dramatic societal changes to be sure, but are they affecting youth travel behavior? And if so, how? To answer these questions we examine (1) how the travel behavior of youth compares to that of older adults, (2) whether the basic determinants of youth travel have changed over time, and (3) whether the societal changes described above affect youth travel behavior. To do this we analyzed nationwide personal mobility trends (measured as person-miles of travel (PMT)) between 1990 and 2009 and find that many key determinants of travel are similar for teens, young adults, and adults: being employed, licensed, having access to cars, and residential area population density all significantly affect PMT regardless of age. By contrast, some socio-economic factors long found to influence adult travel – such as race/ethnicity and household income – are not significant for today's teens. Finally, with the exception of employment, the effects of societal trends (ICTs, GDLs, and young adults "boomeranging" to live at home with parents) on youth travel are surprisingly muted. When it comes to recent changes in teen, youth, (and adult) travel behavior, the adage "it's the economy, stupid" appears to hold.

Zipcar and KRC Research (2010). "**Millennials and Driving: A Survey Commissioned by Zipcar (Nov.2010)**"
<http://www.slideshare.net/colleenmccormick/millennials-survey-5861342>

Key Findings: Millennials are consciously deciding to drive less A majority of millennials would reduce the amount of time they currently drive if alternative transportation options were available to them today The high cost of car ownership is making it difficult for millennials to own a car. Millennials are Choosing to Drive Less. In the past year, I have consciously made an effort to reduce how much I drive, and instead take public transportation, bike/walk or carpool when possible. If there were more options in my area, such as public transportation, car sharing or convenient carpooling, I would drive less than I do now. If there were more options in my area, such as public transportation, car sharing or convenient carpooling, I would drive less than I do now. Millennials Want Transportation Alternatives. Among post-college Millennials fully 67% would drive less if there were viable transportation alternatives. In today's economy, it can be difficult to own a car because of the high cost of gas, parking and maintenance. Cost Of Car Ownership A Key Barrier. With access to social networking sites such as Facebook and Twitter, text messaging and online gaming, I sometimes

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choose to spend time with friends online instead of driving to see them. Almost half of all 18 to 34-year-old drivers are driving less, and nearly two-thirds would drive less if alternative transportation options were available, according to an independent study commissioned by Zipcar, Inc., the world's largest car sharing service. The study of licensed drivers conducted in October by KRC Research revealed that 45 percent of Millennials (ages 18 to 34) said they had consciously made an effort to reduce how much they drive, and 64 percent would drive less if alternative options including public transportation, car sharing or convenient carpooling (ridesharing) were available in their area.

Zipcar and KRC Research (2011). "**Millennials & Driving: A Survey Commissioned by Zipcar November 2011 [Final]**" http://www.slideshare.net/Zipcar_Inc/millennial-slide-share-final .

Driving Deeper: The Millennials Survey. Online survey of 1,045 adults. Ages 18 and over, including 989 licensed drivers. Conducted between October 24 and 27, 2011. 2011 Key Findings. In 2011, Millennials embrace finding alternatives to driving to reduce their time on the road because high costs of car ownership, the environment and social networking. 4. Millennials are Choosing to Drive Less In the past year, I have consciously made an effort to reduce how much I drive, and instead take public transportation, bike/walk or carpool when possible. 5. Thinking Green, Driving Less I want to protect the environment, so I drive less. 6. Millennials Want Transportation Alternatives If there were more options in my area, such as public transportation, car sharing or convenient carpooling, I would drive less than I do now. 7. Cost Of Car Ownership A Key Barrier In today's economy, it can be difficult to own a car because of the high cost of gas, parking and maintenance. 8. A New Way of Socializing With access to social networking sites such as Facebook and Twitter, text messaging and online gaming, I sometimes choose to spend time with friends online instead of driving to see them. 9. Millennials Embrace Sharing Economy How likely are you to participate in each of the following sharing programs? (Media sharing Car sharing Home or vacation sharing programs 10. Millennials Share to Save And which of the following would motivate you most to participate in any sharing programs similar to the ones mentioned above? Saving for Paying off credit Being hassle free Protecting the Not sure retirement/home/coll.. card debt environment 11. Millennials Spend their Money Wisely And now imagine if you could save \$6,000 a year by not owning a car, what would you most likely spend the money you save on Saving the money Paying off credit Travel Paying-off school Buying a house card debt loans/other loans 12. Key Findings Year Over Year (2010 over 2011) More than half of Millennials, a higher proportion than last year, drive less because they want to protect the environment. Nearly seven in 10, more than last year say that they sometimes talk to friends online instead of driving to see them. Younger drivers remain the most committed to seeking alternatives to driving. Zipcar, Inc. (Nasdaq: ZIP), the world's leading car-sharing network, released its second annual independent study of Millennials (18-34-year olds), which examines this generation's attitudes toward personal transportation and car ownership. The Zipcar membership base ranges in age from 18 to 80s; however, Millennials are an important segment for Zipcar, comprising more than half of all members. Millennials account for about 23 percent of the general population, according to the 2010 US Census.

Zipcar and KRC Research (2013). "**Millennials & Technology A Survey Commissioned by Zipcar February 2013** " http://www.slideshare.net/Zipcar_Inc/millennial-slide-share-final-16812323

The Millennials Survey Online survey of 1,015 adults £ Ages 18 and over, including 980 licensed drivers £ Conducted between December 6 and 9, 2012.... 2012 Key Findings The increasing availability of on-demand mobility services (such as car sharing, ride sharing and vehicle sharing) helps many Millennials drive less and makes it easier to for them to live without owning a car. On-demand transportation options (transportation "apps") have a greater impact on Millennials' driving decisions than on the decisions of older generations. Technology, especially mobile devices, is more important to Millennials than a car. Traditional influences, like the high cost of car ownership and environmental concerns of driving, are compelling many Millennials to drive less. 4. Millennials are Choosing to Drive Less In the past year, I have consciously made an effort to reduce how much I drive, and instead take public transportation, bike/walk or carpool when possible. 5. Thinking Green I want to protect the environment, so I drive less. 6. Cost Of Car Ownership A Key Barrier In today's economy, it can be difficult to own a car because of the high cost of gas, parking and maintenance. 7. More Options If there were more options in my area, such as public transportation, car sharing or convenient carpooling, I would drive less than I do now. 8. A New Way of Socializing With access to social

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networking sites such as Facebook and Twitter, text messaging and online gaming, I sometimes choose to spend time with friends online instead of driving to see them.⁹ Teched Out How much more likely are you to purchase something online than to drive or take public transportation to a store? ¹⁰ Technology Wins In your daily routine, losing which piece of technology would have the greatest negative impact on you? TV Mobile phone Computer Car ¹¹ In your daily routine, losing which piece of Mobile Transportation technology would have the greatest negative impact you? To what extent have transportation apps (i.e. taxi apps, car rental reservations, public transportation info, car sharing, ride sharing, etc.) reduced your driving frequency? ¹² In your daily routine, losing which piece of Mobile Transportation technology would have the greatest negative impact on you? To what extent does the availability of transportation apps (i.e. taxi apps, car rental reservations, public transportation info, car sharing, ride sharing, etc.) make it easier to live without owning a car?

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Bibliography Theme 2: Long Distance Travel

bin Salam, Sakib and B. Starr McMullen (2012). Is there still a Southwest effect? *Transportation Research Record: Journal of the Transportation Research Board*, No. 2325. Transportation Research Board of the National Academies, Washington, D.C., pp. 1-8. <http://dx.doi.org/10.3141/2325-01>

The US airline industry is going through a period of consolidation through mergers between leading airlines. A number of recent mergers have been approved by the Antitrust Division of the Department of Justice (DOJ) based on the presence of Southwest Airlines in merger-affected markets. In doing so, the DOJ makes a key assumption that Southwest is unresponsive in its pricing strategy to the reduced competition when its competitors merge. Numerous studies have validated the so-called "Southwest Effect", where potential or actual entry by Southwest Airlines is associated with lower market fares. However, considerably less work has examined Southwest's post-entry pricing strategies. In this study, the authors find that Southwest raised fares more in markets affected by the Delta/Northwest and US/America-West mergers, between 2005-2010. However, Southwest's fares either decreased or rose by less if facing direct or adjacent competition from a low-cost carrier (LCC). Furthermore, Southwest is now merging with AirTran Airways, its biggest LCC competitor and the strongest deterrent to raising its prices in merger-affected markets. This implies that Southwest is no longer a suitable deterrent to post-merger fare hikes, particularly in the absence of other LCCs in those markets

Burge, Peter, Chong Woo Kim and Charlene Rohr (2011). "**Modelling Demand for Long-Distance Travel in Great Britain: Stated preference surveys to support the modelling of demand for high-speed rail**" http://www.rand.org/content/dam/rand/pubs/technical_reports/2011/RAND_TR899.pdf

In order to examine a number of policy interventions (including demand for high-speed rail (HSR)), among policies which will influence long-distance automobile, classic railroad and air travel demand, the United Kingdom Department for Transport is developing a model to predict passenger demand for long-distance travel. Long-distance journeys are defined as (one-way) trips of over 50 miles. In the summer of 2008, a study was conducted to explore the feasibility of developing a multi-modal model of long-distance travel. Since then, National Travel Survey (NTS) data on long-distance travel were used to estimate the travel demand model. This was considered to be phases 1 and 2 of model development. In the Phase 2 study it was recommended that a Stated Preference (SP) study be conducted to provide more recent evidence on the likelihood of automobile, classic railroad and air travelers to transfer to HSR. This required SP surveys with automobile, classic railroad and air travelers who have undertaken long-distance journeys. The specific objectives of the SP study were to: 1. collect background information on a recently traveled long-distance trip; 2. in the context of that trip, provide (parameter) values for the different service components in the mode choice modeling process that underlies the travel demand forecasts; 3. quantify where HSR fits in the modal choice schema; 4. collect background information on travelers' travel preferences, socioeconomic characteristics, and attitudes and, in addition, quantify the impacts of these variables on the demand for HSR.

Carreira, R., L. Patrício, R. Natal Jorge and C. Magee (2014). "**Understanding the travel experience and its impact on attitudes, emotions and loyalty towards the transportation provider-A quantitative study with mid-distance bus trips.**" *Transport Policy* **31**: 35-46. 10.1016/j.tranpol.2013.11.006 <http://www.sciopus.com/inward/record.url?eid=2-s2.0->

Enhancing the travel experience has become a crucial consideration for transportation companies to promote differentiation and customer loyalty. Therefore, transport planners, providers and manufacturers in general are becoming aware of the significance of understanding the passenger experience better, in order to improve transit policies, management and vehicles. The holistic perspective of the travel experience is conceptualized as involving: (1) a thorough set of passenger internal responses (e.g. cognitive and emotional) that are driven by experience factors, some of which are (2) aspects that are not in complete control of the transportation provider, such as waiting areas or the social environment, during (3) all the moments before, throughout and after the trip. Although transportation research has studied the different aspects of transportation quality, empirical studies with such a broad approach to the travel experience and

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its impact on loyalty are still scarce. This article takes a scale development approach to conceptualize, develop and test a multiple-item scale for measuring the travel experience from the defined holistic perspective, analyzing its perceptual dimensions and outcomes based on a quantitative study with 1226 passengers of a mid-distance bus transportation service. The travel experience scale demonstrates good psychometric properties and consists of 28 items aggregated into seven dimensions or experience factors: individual space, information provision, staff's skills, social environment, vehicle maintenance, off-board facilities, and ticket line service. The study shows that all seven experience factors have a significant impact on customer cognitive, emotional and behavioral responses to the transportation service, highlighting the importance of a broad approach to the study and management of the travel experience. The classical dimensions of individual comfort and vehicle maintenance are the ones with the strongest impact on experience outcomes, showing that transportation providers should maintain a strong focus on providing a good core service. However, other factors such as the social environment have an influence on emotions, which in turn affect loyalty to the transportation provider. These results show the need for a careful study and management of the different aspects of the travel experience, and an integrated design and management of the transport system as a whole. © 2013 Published by Elsevier Ltd.

Fischer, L and J Schwieterman (2011). ***"Who Rides Curbside Buses? A passenger survey of discount curbside bus services in six Eastern and Midwestern cities"***.

This study summarizes the results of a survey of passengers using "curbside" bus lines such as BoltBus and Megabus.com ("Megabus") in order to foster a greater understanding of the composition and preferences of the travelers these companies serve. This survey, to our knowledge, marks the first systematic attempt to evaluate the ridership of these discount operators and explore the changes in travel behavior engendered by their services. In addition to identifying some of the characteristics of the passengers served on these intercity carriers, this report compares these characteristics with passengers using conventional bus lines such as Greyhound. The timing for this report is notable due to the rapid expansion by BoltBus and Megabus as well as a rising visibility of smaller operators such as DC2NY Bus in recent years. These carriers are making curbside service an increasingly significant force in cities in the East and Midwest and providing a new travel option to millions of consumers. Since Megabus launched its Chicago hub in 2006, followed by a major expansion along with that of rival BoltBus in the New York region during 2008, the sector has grown to more than 400 daily bus operations serving 60 cities in 17 states. Curbside bus companies have attracted publicity for their steeply discounted fares, free wireless internet, and express services on routes that had seen little new service in decades. Although some routes had already seen the entry of so-called "Chinatown Operators"—bus lines, typically operated by Asian owned businesses, between the Chinatown districts of major cities—other routes filled a void that had left travelers with few options besides private automobile. Unlike conventional operators such as Greyhound and Trailways, curbside operators generally arrive and depart from designated curb locations along city streets, typically near the center of town. Another key difference between the curbside carriers and traditional bus lines is the absence of ticket counters (curbside operators rely almost entirely on online ticket sales) and waiting rooms at departure locations. The sector's robust growth comes in the wake of more than forty years of retrenchment in the intercity bus sector. Starting in the late 1950s and continuing until the early 2000s, the sagging image of bus travel, the rising availability of private automobiles and low-fare air services, and the deterioration of downtown districts took their toll. By the 1990s, many middle- and upper-income consumers considered the intercity bus a mode of last resort. Even after the terrorist acts of 9/11, which made air travel less convenient, the intercity bus continued its slump. Only recently, on account of the emergence and expansion of curbside operators and a general recovery at Greyhound and other conventional lines, has a genuine turnaround occurred.

Frick, Roman and Bente Grimm (2014). ***"Long Distance Mobility, Current Trends and Future Prospectives"*** IFMO, Institute for Mobility Research

While in recent years mobility in the context of everyday life has almost stagnated in central Europe, long-distance mobility continues to grow substantially. Against this background, the study at hand presents the lie of the land with regard to current trends in and future perspectives of long-distance mobility in central Europe, with a particular focus on Germany. In speaking of long-distance mobility, the study refers to all trips longer than 100 km (one-way). The demand for long-distance mobility is likely to grow further in the mid-term future. Hence, the proportion of the total passenger mileage in Germany that is long-distance will

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grow, and its relevance increase. However, long-distance mobility up to a range of a few hundred kilometres in particular is characterised by growth, whereas there are signs of stagnation when it comes to journeys longer than these, to very distant destinations. The segments of long-distance mobility which are currently growing most substantially – and which are expected to continue to do so in the mid-term future – are business trips, and long-distance trips undertaken in the context of everyday life, for example long-distance commuting. Important driving factors for this development are demographic trends and the evolution of settlement patterns, both of which also promote multi-local lifestyles. As the economy continues to globalise, and jobs become more and more specialised, business travel in particular – which accounts for about one-fifth of total long-distance passenger mileage today – continues to grow. In addition, personal day trips have grown in recent years, and now represent a quarter of the German population's long-distance mileage. These growing segments of long-distance mobility are conducive to surface transport. Rail and bus transport profit the most from these developments, but use of the car is also shifting from urban/local travel towards longer-distance trips. The segment representing long-distance trips to very distant destinations is dominated by holiday travel, which accounts for a third of the long-distance passenger mileage and thus represents the largest segment of long-distance mobility by Germans. However, in the last ten years little has changed in this segment with regard to the number of trips, the average trip distance, or the choice of transport modes. Against the background of the modest demographic changes and low-level economic growth in central Europe, holiday travel demand will likely only grow a little in the coming years, if at all. Moreover, the share of holiday trips taken by air has not grown substantially in the last few years. In contrast, air traffic in Germany continues to grow; this, however, is increasingly driven by growing air travel involving passengers from other regions of the world.

Kisia, Duncan, Nichola Angel and Todd Goldman (2014). "***Planes, Trains and Ground Access Models –Lessons from a Revealed Preference Study of Air Passengers in the New York/New Jersey Metropolitan Region***"

Airport ground access mode choice models can provide a great deal of utility for airport facility managers tasked with landside access planning. However, the absence of definitive standards to guide the development of these often results in wide variations in mode choice model parameters that often lead to improper understanding of the air passenger ground access trip that is uniquely distinguished from the traditional set of trips analyzed by regional travel demand models. The Port Authority and its partner agencies have used a variety of models to explore airport ground access mode choice in recent years. While some of these studies have been built upon earlier efforts, none produced a general-purpose, region-wide airport ground transportation access model in a form that could be maintained for on ongoing use. An opportunity to develop such a model arose in late 2010, when the Port Authority partnered with other regional planning agencies to develop a comprehensive model of airport ground access mode choice for the region. A set of ground access mode choice models was developed using data from the 2005 Regional Air Service Demand Study commissioned by the FAA (Federal Aviation Administration). A careful analysis of this data and the application of some unconventional model estimation techniques revealed a number of new and interesting findings regarding the characterization of air passenger attitudes towards travel time and cost. These findings are believed to have broader applicability beyond the geographic boundaries of the New York Metropolitan Region and could further enrich the existing literature on ground access mode choice modeling for major airports.

Klein, N. (2009). Emergent Curbside Intercity Bus Industry: Chinatown and Beyond. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2111. Transportation Research Board of the National Academies, Washington, D.C. pp. 83-89.

The first study of the emerging curbside intercity bus industry, commonly called the Chinatown bus, is presented. The study of this relatively unknown industry addresses three research questions. First, why and how did the intercity curbside bus industry develop? Second, what services are operated by the curbside carriers and how do these services compare with competing travel options? Finally, how do the economics of operating curbside buses differ from those of traditional bus companies? The research speaks to policy questions about the appropriate role of regulation in transportation and the competition between private and public transportation providers. The findings indicate that in the past 10 years, curbside buses have grown to become an important transportation provider in the Northeast Corridor: more than 2,500 low-fare bus trips per week connect New York City to Washington, D.C.; Philadelphia, Pennsylvania; and Boston,

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Massachusetts. More than 100 buses depart each week to more than 30 other cities, traveling as far as Atlanta, Georgia, and Toronto, Canada. Traditional bus companies, such as Greyhound Lines and Peter Pan, have begun their own curbside intercity bus services either to mitigate the competition from new companies or because they recognize the competitive advantages of curbside operations. It is found that curbside bus operations offer significant cost savings compared with traditional bus services by lowering labor costs and avoiding terminal fees, although at the cost of limited accessibility for disabled passengers, reduced passenger safety, and other social concerns.

Lee, Brian H. Y., Matthew Coogan and Thomas Adler (2014). "***The Application of Attitude-Based Latent Factors in Analyzing Public Modal Shares of Inter-City Travel in Northeastern Rural Regions.***" Spires Program. University of Vermont, Transportation Research Center

The aims of this proposed research effort are twofold. First, little is known about inter-city travel behaviors in rural regions; this research will help fill that gap in the literature by examining trips and trip making behaviors between cities in Northern New England and New York and, in particular, travels with at least one end in a rural area and those between smaller communities. Second, there have been several new research approaches developed for incorporating attitudinal and behavioral components to the travel demand forecast and analysis process; this research will serve as the foundation for a line of research efforts to merge a number of these strains of emerging research in the literature into one comprehensive study. While there is some consensus in the literature that attitudes and beliefs should be fully integrated into the analysis of travel behavior, there is less consensus on just how that should be done. The present project will focus on exploring the fundamental nature of this problem. The research team will examine different market segmentation techniques. Further, there is strong evidence that combining market segmentation with the Theory of Planned Behavior, a theoretical foundation for a broad range of research on behavioral outcomes in social psychology, will allow the incorporation of a wide variety of attitudes and beliefs into models that examine alternative behavioral explanations. Both a priori segmentation schemes, as well as post hoc determinations of market segments using latent class analysis techniques will be considered in the exploration of different market segmentations. The aims of this proposed research effort are twofold. First, little is known about inter-city travel behaviors in rural regions; this research will help fill that gap in the literature by examining trips and trip making behaviors between cities in Northern New England and New York and, in particular, travels with at least one end in a rural area and those between smaller communities. Second, there have been several new research approaches developed for incorporating attitudinal and behavioral components to the travel demand forecast and analysis process; this research will serve as the foundation for a line of research efforts to merge a number of these strains of emerging research in the literature into one comprehensive study.

Nordlund, Annika and Kerstin Westin (2013). "***Influence of values, beliefs, and age on intention to travel by a new railway line under construction in northern Sweden.***" Transportation Research Part A: Policy and Practice **48**: 86-95.

The aim is to investigate determinants of intentions to use a new railway line under construction in the northern Sweden. To this end a test was made of a two-part hierarchical model of train-use intentions positing influences from general values and beliefs as well as specific beliefs about the new railway line. A questionnaire was sent to a randomly selected sample of 1238 citizens residing in seven municipalities along the new railway line. In order to also investigate potential generation differences participants were sampled in four age groups, young adults, young middle-aged, middle-aged, and pensioners. The results supported the proposed hierarchical model showing that general values and beliefs influence intentions primarily through the specific beliefs about the railway line. In addition, the results showed that the youngest age group is more open to change and has stronger intentions to use the new railway.

Resource-Systems-Group, Inc., M. Coogan, CONEG Policy Research Center, D. Brand, M Hansen, H Kivett, J Last, R Marchi, M. S Ryerson, M. Jordan Taylor and L. Thompson (2014). *ACRP Report 118: Integrating Aviation and Passenger Rail Planning*. Transportation Research Board of the National Academies, Washington, D.C.

The objectives of this research are to (1) provide guidance to airport and rail operators, state and regional transportation planners, elected officials, and interested stakeholders that identifies planning process

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options, funding challenges, and potential actions; and (2) develop methods and tools necessary to improve integration of rail services with airports, particularly in congested corridors. As part of this process, it is important to (a) identify the challenges involved in a variety of institutional settings in different regions and develop ways to better integrate inter-agency planning processes; (b) identify specific site planning and service coordination actions to promote air/rail transfers; (c) define the data and analysis capabilities needed to determine the feasibility and effectiveness of improved integration of air and rail services; and (d) develop and demonstrate the application of methods and tools to support integrated planning for air and rail services and decision making.

Resource-Systems-Group, M. Coogan, M Hansen, M S Ryerson, L Kiernan, J Last, R Marchi and R Yatzek (2010). *ACRP Report 31: Innovative Approaches to Addressing Aviation Capacity Issues in Coastal Mega-regions*. Transportation Research Board of the National Academies, Washington, D.C. <http://www.trb.org/Publications/Blurbs/163311.aspx>

This report examines the aviation capacity issues in the two coastal mega-regions located along the East and West coasts of the United States. The report suggests integrated strategic actions to enhance decision making to address the constrained aviation system capacity and growing travel demand in the high-density, multijurisdictional, multimodal, coastal mega-regions. New and innovative processes are needed if the aviation capacity issues in these congested coastal mega-regions are going to be successfully addressed. These high-density areas invite an entirely new approach for planning and decision making that goes beyond the existing practice for transportation planning and programming that is usually accomplished within single travel modes and political jurisdictions or regions. This research will be useful for airport operators, regional transportation planners, and transportation agencies, as well as public officials at the federal, state, and local levels and other stakeholders involved in dealing with aviation capacity issues in the coastal mega-regions.

Ripplinger, David, Jeremy Mattson and Del Peterson (2011). "***Travel Behavior of the Lone Rangers: An Application of Attitudinal Structural Equation Modeling to Intercity Transportation Market Segmentation.***" Small Urban and Rural Transit Center, Upper Great Plains Transportation Institute, North Dakota State University. <http://www.ugpti.org/pubs/pdf/DP239.pdf>

Travel behavior information is valuable to transportation policymakers, planners, and service providers. While aggregate data are helpful, segmenting a market into smaller groups allows for more targeted planning, promotion, operation, and evaluation. In this study, intercity market segments based on traveler attitudes are identified using structural equation modeling (SEM). The study focuses on rural and small urban areas, using survey data for residents of North Dakota and west central and northwest Minnesota. Attitudes toward travel time, flexibility, and privacy are found to have the strongest explanatory power. The socioeconomic profile of each market segment is identified. Individuals living in the study's upper Midwest market area are assigned to market segments based on their socioeconomic characteristics to determine market segment size. Mode shares for automobile, air, intercity bus, intercity rail, and van service are estimated for each market segment. Intercity bus and train mode shares are predicted to double in each market segment when travel speeds are increased to those experienced by automobile travelers.

Schwieterman, J and L. Fischer (2011). "***Variations in the Rates of Passenger Usage of Portable Technology on Intercity Buses, Trains and Planes: Implications for Transportation Planning.***" *Journal of Transportation Law, Logistics and Policy* 78(1).

In recent years, the use of portable electronic devices by passengers on intercity transportation services has risen markedly. Transportation providers support the use of such devices by installing Wi-Fi systems, power outlets, and cellular telephone signal boosters for passenger use. To fill a void in research about the effects of portable electronic technology on intercity travel behavior, this study evaluates newly collected data for 7,028 passengers on 96 bus, train, and air trips in 14 states. The paper explores how usage differs by mode and time of day as well as the implications that these differences have on various sectors of the U.S. transportation system. Interpreted broadly, the research findings suggest that the ability to use portable electronics may be a factor offsetting the longer travel times associated with certain bus and train trips, and provides a new incentive for travelers to use transportation services that operate to and from the downtown areas of major cities.

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Schwieterman, Joseph, M. Schulz, B. Antolin and Michel. M. (2015). "**Adding on Amenities, Broadening the Base: 2014 Year-in-Review: Intercity Bus Service in the United States.**" Chaddick Institute for Metropolitan Development, DePaul University.

Scott, Marcia , Eileen Collins and Arthur Wicks (2013). "**Curbside Intercity Bus Industry: Research of Transportation Policy Opportunities and Challenges.**" University of Delaware, University Transportation Center.

This report from the Institute for Public Administration (IPA) at the University of Delaware (UD) serves to document the industry's unprecedented growth and related transportation policy issues within the Northeast Corridor. With project support from the University of Delaware University Transportation Center (UD-UTC), the team conducted a literature review on the intercity bus industry, a field assessment of curbside operations, survey of passengers, and a June 13, 2012 Curbside Intercity Bus Transportation Policy Forum for industry stakeholders. A case study on a local Chinatown bus company was also conducted to spotlight the alarming industry issue of reincarnated carriers—companies that have been shut down by the federal government for violating laws and regulations, yet defy enforcement by continuing to operate under other names or companies.

Sperry, Benjamin R. and Curtis A. Morgan (2011). "**How Fast Is a Fast Train? Comparing Attitudes and Preferences for Improved Passenger Rail Service among Urban Areas in the South Central High-Speed Rail Corridor**" <http://swuttc.tamu.edu/publications/technicalreports/161003-1.pdf>

High-speed passenger rail is seen by many in the U.S. transportation policy and planning communities as an ideal solution for fast, safe, and resource-efficient mobility in high-demand intercity corridors between 100 and 500 miles in total endpoint-to-endpoint length. As the nation moves forward with a significant investment to improve its intercity passenger rail system, a number of planning and policy barriers still exist, making it difficult to fully realize the anticipated benefits of high-speed passenger rail. Using data from an Internet-based survey of residents in three communities in Central Texas—Waco, Temple, and Hillsboro—this research project examined the potential impacts of new intercity passenger rail service on small- or medium-sized communities located in the intermediate area between two larger urban areas that form the endpoints of a federally designated intercity high-speed rail corridor. Responses from more than 1,000 surveyed residents found that residents' attitudes toward new intercity passenger rail service are generally favorable and that trains could be used instead of automobiles for some intercity trips. The project's findings provide a foundation for later investment-grade ridership studies in the corridor and have potential applications in planning for intercity passenger rail and transportation policy development.

Steer-Davies-Gleave (2011). "**HSIPR Best Practices: Ridership and Revenue Forecasting.**"

This report provides a high-level description of the steps typically involved in forecasting the ridership and revenue of a high-speed/intercity passenger rail (HSIPR) service. While particular studies may, for a variety of reasons, use approaches and methods that differ somewhat from those described here, the description here is believed to be an accurate representation of current standard practice in HSIPR forecasting. The report is intended for non-specialists who may be called upon to review HSIPR ridership forecasting studies prepared by others. It provides information on the range of data and methods used in HSIPR forecasting at different stages of study, and flags particular areas or subjects that will generally require in depth examination by subject area experts. The intent is to provide information and guidance that will assist generalist reviewers to understand and evaluate forecasting studies. Similar reports have been prepared in the areas of HSIPR public benefits assessment and operating cost estimation. It should be noted that, in a HSIPR study, forecasts will typically be prepared for both a "build" situation that includes the proposed project, as well as a "no-build" situation without the project. The specific definition of the no-build situation needs to be agreed with study reviewers. Project benefits and costs are generally defined in terms of differences between the two situations.

Walsh, M. (2000). **Making Connections: The Long-Distance Bus Industry in the USA.** , Ashgate, Aldershot, UK
Making Connections examines the varied paths of the American intercity bus industry from its origins in the second decade of the twentieth century to deregulation in 1982. This sector of transport has been much neglected by historians and this book uncovers a range of useful and pertinent information to those who are interested in understanding entrepreneurial endeavours, patterns of mobility and consumer attitudes. It

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analyses the development of the national industry, probes the growth of particular companies and investigates specific aspects of business behaviour. The book is presented as a series of focused essays which offer insights into such topics as regulation, marketing, gender patterns and intermodal competition. It draws on diverse archival materials, government surveys and findings, trade publications, interviews and photographs. A wide-ranging bibliographical essay offers a guide to available sources. Making Connections is a valuable contribution to filling one of the gaps in American economic and social history.

Wardman, Mark, Abigail Bristow, Jeremy Toner and Geoff Tweddle (2002). "**Review of research relevant to rail competition for short haul air routes.**" *Transport Policy* 2(3): 153-158.

This report addresses several loosely related subjects associated with an envisaged sustainable growth of the aviation sector. As well as examining the issue of replacing some air routes with high-speed rail, this study informs on the state of research for valuing the environmental effects of transport. It also looks at how certain aspects of the air market have stimulated demand on some routes, in particular the impact of low cost carriers and the practice of hubbing by the major operators.

3. Attitudinal Theories Applied to Transportation

Bibliography Theme 3: Attitudinal Theories Applied to Transportation

Aarts, Henk, Bas Verplanken and Ad Van Knippenberg (1997). "**Habit and information use in travel mode choices.**" Acta Psychologica **96**(1): 1-14.

This study focuses on the role of habit in the process of information use underlying daily travel mode choices. Based on the 'policy capturing' paradigm, eighty-two students performed a multiattribute travel mode judgment task, in which they could use information about travel circumstances in order to make a number of judgments. Measures of information use were obtained by performing multiple regression analyses for each subject. It was found that habit reduced the elaborateness of information use in judgments of travel mode use. This effect was independent of effects of manipulated accountability demands.

Ajzen, Icek (1991). "**The theory of planned behavior.**" Organizational Behavior and Human Decision Processes **50**(2): 179-211. [http://dx.doi.org/10.1016/0749-5978\(91\)90020-T](http://dx.doi.org/10.1016/0749-5978(91)90020-T)

Research dealing with various aspects of the theory of planned behavior (Ajzen, 1985, 1987) is reviewed, and some unresolved issues are discussed. In broad terms, the theory is found to be well supported by empirical evidence. Intentions to perform behaviors of different kinds can be predicted with high accuracy from attitudes toward the behavior, subjective norms, and perceived behavioral control; and these intentions, together with perceptions of behavioral control, account for considerable variance in actual behavior. Attitudes, subjective norms, and perceived behavioral control are shown to be related to appropriate sets of salient behavioral, normative, and control beliefs about the behavior, but the exact nature of these relations is still uncertain. Expectancy-value formulations are found to be only partly successful in dealing with these relations. Optimal rescaling of expectancy and value measures is offered as a means of dealing with measurement limitations. Finally, inclusion of past behavior in the prediction equation is shown to provide a means of testing the theory's sufficiency, another issue that remains unresolved. The limited available evidence concerning this question shows that the theory is predicting behavior quite well in comparison to the ceiling imposed by behavioral reliability.

Anable, Jillian and Birgitta Gatersleben (2005). "**All work and no play? The role of instrumental and affective factors in work and leisure journeys by different travel modes.**" Transportation Research Part A: Policy and Practice **39**(2-3): 163-181. <http://dx.doi.org/10.1016/j.tra.2004.09.008>

This paper examines the relative importance that people attach to various instrumental and affective journey attributes when travelling either for work or for a leisure day trip and presents how journeys by various travel modes score on these attributes. Although not a comparative paper, data are presented for two studies which used some identical measurements: one on commuter journeys and one on leisure journeys. The results show that for work journeys, respondents tend to attach more importance to instrumental aspects, and especially to convenience than to affective factors. For leisure journeys, however, respondents appear to attach almost equal importance to instrumental and affective aspects, particularly flexibility, convenience, relaxation, a sense of freedom and 'no stress'. Each study also examines (i) how regular users' evaluate their own mode and (ii) how car users perceive the performance of alternative modes compared to their importance ratings. This 'gap' analysis reveals on which modes and for which attributes the greatest deficiencies in performance lie. The data for both the work and leisure studies shows that for car users, alternative transport modes are inferior on the salient attributes such as convenience and flexibility even though car users rate modes such as walking and cycling as performing well, if not better, on less important attributes such as the environment, health and even excitement. Nevertheless, for those who cycle and walk regularly, satisfaction with their own travel mode as measured by the gap between importance and performance on salient attributes is better than for those who mostly use the car. Conclusions are made as to how greater attention to affective factors may improve our understanding of mode choice.

Backer-Grøndahl, A., A. Fyhri, P. Ulleberg and A. H. Amundsen (2009). "**Accidents and unpleasant incidents: Worry in transport and prediction of travel behavior.**" Risk Analysis **29**(9): 1217-1226. 10.1111/j.1539-6924.2009.01266.x <http://www.scopus.com/inward/record.url?eid=2-s2.0-69049091999&partnerID=40&md5=1a7d198305fab835d893eaeaaeda599e>

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Worry on nine different means of transport was measured in a Norwegian sample of 853 respondents. The main aim of the study was to investigate differences in worry about accidents and worry about unpleasant incidents, and how these two sorts of worry relate to various means of transport as well as transport behavior. Factor analyses of worry about accidents suggested a division between rail transport, road transport, and nonmotorized transport, whereas analyses of worry about unpleasant incidents suggested a division between transport modes where you interact with other people and "private" transport modes. Moreover, mean ratings of worry showed that respondents worried more about accidents than unpleasant incidents on private transport modes, and more about unpleasant incidents than accidents on public transport modes. Support for the distinction between worry about accidents and unpleasant incidents was also found when investigating relationships between both types of worry and behavioral adaptations: worry about accidents was more important than worry about unpleasant incidents in relation to behavioral adaptations on private means of transport, whereas the opposite was true for public means of transport. Finally, predictors of worry were investigated. The models of worry about accidents and worry about unpleasant incidents differed as to what predictors turned out significant. Knowledge about peoples' worries on different means of transport is important with regard to understanding and influencing transport and travel behavior, as well as attending to commuters' welfare. © 2009 Society for Risk Analysis.

Bamberg, Sebastian, Icek Ajzen and Peter Schmidt (2003). "**Choice of travel mode in the theory of planned behavior: The roles of past behavior, habit, and reasoned action.**" Basic and applied social psychology 25(3): 175-187.

Relying on the theory of planned behavior (Ajzen, 1991), a longitudinal study investigated the effects of an intervention-introduction of a prepaid bus ticket-on increased bus use among college students. In this context, the logic of the proposition that past behavior is the best predictor of later behavior was also examined. The intervention was found to influence attitudes toward bus use, subjective norms, and perceptions of behavioral control and, consistent with the theory, to affect intentions and behavior in the desired direction. Furthermore, the theory afforded accurate prediction of intention and behavior both before and after the intervention. In contrast, a measure of past behavior improved prediction of travel mode prior to the intervention, but lost its predictive utility for behavior following the intervention. In a test of the proposition that the effect of past on later behavior is due to habit formation, an independent measure of habit failed to mediate the effects of past on later behavior. It is concluded that choice of travel mode is largely a reasoned decision; that this decision can be affected by interventions that produce change in attitudes, subjective norms, and perceptions of behavioral control; and that past travel choice contributes to the prediction of later behavior only if circumstances remain relatively stable.

Bamberg, S. and P. Schmidt (2003). "**Incentives, morality, or habit? Predicting students' car use for University routes with the models of Ajzen, Schwartz, and Triandis.**" Environment and Behavior 35(2): 264-285. 10.1177/0013916502250134 <http://www.scopus.com/inward/record.url?eid=2-s2.0-0037370179&partnerID=40&md5=76b10f8e6fdb968a219152a55eedc78b>

The predictive power of the Ajzen, Triandis, and Schwartz models are compared in the context of car use for university routes. Two hundred fifty-four students filled out a questionnaire designed to measure the components of the three models. In the prediction of intention to use a car, results indicated that one variable from the Triandis model-role beliefs-increased the explanatory power offered by the components of the Ajzen model. In the prediction of self-reported car use, one variable of the Triandis model-car use habit-significantly increased the predictive power of the Ajzen model. The central variable of the Schwartz model-personal norm-exerted no significant effect either on intention or on behavior. The implications of the findings for interventions to reduce the car use of students for university routes are discussed.

Collins, Christy M and Susan M Chambers (2005). "**Psychological and situational influences on commuter-transport-mode choice.**" Environment and Behavior 37(5): 640-661.

The relative importance and relationship between psychological and situational factors in predicting commuter-transport-mode choice was tested by four hypotheses. First, the influence of individuals' values on commuter behavior is mediated by their corresponding beliefs about the environmental threat of cars (mediation hypothesis). Second, the influence of these beliefs on behavior is moderated by individual consideration of future consequences and control beliefs (moderation hypothesis). Third, cost, time, and

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access factors contribute to individuals' commuter choice (situational hypothesis). Fourth, situational and psychological factors jointly influence proenvironmental behavior (interaction hypothesis). A sample of 205 Australian university students completed a survey to measure these relationships. Regression analyses indicated support for the mediation, situational, and interaction hypotheses. It was concluded that to achieve a transport-mode shift to public transport, public policy strategies should focus on individuals' transport-related environmental beliefs (personal control and environmental effect of cars) and situations (access to public transport at reduced cost).

Dobson, Ricardo, Frederick Dunbar, Caroline J Smith, David Reibstein and Christopher Lovelock (1978). **"Structural models for the analysis of traveler attitude-behavior relationships."** *Transportation* 7(4): 351-363.

Traveler attitudes and behavior have been shown to correlate in numerous previous studies. However, the correlation by itself leaves open the nature of the interrelationships between traveler attitudes and behavior. For example, attitudes could either cause or be caused by behavior. In fact, both options are concurrently possible. Structural equations are applied to a set of data gathered from Los Angeles central business district workers to ascertain the direction and nature of interrelationships between attitudes and behavior with respect to frequency of taking the bus to work. A mutual dependence between attitudes and behavior is demonstrated in the context of this dataset and behavioral choice situation; behavior and attitudes concurrently cause each other. In addition, it is found that two attitudinal components, perceptions of and affect toward a mode, function differently with respect to travel behavior.

Donald, I. J., S. R. Cooper and S. M. Conchie (2014). **"An extended theory of planned behaviour model of the psychological factors affecting commuters' transport mode use."** *Journal of Environmental Psychology* 40: 39-48. 10.1016/j.jenvp.2014.03.003 <http://www.scopus.com/inward/record.url?eid=2-s2.0-84902473003&partnerID=40&md5=1040832481ce5699cd6da426e8b28d0e>

The present study tested an extended theory of planned behaviour (TPB) model within the domain of transport mode choice and identified the most important factors impacting on whether participants drove or used public transport to commute to work. Structural equation modelling of data from 827 participants showed that car use was determined by intention and habit but not perceived behavioural control (PBC), whereas public transport use was influenced solely by intention. The analysis also revealed that TPB variables (attitude, subjective norm and PBC) influenced use of both transport modes indirectly through their effects on intention and habit. In contrast, the incremental validity of variables not contained in the model (moral norm, descriptive norm and environmental concern) was mixed and varied according to transport mode. Theoretical and applied implications of the findings are discussed. © 2014 Elsevier Ltd.

Dong, Zhi, Linbo Li, Bing Wu and Shanshan Zhao (2011). **"Analyzing Public Transportation Use Behavior Based on the Theory of Planned Behavior: To What Extent Does Attitude Explain the Behavior?"**. ICCTP 2011, 11th International Conference of Chinese Transportation Professionals (ICCTP) Nanjing, China August 14-17, 2011. <http://ascelibrary.org/doi/abs/10.1061/41186%28421%2943>

Based on the theory of planned behavior (TPB) and its approach of investigation, this paper explores the psychological factors influencing public transport use behavior. Questionnaires containing TPB variables such as intention, attitude, subjective norm and perceived behavioral control are designed and SPSS is used to analyze the relationships among the variables. Correlation analysis and regression models show TPB can well explain public transport use. The behavior is positively correlated with intention and attitude and high coefficients are obtained by regression. People with more positive attitudes will have higher intention and be more inclined to use public transport. Attitude is then actively affected by speed, freedom, convenience and other qualities of a travel mode. The conclusions can help transport planning and management to better understand travelers' behaviors and psychological demands and then formulate corresponding policies so as to enhance the competitiveness of public transport.

Evans, Gary W. and Richard E. Wener (2007). **"Crowding and personal space invasion on the train: Please don't make me sit in the middle."** *Journal of Environmental Psychology* 27(1): 90-94. <http://dx.doi.org/10.1016/j.jenvp.2006.10.002> <http://www.sciencedirect.com/science/article/pii/S0272494406000636>

Mass transit users frequently experience crowding during their commutes. In this study of 139 urban

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passenger train commuters during rush hour, we found that the density of the train car was inconsequential for multiple indices (self-report, salivary cortisol, performance aftereffects) of stress whereas the immediate seating density proximate to the passenger significantly affected all three indices. When people had to sit close to other passengers, they experienced adverse reactions. These results are consistent with prior work indicating that individual spacing among persons that leads to personal space invasions is a more salient environmental condition than density per se. The findings also have implications for the design of mass transit vehicles.

Fielding, Kelly S., Rachel McDonald and Winnifred R. Louis (2008). "***Theory of planned behaviour, identity and intentions to engage in environmental activism.***" Journal of Environmental Psychology **28**(4): 318-326.

<http://dx.doi.org/10.1016/j.jenvp.2008.03.003>

This study incorporated identity constructs into the theory of planned behaviour (TPB) to investigate intentions to engage in environmental activism. First year students and participants of a students of sustainability conference (n=169) were administered a questionnaire survey that measured standard TPB constructs as well as environmental group membership and self-identity as an environmental activist. Consistent with predictions, environmental group membership and self-identity were positive predictors of intentions. Thus, greater involvement in environmental groups and a stronger sense of the self as an environmental activist were associated with stronger intentions to engage in environmental activism. There was also evidence that self-identity was a stronger predictor of intentions for participants with low rather than high environmental group membership. In accordance with the standard TPB model, participants with more positive attitudes toward and a greater sense of normative support for environmental activism also had greater intentions to engage in the behaviour. The implications for groups seeking to harness support for activities to protect the environment are discussed.

Fishbein, M. and I. Ajzen (2010). **Predicting and changing behavior: The reasoned action approach**, Taylor and Francis.

This book describes the reasoned action approach, an integrative framework for the prediction and change of human social behavior. It provides an up-to-date review of relevant research, discusses critical issues related to the reasoned action framework, and provides methodological and conceptual tools for the prediction and explanation of social behavior and for designing behavior change interventions. © 2010 by Taylor and Francis Group, LLC.

Fujii, S and R Kitamura (2003). "***What does a one-month free bus ticket do to habitual drivers? An experimental analysis of habit and attitude change.***" Transportation Volume 30, (Issue 1): pp 81-95.

The aim of this study was to investigate whether a temporary structural change would induce a lasting increase in drivers' public transport use. An experiment targeting 43 drivers was carried out, in which a one-month free bus ticket was given to 23 drivers in an experimental group but not to 20 drivers in a control group. Attitudes toward, habits of, and frequency of using automobile and bus were measured immediately before, immediately after, and one month after the one-month long intervention. The results showed that attitudes toward bus were more positive and that the frequency of bus use increased, whereas the habits of using automobile decreased from before the intervention, even one month after the intervention period. Furthermore, the increase in habitual bus use had the largest effect on the increase in the frequency of bus use. The results suggest that a temporary structural change, such as offering auto drivers a temporary free bus ticket, may be an important travel demand management tool for converting automotive travel demand to public-transport travel demand.

Gardner, Benjamin and Charles Abraham (2008). "***Psychological correlates of car use: A meta-analysis.***" Transportation Research Part F: Traffic Psychology and Behaviour **11**(4): 300-311.

<http://dx.doi.org/10.1016/j.trf.2008.01.004> <http://www.sciencedirect.com/science/article/pii/S1369847808000144>

This meta-analysis synthesised quantitative research into potentially modifiable psychological correlates of car use and intentions to drive. Online psychology and transportation databases were searched, and inclusion criteria applied to potentially relevant records. An ancestry approach was also employed to search selected publications. Meta-analyses of effect size were performed on 23 unique study datasets. Results generally supported the predictive utility of variables derived from the Theory of Planned Behaviour, though

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cognitions towards not driving displayed uniformly larger effects than were observed for car use cognitions. There was also a strong effect of habit on behaviour. Support for effects of pro-environment cognitions on driving was weak. However, a dearth of available evidence limited our findings and precludes development of clear evidence-based recommendations for intervention design. Directions for future research are discussed.

Gatersleben, B., N. Murtagh and E. White (2013). "**Hoody, goody or buddy? How travel mode affects social perceptions in urban neighbourhoods.**" *Transportation Research Part F: Traffic Psychology and Behaviour* **21**: 219-230. 10.1016/j.trf.2013.09.005 <http://www.scopus.com/inward/record.url?eid=2-s2.0-84886656792&partnerID=40&md5=cdc0dd83ee59c9e9b8ae7c390026489c>

When travelling through a new environment people can and do make very quick judgements about the local conditions. This paper explores the idea that such judgements are affected by the travel mode they use. We hypothesise that drivers generate a more superficial impression of the things they observe than those who walk because they are exposed to less information. This prediction is based on social psychological research that demonstrates that information that becomes available in "thin slices" affects superficial judgements. A survey study (n = 644) demonstrated that perceptions of a less affluent area are indeed negatively related to more driving and positively related to more walking, but only for those who do not live there. Perceptions of a neighbouring affluent area are positively related to more driving. Two experimental studies (n = 245 and n = 91) demonstrated that explicit (but not implicit) attitudes towards a group of young people in an ambiguous social situation are more negative when they are viewed from the perspective of a car user in particular in relation to a pedestrian perspective. These findings suggest that mode use may affect communities by influencing social judgements. © 2013 Elsevier Ltd. All rights reserved.

Golob, Thomas F (2003). "**Structural equation modeling for travel behavior research.**" *Transportation Research Part B: Methodological* **37**(1): 1-25.

Structural equation modeling (SEM) is an extremely flexible linear-in-parameters multivariate statistical modeling technique. It has been used in modeling travel behavior and values since about 1980, and its use is rapidly accelerating, partially due to the availability of improved software. The number of published studies, now known to be more than fifty, has approximately doubled in the past three years. This review of SEM is intended to provide an introduction to the field for those who have not used the method, and the compendium of applications for those who wish to compare experiences and avoid the pitfall of reinventing previous research.

Harms, Sylvia (2003). "**From routine choice to rational decision making between mobility alternatives.**" Paper delivered at 3rd Swiss Transport Research Conference, Monte Verità/Ascona, Switzerland, Citeseer

The own car being used both frequently and satisfyingly, people soon develop car use routines: Activating a certain travel goal leads to the automatic generation of the car as a behavioral response. Other mobility alternatives principally being at a person's disposal are not taken into consideration for use anymore. On the one hand, such routines are helpful since they avoid cognitive overload. On the other hand, they have fatal effects on the perception and adoption of ecologically promising mobility alternatives: Such options are largely ignored, and if they are nevertheless perceived, no evaluation with respect to own needs and desires takes place. The political aim of inducing behavior change by promoting the use of ecological innovations is thus undermined. A retrospective qualitative study (interviews and group discussions using the grounded theory approach) with 39 participants of two Swiss car-sharing organizations shows that car owners indeed first had to undergo a break-through of their car-use routines before they became aware of the car-sharing offer and took it into consideration as an own behavioral alternative. Triggering events for such a break-through were changes in a person's life situation or her outer mobility conditions which led to a change in her mobility requirements, opportunities or abilities. I.e., the own car either could not be used anymore or its use was less and less wanted so that the need for new mobility options increased. After this change from a routine to a conscious, rational decision-making state, the adoption of car sharing depended on actual mobility needs as well as personal attitudes and values. Those factors, however, had been insignificant under strong car-use routines. After an empirically-based theoretical modeling of this process, a quantitative questionnaire was distributed to 655 Swiss mobility participants who had either joined a car sharing-organization just a few weeks before the investigation, only recently had asked for information on car

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sharing, or who generally would have had access to car sharing, but didn't show interest in joining it jet (i.e., a random sample out of the urban, German-speaking Swiss population). The results underline the importance of significant and/or cumulative-gradual changes in the mobility-relevant decision-making context for weakening car-use routines and opening the way for conscious, rational decision-making. At the same time, by comparing the new car sharing users to the other population samples, a detailed mobility and attitudinal profile of to-day's car-sharing adopters could be drawn.

Haustein, Sonja and Marcel Hunecke (2007). "**Reduced Use of Environmentally Friendly Modes of Transportation Caused by Perceived Mobility Necessities: An Extension of the Theory of Planned Behavior.**" Journal of Applied Social Psychology **37**(8): 1856-1883. 10.1111/j.1559-1816.2007.00241.x <http://dx.doi.org/10.1111/j.1559-1816.2007.00241.x>

An extended version of the theory of planned behavior (TPB; Ajzen, 1991) was used to explain travel mode choice. As a new predictor, perceived mobility necessities (PMNs) were introduced, which are defined as people's perceptions of mobility-related consequences of their personal living circumstances. The database consisted of a survey of 1,545 car users in 3 large German cities. Using structural equation modeling, PMNs were integrated into TPB and showed the expected significant negative effect on use of environmentally friendly modes. In-depth interviews with 82 selected participants indicated that PMN moderates the relationship between public transportation attitude and intention. This moderator effect was confirmed by a regression analysis. The extension of TPB by PMN allows deduction of more differentiated intervention strategies.

Heath, Yuko and Robert Gifford (2002). "**Extending the Theory of Planned Behavior: Predicting the Use of Public Transportation.**" Journal of Applied Social Psychology, **32**, **10**: 2154-2189.

An expanded version of the theory of planned behavior (TPB) was used to predict and explain public transportation use. A pre-post design was used to examine changes in university students' bus ridership after the implementation of a universal bus pass (U-pass) program. Bus ridership significantly increased after the U-pass was implemented and associated changes in attitudes and beliefs about transportation modes were found. In both phases, students' public transportation use was well predicted by the original TPB. However, two additional constructs—a descriptive norm, and the interaction between intention and perceived behavioral control—significantly improved prediction in both phases of the study. These constructs might be useful additions to the original TPB, at least in this behavioral domain.

Hilliam, A and J Farrington (2005). "**Using behavioural psychology to plan, market and manage transport.**"

Prior to mass car ownership, viable public transport services could be provided in most rural areas. With car ownership and use increasingly being the first choice of even elderly people, those households which depend on public transport are finding themselves unable to access essential services and facilities. Traditional methods of transport delivery are decreasingly successful, with unsustainable rural bus subsidies failing to meet the needs of the population. New approaches are emerging with systems that are more demand responsive. The CO-OPERATE project was funded under the UK Future Integrated Transport Research programme managed by the Department for Transport, to identify techniques to foster joint working between users and providers. This paper describes the CO-OPERATE approach and in particular how personal construct psychology techniques were adapted for use in the transport sector to help stimulate attitude change and manage behaviour change. To test the emerging techniques a pilot area was used in North East Scotland to analyse user perceptions within a situation of change in rural transport management. From this basis, the research developed a toolkit which has the potential to be applied across Europe for involving more stakeholders in improving rural accessibility. The research also identified areas where organisational culture change, developments in administration and funding, enhancements in marketing, routes to increase understanding of local perceptions of public transport, and stimulation of local and community based initiatives can all be used to build bridges to co-operation between stakeholders to enhance service delivery.

Holz-Rau, Christian and Joachim Scheiner (2010). "**Travel mode choice: affected by objective or subjective determinants?**" Transportation **34**(4): 487-511.

The contribution presents theoretical considerations concerning the connections between life situation,

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lifestyle, choice of residential location and travel behaviour, as well as empirical results of structural equation models. The analyses are based on data resulting from a survey in seven study areas in the region of Cologne. The results indicate that lifestyles influence mode choice, although just slightly, even when life situation is controlled for. The influence of life situation on mode choice exceeds the influence of lifestyle. The influence which lifestyle and in parts also life situation have on mode choice is primarily mediated by specific location attitudes and location decisions that influence mode choice, likewise. Here objective spatial conditions as well as subjective location attitudes are important.

Hunecke, Marcel, Anke Blöbaum, Ellen Matthies and Rainer Höger (2001). "**Responsibility and Environment: Ecological Norm Orientation and External Factors in the Domain of Travel Mode Choice Behavior.**" Environment and Behavior **33**(6): 830-852. 10.1177/00139160121973269 <http://eab.sagepub.com/content/33/6/830.abstract>

In the domain of travel mode choice behavior, the interaction between ecological norm orientation and the external aspects "fare" and "subway station range" was investigated in an experimental field study. The ecological norm orientation is conceptualized based on the Schwartz theory on altruistic behavior, which is then applied to the environmental context. In a random sample of 160 persons, fare was experimentally manipulated by distributing free public transport tickets, whereas the station range was varied by selecting test participants at different distances from a station. Within the norm activation model, the mobility-specific personal ecological norm proves to be the strongest predictor of travel mode choice as recorded in standardized questionnaires. Reducing the fare by distributing free tickets has a quantitatively similar effect. The results suggest that the "economy-plus-moral" formula best describes the fact that the integrative mechanism (external factor fare plus normative ecological orientation) is the determinant of travel mode choice.

Hunecke, M., S. Haustein, S. Grischkat and S. Böhler (2007). "**Psychological, sociodemographic, and infrastructural factors as determinants of ecological impact caused by mobility behavior.**" Journal of Environmental Psychology **27**(4): 277-292. 10.1016/j.jenvp.2007.08.001 <http://www.scopus.com/inward/record.url?eid=2-s2.0-36148994349&partnerID=40&md5=e647c297a14d8b68ddab8566d98e38a1>

In this study, the relevance of psychological variables as predictors of the ecological impact of mobility behavior was investigated in relation to infrastructural and sociodemographic variables. The database consisted of a survey of 1991 inhabitants of three large German cities. In standardized interviews attitudinal factors based on the theory of planned behavior, further mobility-related attitude dimensions, sociodemographic and infrastructural characteristics as well as mobility behavior were measured. Based on the behavior measurement the ecological impact of mobility behavior was individually assessed for all participants of the study. In a regression analysis with ecological impact as dependent variable, sociodemographic and psychological variables were the strongest predictors, whereas infrastructural variables were of minor relevance. This result puts findings of other environmental studies into question which indicate that psychological variables only influence intent-oriented behavior, whereas impact-oriented behavior is mainly determined by sociodemographic and household variables. The design of effective intervention programs to reduce the ecological impact of mobility behavior requires knowledge about the determinants of mobility-related ecological impact, which are primarily the use of private motorized modes and the traveled distances. Separate regression analyses for these two variables provided detailed information about starting points to reduce the ecological impact of mobility behavior. © 2007 Elsevier Ltd. All rights reserved.

Kaiser, Florian G, Gundula Hübner and Franz X Bogner (2005). "**Contrasting the Theory of Planned Behavior With the Value-Belief-Norm Model in Explaining Conservation Behavior.**" Journal of Applied Social Psychology **35**(10): 2150-2170.

In this paper, we contrast the value-belief-norm (VBN) model and the theory of planned behavior (TPB) for the first time regarding their ability to explain conservation behavior. The participants represent a convenience sample of 468 university students. Using survey data and adopting previously established compound measures, structural equation analyses revealed a remarkable explanatory power for both theories: TPB's intention accounted for 95% of people's conservation behavior and VBN's personal norms accounted for 64%. Compared to the VBN model, the TPB covered its concepts more fully in terms of proportions of explained variance. More importantly, the fit statistics revealed that only the TPB depicts the

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relations among its concepts appropriately, whereas the VBN model does not.

Kaplan, S., F. Manca, T. A. S. Nielsen and C. G. Prato (2015). "**Intentions to use bike-sharing for holiday cycling: An application of the Theory of Planned Behavior.**" *Tourism Management* **47**: 34-46. 10.1016/j.tourman.2014.08.017 <http://www.scopus.com/inward/record.url?eid=2-s2.0->

This study explored the behavioral factors underlying tourist intentions to use urban bike-sharing for cycling while on holiday. The analytical framework relied on the Theory of Planned Behavior relating tourist intentions to favorable attitudes toward cycling, interest in bicycle technology, favorable subjective norms toward cycling, and perceived cycling ease. The case-study focused on the new bike-sharing system in Copenhagen (Denmark) and questioned 655 potential tourists about a hypothetical holiday scenario. Structural equation models revealed: (i) a great interest in using bike-sharing, frequently and for multiple purposes; (ii) a relation between holiday cycling and living in a cycling-friendly country, past cycling experience, and habitual transport mode choice during daily life; (iii) an appeal of electric bicycles to tourists with high interest in bicycle technology, low perceived cycling ease, and weak favorable norms toward cycling; (iv) a relation between frequent and multi-purpose cycling intentions and favorable to stronger attitudes and norms toward cycling, and greater perceived likelihood that the holiday partners would cycle. © 2014 Elsevier Ltd.

Karash, Karla, Matthew Coogan, Tom Adler, Chris Cluett, Susan Shaheen, Icek Ajzen and Monica Simon (2008). *TCRP Report 123: Understanding How Individuals Make Travel and Location Decisions: Implications for Public Transportation*, Transportation Research Board of the National Academies, Washington, D.C.

This report explores a broader social context for individual decision making related to residential location and travel behavior and consequently will be of interest to planners, researchers, transit managers, and decision makers. The findings from this research contribute to efforts to predict mode choice and how to influence it through better policies and design, education, and communication.

Kim, Sungyop, Gudmundur F. Ulfarsson and J. Todd Hennessy (2007). "**Analysis of light rail rider travel behavior: Impacts of individual, built environment, and crime characteristics on transit access.**" *Transportation Research Part A: Policy and Practice* **41**(6): 511-522. <http://dx.doi.org/10.1016/j.tra.2006.11.001>

This paper analyzes factors that influence the mode choice for trips between home and light rail stations, an often neglected part of a person's trip making behavior. This is important for transit planning, demand modeling, and transit oriented development. Using transit survey data describing St. Louis MetroLink riders in the United States, this study found that some of the factors associated with increased shares of walking relative to other modes were full-time student status, higher income transit riders, and trips made during the evening. It was also found that crime at stations had an impact. In particular, crime made female transit riders more likely to be picked-up/dropped-off at the station. Females are more likely to be picked-up or dropped-off at night. Bus availability and convenience showed that transit riders that have a direct bus connection to a light rail station were more likely to use the bus. Private vehicle availability was strongly associated with increased probability of drive and park, when connecting to light rail.

Li, L., J. Xiong, A. Chen, S. Zhao and Z. Dong (2015). "**Key strategies for improving public transportation based on planned behavior theory: Case study in Shanghai, China.**" *Journal of Urban Planning and Development* **141**(2). 10.1061/(ASCE)UP.1943-5444.0000203 <http://www.scopus.com/inward/record.url?eid=2-s2.0-84929630370&partnerID=40&md5=c78d0bc2968e9a8ce7c3fc4705ede9bb>

To advance public transportation development, it should be explored from the perspective of behavioral analysis. This paper adopts the theory of planned behavior (TPB) to study public transportation choice behaviors. The first aim is to explore the necessity of dividing subjective norms into an injunctive norm and a descriptive norm and to explore their roles in predicting behaviors. The second aim is to investigate the mechanism related to several key variables and their role in forming the intention to take transit. The third aim is to develop appropriate improvement strategies through the analysis of behavior, subjective norms, or perceived control beliefs. Empirical data were collected by distributing online and hard-copy questionnaires in Shanghai, China. A sample of 393 valid questionnaires was collected. An ordinal regression model was constructed based on the empirical data. The results reveal that TPB can be applied to explain choice behaviors with respect to public transport. Among the factors affecting travelers' intentions, attitude toward

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public transport is most decisive. Descriptive norms seem to have more direct effects on public transport use behaviors on the basis of the correlation coefficients. Injunctive norms, at least in this case, have a more obvious influence on travelers' intention to take public transport than do descriptive norms. Furthermore, on the basis of belief analysis, some critical approaches to improving the competitiveness of Shanghai public transportation are proposed that can be used to develop people-oriented public transportation policies and strategies in other similar cities. © 2014 American Society of Civil Engineers.

Lyons, G., P. Goodwin, M. Hanly, G. Dudley, K. Chatterjee, J. Anable, P. Wiltshire and Y. Susilo (2008). "**Public attitudes to transport - knowledge review of existing evidence**"

This report summarises research into public attitudes to public and private transport in the UK. Attitudes to car use reflect attitudes to lifestyles and aspirations. Trends in bus use show an increase in the capital city of London and an average decrease in other areas. Walking generates positive views in most people; cycling is seen in a less positive light. Rail passengers were mostly satisfied with service provision. Attitudes to air travel varied widely: low prices often made flying an attractive option. Traffic congestion is seen as a problem although people learn to cope with it. Attitudes to road transport improvement policy vary according to the personal effect felt. Concern exists about climate change, although willingness to change behaviour is affected by personal benefit or cost. There are substantial concerns about safety and security while travelling. The health benefits of walking or cycling are admitted. Transport improves quality of life by allowing users access to economic and social activities but decreases it in terms of impact on the local environment. A minority of the population finds difficulty accessing local facilities and services because of lack of transport or high costs. The authors found that wording of questionnaires could influence results; there may be a divergence between intention and actual behaviour; and there is a lack of evidence on how attitudes change over time.

Mokhtarian, P. L., I. Salomon and M. E. Singer (2015). "**What Moves Us? An Interdisciplinary Exploration of Reasons for Traveling.**" *Transport Reviews* 35(3): 250-274. 10.1080/01441647.2015.1013076

[http://www.scopus.com/inward/record.url?eid=2-s2.0-](http://www.scopus.com/inward/record.url?eid=2-s2.0-84928589626&partnerID=40&md5=aa8eb092390edfae132036f7d807bb40)

[84928589626&partnerID=40&md5=aa8eb092390edfae132036f7d807bb40](http://www.scopus.com/inward/record.url?eid=2-s2.0-84928589626&partnerID=40&md5=aa8eb092390edfae132036f7d807bb40)

Abstract: We review a number of theories of motivation, and typologies of motivations, in psychological theory and in application to a variety of specific contexts, including shopping, eating, leisure, tourism, and travel. A recurring theme is the distinction between extrinsic (instrumental, utilitarian, functional) and intrinsic (autotelic, hedonic, experiential) motivations. We suggest that travel is a behavior to which intrinsic motivations apply, and that focusing exclusively on the extrinsic motivations to travel runs the risk of substantially underestimating the demand for travel, and the resistance to policies attempting to reduce it or to technologies (notably, information and communication technologies) expected to (partly) replace it. We offer a number of suggestions for improving standard travel surveys to help obtain the data needed to explore intrinsic motivations more fully. As better data become available, travel behavior models can be refined to partly account for such motivations. We believe that the resulting insights will be extremely valuable to policy-makers, planners, and behavioral scholars. © 2015 Taylor & Francis.

Namgung, M. and G. Akar (2014). Role of Gender and Attitudes on Public Transportation Use. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2415. Transportation Research Board of the National Academies, Washington, D.C. pp. 136-144.

This study aimed to evaluate gender differences in public transportation-related attitudes and their effects on transit use. How did attitudes affect people's transit use? Did public transit-related attitudes differ by gender in general and by status group (faculty, staff, and students)? This research aimed to address these questions. The analysis was based on data collected from the 2012 campus transportation survey at Ohio State University. The survey questionnaire covered individuals' sociodemographic characteristics, commute mode choices, and attitudes toward driving and taking public transit, including reliability, safety, flexibility, convenience, accessibility, and comfort. After the descriptive analysis of perceptions that were segmented on the basis of gender and status (faculty, staff, undergraduates, and graduate students), binary logit models were estimated to assess the influences of individuals' attitudes on transit use while controlling for other factors. First a binary logit model measuring the effects of respondents' status (student, staff, or faculty), car ownership, ethnicity, proximity to bus stops, and distance to campus was estimated. Then respondents'

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attitudes were added to the existing model. Results indicated that including attitudes significantly increased the explanatory power of the model, and the results revealed the significant connections between attitudes related to public transportation and public transit use. The findings of this study can help transportation planners understand the ways attitudes affect transit use and the differences across genders. Although the study used data from Ohio State University, the findings can help in developing plans for increasing alternative transportation use on other campuses, as well as in surrounding areas.

Noblet, C. L., J. Thøgersen and M. F. Teisl (2014). **"Who attempts to drive less in New England?"** Transportation Research Part F: Traffic Psychology and Behaviour **23**: 69-80. 10.1016/j.trf.2013.12.016

Transport policy often aims to change the modal split and/or reduce driving by means of both structural and psychological interventions, often referred to as 'hard' and 'soft' policy, respectively. We investigate how socio-structural contexts and psychological motivators interact in determining travel choices in New England (USA). In total, 1340 New England residents responded to a mail survey, which asked them about their use of alternative travel modes, their attempts to drive less, and a range of potential psychological and structural antecedents. Responses were analyzed with structural equation modeling. We find an individual's context and their problem awareness, attitudes, and norms are important components of travel decisions. This suggests combining "hard" and "soft" policy interventions for maximum impact. We also find significant differences across the New England states, indicating travel interventions should consider contextual differences across regions. Implications for policy and future research are discussed. © 2014 Published by Elsevier Ltd.

Nordfjærn, T., H. B. Lind, T. Öimşekoğlu, S. H. Jørgensen, I. O. Lund and T. Rundmo (2015). **"Habitual, safety and security factors related to mode use on two types of travels among urban Norwegians."** Safety Science **76**: 151-159. 10.1016/j.ssci.2015.03.001 <http://www.scopus.com/inward/record.url?eid=2-s2.0-84925130145&partnerID=40&md5=d3c1a80393660ae361070bd22c56ed54>

This study aims to investigate psychological factors related to mode use on urban work/education and leisure travels, and to examine such factors related to intentions of using public transport. A survey was conducted in a random representative sample of the Norwegian population living in urban regions recruited from the Norwegian population registry (. n= . 1039). A two-cluster solution for mode use was revealed: individuals who mainly used public or health-promoting transport, and individuals who primarily used a car on the respective travels. The results suggest that car habit strength is more strongly related to car use on work/education travels. The probability component of risk perception was related to mode use on leisure travels, and there was a weak association between the consequence component and use. High perceived probability of accidents in public transport was associated with use of public transport, while high corresponding risk estimates in private motorized transport were associated with car use. Strong car habit strength and high perceived probabilities of accidents and security issues in public transport were related to a reduced intention of using public transport. Increased worry of private motorized transport and a high demand for risk mitigation related to public modes were associated with an increased intention to use public transport. Work/education travels could be more habitual than leisure travels. Risk perception may be a result of exposure to specific modes, rather than a predictor of mode use. Safety and security factors also appeared as more relevant for leisure travels than for work/education travels. © 2015 Elsevier Ltd.

Nordfjærn, T., Ö Şimşekoğlu, H. B. Lind, S. H. Jørgensen and T. Rundmo (2014). **"Transport priorities, risk perception and worry associated with mode use and preferences among Norwegian commuters."** Accident Analysis and Prevention **72**: 391-400. 10.1016/j.aap.2014.07.028 <http://www.scopus.com/inward/record.url?eid=2-s2.0-84907321987&partnerID=40&md5=06b127262976ae43628db4b41efe90fd>

There is currently scant research on the role of transport priorities, risk perception and worry for travel mode use and preferences. The present study aims to examine these factors in relation to mode use and preferences among Norwegian commuters. A web-based survey was conducted in a randomly obtained representative sample of daily commuters in the extended greater Oslo area (n = 690). The results showed that those who prioritized efficiency and flexibility tended to commute by car, while those who prioritized safety and comfort used public (e.g. metro, tram, and train) or active (e.g. walking and cycling) transport. In a free choice scenario, the respondents who prioritized flexibility reported a preference for using a car, whereas those who prioritized safety and comfort preferred public and active transport for their commuter

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travels. Risk perception of high impact events, such as terrorism and major accidents, as well as risk perception related to personal impact risks (theft, violence etc.) were related to car use on commuter travels. Transport-related worry exerted weak influences on mode use and preferences. Increased speed on rail transport and more frequent departures may be effective in reducing car use on commuter travels. Risk communication should focus on highlighting the low risk of experiencing security and safety issues in the public transport sector, and this message should be complemented by efforts to reduce the probability of negative events affecting public transport. © 2014 Elsevier Ltd.

Ory, David and Patricia Mokhtarian (2005). "**When is getting there half the fun? Modeling the liking for travel.**" *Transportation Research Part A: Policy and Practice* **39**(2–3): 97-123. <http://dx.doi.org/10.1016/j.tra.2004.09.006>

This paper analyzes empirically measured values of Travel Liking—how much individuals like to travel, in various overall, mode-, and purpose-based categories. The study addresses two questions: what types of people enjoy travel, and under what circumstances is travel enjoyed? We first review and augment some previously hypothesized reasons why individuals may enjoy travel. Then, using data from 1358 commuting residents of three San Francisco Bay Area neighborhoods, a total of 13 ordinary least-squares linear regression models are presented: eight models of short-distance Travel Liking and five models of long-distance Travel Liking. The results indicate that travelers' attitudes and personality (representing motivations) are more important determinants of Travel Liking than objective travel amounts. For example, while those who commute long distances do tend to dislike commute travel (as expected), the variables entering the models that hold the most importance relate to the personality and attitudes of the traveler. Most of the hypothesized reasons for liking travel are empirically supported here.

Ory, David and Patricia Mokhtarian (2009). "**Modeling the structural relationships among short-distance travel amounts, perceptions, affections, and desires.**" *Transportation Research Part A: Policy and Practice* **43**(1): 26–43. <http://dx.doi.org/10.1016/j.tra.2008.06.004>

Using structural equation modeling, the relationships among travel amounts, perceptions, affections, and desires across five short-distance (one-way trips of less than 100 miles) travel categories (overall, commute, work/school-related, entertainment/social/recreation, and personal vehicle) are examined. The models are estimated using data collected in 1998 from more than 1300 working commuters in the San Francisco Bay Area. A cross-model analysis reveals three robust relationships, namely: (1) myriad measures of travel amounts work together to affect perceptions; (2) perceptions are consistently important in shaping desires; and (3) affections have a positive relationship with desires. The second finding suggests that two individuals who travel the same objective amount may not have the same desire to reduce their travel: how much individuals perceive their travel to be is important. The third point argues that the degree to which travel is enjoyed is a key determinant of shaping desires to reduce travel: the more travel is enjoyed, the less the desire to reduce it.

Osman Idris, A., K. M. N. Habib, A. Tudela and A. Shalaby (2015). "**Investigating the effects of psychological factors on commuting mode choice behaviour.**" *Transportation Planning and Technology* **38**(3): 265-276.

10.1080/03081060.2014.997451 <http://www.scopus.com/inward/record.url?eid=2-s2.0-84924200182&partnerID=40&md5=36cdaa11dbcd9a948378790f7e41b783>

This paper utilizes socio-psychometric survey data to investigate the influence of attitudes, affective appraisal and habit formation on commuting mode choice. The data-set was collected in 2009–2010 in Edmonton, Alberta. In addition to conventional socio-economic, demographic and modal attributes, the survey gathered psychological information regarding habitual behaviour, affective appraisal and personal attitudes. Different psychometric tools were used to capture psychological factors affecting mode choice. Habitual behaviour was measured using Verplanken's response-frequency questionnaire. Affective appraisal was indirectly estimated using the Osgood's semantic differential. Five-point Likert scales were used to measure attitude. The structural equation modelling (SEM) approach was used to investigate the effects of psychological factors on mode choice behaviour. SEM captures the latent nature of psychological factors and uses path diagrams to identify the directionality as well as intensity of the relationships. The investigation reveals that passengers have positive emotions towards their chosen mode. Further, evidence of the superiority of the car as a travel alternative was established in terms of strong habit towards it, such that passengers would use the car for almost every single trip. © 2015, © 2015 Taylor & Francis.

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Outwater, Maren L, S Castleberry, Y Shiftan, M Ben-Akiva, Y Shuang Zhou and A Kuppam (2003). "**Use of structural equation modeling for an attitudinal market segmentation approach to mode choice and ridership forecasting**". 10th International Conference on Travel Behaviour Research, Lucerne, Switzerland, Citeseer

The San Francisco Bay Area Water Transit Authority is evaluating expanded ferry service, as required by the California Legislature. As part of this process, Cambridge Systematics developed forecasts using a combination of market research strategies and the addition of non-traditional variables into the mode choice modeling process. The focus of this work was on expanding the mode choice model to recognize travelers' attitudes and different types of urban travelers making different modal choices. We used structural equation modeling to simultaneously identify the attitudes of travel behaviours and the causal relationships between traveler's socioeconomic profile and traveler attitudes. We extracted six attitudinal factors, three of which were used to partition the ferry riding market into eight segments. These market segments were used to estimate stated-preference mode choice models for 14 alternative modes, which separated the traveler's reaction to time savings by market segment and recognized that modal choices are different for market segments that are sensitive to travel stress or desire to help the environment. The new mode choice models were applied within the framework of the Metropolitan Transportation Commission's regional travel model and calibrated to match modal shares, modes of access to each ferry terminal, ridership by route and time period, and person trips by mode at screenline crossings. Additional validation tests of significant changes in ferry service in recent years were used to confirm the reasonableness of the SP model. The model has been applied for three future year alternatives and to test the sensitivity of pricing, service changes and alternative transit modes.

Outwater, Maren L, Bhargava Sana, Nazneen Ferdous, William Woodford, Chandra Bhat, Raghu Sidharthan, Ram Pendyala and Stephane Hess (2014). TCRP H-37 Characteristics of Premium Transit Services That Affect Mode Choice: Key Findings and Results. Presented at 93rd Annual Meeting of the Transportation Research Board, Washington, D.C.

This research seeks to improve the understanding of the full range of determinants for mode choice behavior and to offer practical solutions to practitioners on representing and distinguishing these characteristics in travel demand forecasting models. The principal findings are that awareness and consideration of transit services is significantly different than the perfect awareness and consideration of all modes which is an underlying assumption of mode choice and forecasting models. Furthermore, inclusion of non-traditional transit attributes and attitudes can maintain or improve the ability of mode choice models to predict the usage of premium transit modes while reducing the weight on modal constants that vary between transit sub-modes. Additional methods and analyses are necessary to bring these results into practice. This paper focuses on the key findings and results of the research of the value of non-traditional transit service attributes on modal choice, the influence of awareness and consideration of transit service on modal alternatives, and the importance of traveler attitudes on both awareness and consideration of transit and on the choice of transit or auto in mode choice. The models estimated to support these findings are described, but not in detail, due to the space limitations, but are available in the Transit Cooperative Research Program H-37A Final Report. The paper also documents the findings of the implementation testing, which concludes that including path choices and non-traditional transit service attributes in mode choice models can reduce the weight of the modal constants.

Parkany, Emily, Ryan Gallagher and Phillip Viveiros (2004). Are Attitudes Important in Travel Choice? *Transportation Research Record: Journal of the Transportation Research Board*, No. 1894. Transportation Research Board of the National Academies, Washington, D.C. pp. 127-139.

A huge body of literature in social psychology describes 70 years of theory and experimentation relating attitudes to behavior. Much of it suggests a stronger causal link between choices and attitudes than that between attitudes and choices—attitude models conditioned on revealed choice explain more than knowledge of peoples' attitudes and determination of what choice they will make. Alternative analyses suggest that attitudinal and other data should be used to determine respondents' intentions rather than their desires to better predict behavior. Attitude studies are becoming more prevalent in the study of transportation behavior, but researchers vary in what kinds of attitudes are considered and how attitudes influence the transportation decision process. The social psychology literature is briefly highlighted, transportation applications are reviewed, and a case study is presented. Cognitive, affective, and behavioral

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attitudes help explain the intentions of those surveyed for the case study. These results and the literature suggest that attitudes are very important, but caution is recommended regarding survey wording and capturing behavior intentions. In addition, the results suggest that to explain behavior, a circular behavior process including attitudes is better at explaining choices compared with the use of only cognitive and affective attitudes.

Popuri, Yasasvi, Kimon Proussaloglou, Cemal Ayvalik, Frank Koppelman and Aimee Lee (2011). **"Importance of traveler attitudes in the choice of public transportation to work: findings from the Regional Transportation Authority Attitudinal Survey."** *Transportation* 38(4): 643-661. 10.1007/s11116-011-9336-y
<http://dx.doi.org/10.1007/s11116-011-9336-y>

The commute mode choice decision is one of the most fundamental aspects of daily travel. Although initial research in this area was limited to explaining mode choice behavior as a function of traveler socioeconomics, travel times, and costs, subsequent studies have included the effect of traveler attitudes and perceptions. This paper extends the existing body of literature by examining public transit choice in the Chicago area. Data from a recent Attitudinal Survey conducted by the Regional Transportation Authority (RTA) in Northeastern Illinois were used to pursue three major steps. First, a factor analysis methodology was used to condense scores on 23 statements related to daily travel into six factors. Second, the factor scores on these six dimensions were used in conjunction with traveler socioeconomics, travel times, and costs to estimate a binary logistic regression of public transit choice. Third, elasticities of transit choice to the six factors were computed, and the factors were ranked in decreasing order of these elasticities. The analysis provided two major findings. First, from a statistical standpoint, the attitudinal factors improved the intuitiveness and goodness-of-fit of the model. Second, from a policy standpoint, the analysis indicated the importance of word-of-mouth publicity in attracting new riders, as well as the need for a marketing message that emphasizes the lower stress level and better commute time productivity due to transit use.

Redman, Lauren, Margareta Friman, Tommy Gärling and Terry Hartig (2013). **"Quality attributes of public transport that attract car users: A research review."** *Transport Policy* 25(0): 119-127.
<http://dx.doi.org/10.1016/j.tranpol.2012.11.005>

The transport sector presents contentious issues with respect to sustainable development, particularly regarding the use of private motorised vehicles in urban areas. Public transport (PT) together with cycling and walking are generally agreed to be sustainable alternatives to private car use. This paper aims to contribute to a better understanding of those aspects of PT quality most likely to attract car users. Toward achieving this aim, relevant research was sought to answer the following two questions: What quality attributes of PT services are attractive to users? And what changes in quality attributes of PT services would encourage modal shift from private motor vehicles to PT? Using a qualitative systematic review, it is concluded that while service reliability and frequency are important PT attributes in general, those attributes most effective in attracting car users are largely affective and connected to individual perceptions, motivations and contexts. Reduced fare promotions and other habit-interrupting transport policy measures can succeed in encouraging car users to try PT services initially. Attributes over and above basic accessibility, reliability and mobility provision, perceived by the target market as important service attributes, must then be provided in sustaining the switch from car use after promotional tactics have expired.

Rhodes, R. E., S. G. Brown and C. A. McIntyre (2006). **"Integrating the perceived neighborhood environment and the theory of planned behavior when predicting walking in a Canadian adult sample."** *Am J Health Promot* 21(2): 110-118.

PURPOSE: To integrate the characteristics of the perceived environment with the theory of planned behavior (TPB) to determine (1) whether the TPB mediates relations among environmental characteristics and walking, and (2) whether the environment moderates TPB-walking relations. DESIGN: Cross-sectional. SETTING: South Vancouver Island, British Columbia, Canada. SUBJECTS: Random sample of 351 adults (36% response rate). MEASURES: Participants completed measures of the perceived neighborhood environment, the TPB, and walking behavior that was assessed using an adapted Godin leisure time questionnaire. RESULTS: Results using structural equation modeling indicated that the TPB mediated the environment-walking relationship. Specifically, retail land-mix use and neighborhood aesthetics were associated with walking through affective and instrumental attitudes. Results using moderated regression analyses showed that recreation land-mix

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use moderated the intention-behavior relationship, with those individuals who perceived closer access to recreation facilities having a larger intention-behavior relationship. A significant moderating effect for crime on the instrumental attitude-intention relationship was also identified, but the effect size was small to trivial. CONCLUSIONS: These results suggest that the perceived neighborhood may influence walking through attitudes and may also influence the intention-behavior gap. Prospective studies using objective walking and environment data are required to improve the veracity of the findings and to identify possible causal relationships.

Scherer, Milena and Katrin Dziekan (2012). "**Bus or rail: an approach to explain the psychological rail factor.**" Journal of Public Transportation **15**(1): 75-93.

Many public transport studies have found that potential passengers consider rail based public transport to be superior to bus systems. Why is this? Two studies have been completed in Germany and Switzerland in search of explanations for this so called psychological rail factor. In this article, these two studies are presented and discussed to introduce the schemata approach and to help identify differences of attributions towards rail- and bus-based public transport. The research found a psychological rail factor (i.e., a preference for using rail assuming equal service conditions) of 63 percent for regional train and 75 percent for trams compared to bus services. The rail factor is highly loaded with emotional and social attributions. They account for 20–50 percent of the share in the different schemata for bus, rail, and tram.

Schultz, P Wesley, Jessica M Nolan, Robert B Cialdini, Noah J Goldstein and Vldas Griskevicius (2007). "**The constructive, destructive, and reconstructive power of social norms.**" Psychological science **18**(5): 429-434.

Despite a long tradition of effectiveness in laboratory tests, normative messages have had mixed success in changing behavior in field contexts, with some studies showing boomerang effects. To test a theoretical account of this inconsistency, we conducted a field experiment in which normative messages were used to promote household energy conservation. As predicted, a descriptive normative message detailing average neighborhood usage produced either desirable energy savings or the undesirable boomerang effect, depending on whether households were already consuming at a low or high rate. Also as predicted, adding an injunctive message (conveying social approval or disapproval) eliminated the boomerang effect. The results offer an explanation for the mixed success of persuasive appeals based on social norms and suggest how such appeals should be properly crafted.

Şimşekoğlu, T., T. Nordfjærn and T. Rundmo (2015). "**The role of attitudes, transport priorities, and car use habit for travel mode use and intentions to use public transportation in an urban Norwegian public.**" Transport Policy **42**: 113-120. 10.1016/j.tranpol.2015.05.019 <http://www.scopus.com/inward/record.url?eid=2-s2.0-84930940156&partnerID=40&md5=bc5a568e786c901f72f44d8204f68cba>

The present study aims to identify clusters of transport users and to examine the role of transport priorities, travel mode use attitudes, and car use habit on travel mode use. An additional aim is to test whether such factors predict intentions to use public transport and reported use of public transport. Data were collected via a self-completion questionnaire survey conducted in June and August 2013. Participants included a total of 1039 people who were randomly selected from the urban regions of Norway using the Norwegian population registry. Due to missing data on travel mode use variables the analyses were conducted with 546 observed cases. Two clusters of transport users were identified; individuals who primarily use public and health-promoting transport (e.g. public transportation users, bicyclists) and car users. Logistic regression analysis showed that older age, strength of the car use habit, and priorities of flexibility (e.g. prioritize being able to choose the exact time of travel) increased the odds of car use. Structural Equation Modeling showed that priority of convenience, priority of safety and security, and favorable attitudes towards public transport use were positive predictors of intentions to use public transportation, while car use habit was a negative predictor of both intentions to use public transportation and reported public transportation use. Traffic safety campaigns aiming to increase public transportation use in the urban Norwegian public could focus on increasing the attractiveness of public transport, particularly by improving flexibility of such transport. © 2015 Elsevier Ltd.

Spears, Steven, Douglas Houston and Marlon G Boarnet (2013). "**Illuminating the unseen in transit use: A framework for examining the effect of attitudes and perceptions on travel behavior.**" Transportation Research

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Part A: Policy and Practice 58: 40-53.

This study develops the Perception–Intention–Adaptation (PIA) framework to examine the role of attitudes, perceptions, and norms in public transportation ridership. The PIA framework is then applied to understand the relative importance of socio-demographic, built environment, transit service, and socio-psychological factors on public transit use for 279 residents of south Los Angeles, California, a predominately low-income, non-white neighborhood. Confirmatory factor analysis based on 21 survey items resulted in six transit-relevant socio-psychological factors which were used in regression models of two measures of transit use: the probability of using transit at least once in the 7-day observation period, and the mean number of daily transit trips. Our analysis indicates that two PIA constructs, attitudes toward public transportation and concerns about personal safety, significantly improved the model fit and were robust predictors of transit use, independent of built environment factors such as near-residence street network connectivity and transit service level. Results indicate the need for combined policy approaches to increasing transit use that not only enhance transit access, but also target attitudes about transit service and perceptions of crime on transit.

Steg, Linda (2003). "**Can Public Transport Compete with the Private Car.**" *IATSS RESEARCH* 27(2).

Public transport is often perceived to be a poor alternative for car use. This paper describes who may be open to use public transport more often, and how people might be persuaded to use it. A computerised questionnaire study was conducted among 1,803 Dutch respondents in May 2001. Results revealed that especially fervent car users disliked public transport. For them, the car outperformed public transport not only because of its instrumental function, but also because the car represents cultural and psychological values, e.g. the car is a symbol of freedom and independence, a status symbol and driving is pleasurable. So, for fervent car users, car use is connected with various important values in modern society. Infrequent car users judged less positively about the car and less negatively about public transport. Consequently, they may be open to use public transport more regularly. In contrast, many efforts are needed to stimulate fervent car users to travel by public transport, because in their view, public transport cannot compete with their private car. In this case, policies should be aimed at reducing the functional, psychological and cultural values of private cars, as well as increasing the performance of public transport and other (more) environmentally sound modes of transport on these aspects.

Steg, Linda (2005). "**Car use: lust and must. Instrumental, symbolic and affective motives for car use.**"

Transportation Research Part A: Policy and Practice 39(2–3): 147-162. <http://dx.doi.org/10.1016/j.tra.2004.07.001>

This paper reports results of two questionnaire studies aimed at examining various motives for car use. In the first study, a random selection of 185 respondents who possess a driving licence were interviewed. Respondents were recruited from the cities of Groningen and Rotterdam, The Netherlands. The sample of the second study comprised a random selection of 113 commuters who regularly travelled during rush hours in and around Rotterdam, a region in the west of the Netherlands. First, it was examined which categories of car use motives may be distinguished. As proposed by Dittmar's (1992) [The social psychology of material possessions: to have is to be. Havester Wheatsheaf, Hemel Hempstead, UK; St. Martin's Press, New York] model on the meaning of material possessions, results from both studies revealed that car use not only fulfils instrumental functions, but also important symbolic and affective functions. Second, it was studied to what extent these different motives are related to the level of car use. From the results of study 2, it appeared that commuter car use was most strongly related to symbolic and affective motives, and not to instrumental motives. Third, individual differences in the relative importance of the three categories of motives were investigated. In both studies, most group differences were found in the evaluation of the symbolic and affective motives (and not the instrumental ones). Especially frequent drivers, respondents with a positive car attitude, male and younger respondents valued these non-instrumental motives for car use. These results suggest that policy makers should not exclusively focus on instrumental motives for car use, but they should consider the many social and affective motives as well.

Steg, Linda and Robert Gifford (2005). "**Sustainable transportation and quality of life.**" *Journal of Transport Geography* 13(1): 59-69. <http://dx.doi.org/10.1016/j.jtrangeo.2004.11.003>

We consider the continuing increase in the use and density of automobiles (more vehicles with fewer people in them travelling greater distances over proportionally shorter roads) in relation to transportation sustainability and quality of life. The social dilemma perspective views this trend as the outcome of an

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unfortunate preference for short-term gains by car users at the cost of long-term losses to society. Approaches to measuring quality of life, its relation to sustainable transport alternatives, and the potential implications for informing policy, are considered.

Steg, L., G. Perlaviciute, E. van der Werff and J. Lurvink (2014). "***The Significance of Hedonic Values for Environmentally Relevant Attitudes, Preferences, and Actions.***" Environment and Behavior 46(2): 163-192. 10.1177/0013916512454730 <http://www.scopus.com/inward/record.url?eid=2-s2.0-84891596683&partnerID=40&md5=dc61b421e5fabfcac90098212272df5a>

This article aimed to demonstrate that hedonic values are important for understanding environmentally relevant beliefs, preferences, and actions, next to egoistic, altruistic, and biospheric values. In four studies, the authors found consistent support for their hypothesis that hedonic, egoistic, altruistic, and biospheric values can be distinguished empirically, suggesting that the distinction between the four types of values is not only theoretically meaningful but also recognized by individuals. Importantly, in line with the authors' expectations, hedonic values appeared to be significantly and negatively related to a range of environmentally relevant attitudes, preferences, and behaviors, even when the other values were controlled for. This suggests that it is indeed important to include hedonic values in environmental studies and that interventions aimed to promote proenvironmental actions should consider hedonic consequences of actions, as these may be important barriers for behavior change. © 2012 SAGE Publications.

Steg, Linda, Charles Vlek and Goos Slotegraaf (2001). "***Instrumental-reasoned and symbolic-affective motives for using a motor car.***" Transportation Research Part F: Traffic Psychology and Behaviour 4(3): 151-169. [http://dx.doi.org/10.1016/S1369-8478\(01\)00020-1](http://dx.doi.org/10.1016/S1369-8478(01)00020-1)

This study was aimed at clarifying the relative importance of symbolic-affective as opposed to instrumental-reasoned motives for car use. We examined which motivational dimensions are underlying the (un)attractiveness of car use, in order to distinguish a limited set of main motive categories. Three methods were developed, which differed in the extent to which the purpose of the task was apparent. The tasks were: (1) a similarity sorting of car-use episodes, (2) a Q-sorting following attractiveness of car-use episodes, and (3) a semantic-differential method for evaluating (un)attractive aspects of car use. The symbolic-affective motives for car use were better expressed when the aim of the research task was not too apparent. If the aim of the task was evident, respondents tended to evaluate car use in terms of instrumental-reasoned motives. Overall, the results indicate that both instrumental-reasoned and symbolic-affective functions of the motor car are significant dimensions underlying the attractiveness of car use.

Steinberg, L. and K. C. Monahan (2007). "***Age differences in resistance to peer influence,***" " Developmental psychology, 43(6), : pp. 1531-1543.

Prior research describes the development of susceptibility to peer pressure in adolescence as following an inverted U-shaped curve, increasing during early adolescence, peaking around age 14, and declining thereafter. This pattern, however, is derived mainly from studies that specifically examined peer pressure to engage in antisocial behavior. In the present study, age differences and developmental change in resistance to peer influence were assessed using a new self-report instrument that separates susceptibility to peer pressure from willingness to engage in antisocial activity. Data from four ethnically and socioeconomically diverse samples comprising more than 3,600 males and females between the ages of 10 and 30 were pooled from one longitudinal and two cross-sectional studies. Results show that across all demographic groups, resistance to peer influences increases linearly between ages 14 and 18. In contrast, there is little evidence for growth in this capacity between ages 10 and 14 or between 18 and 30. Middle adolescence is an especially significant period for the development of the capacity to stand up for what one believes and resist the pressures of one's peers to do otherwise. (PsycINFO Database Record (c) 2012 APA, all rights reserved)

TransitCenter and RSG Inc. (2014). "***Who's On Board, Mobility Attitudes Survey 2014***"

The goal of this study is a definitive understanding of the differences in attitudes and behaviors among the US population with respect to public transportation and neighborhood choice. We aim to understand which characteristics and beliefs are behind those differences. To that end, we conducted a large online survey (11,842 respondents) across 46 Metropolitan Statistical Areas (MSAs) in the United States. The selected MSAs span the full geography of the U.S. and include some cities with well-developed transit systems and others

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with less developed transit system. The sample also ensured minimum quotas for all age groups, allowing the study to compare different generations, geographies, and neighborhood types. The results reveal that the most important factors in determining whether someone is at least an occasional transit user are: • High population density of home neighborhood (POSITIVE EFFECT) • Being employed or a student (POSITIVE EFFECT) • Being an ethnic minority (POSITIVE EFFECT) • High-quality local transit (POSITIVE EFFECT) • High income (NEGATIVE EFFECT) Surprisingly, education level and the presence of children in the home do not appear to have a strong association with transit use either way when the other variables are controlled for. This suggests that despite high rates of transit use in college, most former students do not continue to ride transit after that experience. People with kids, meanwhile, may be just as willing as others to take transit when it is available in their neighborhoods. We are able to explore what factors generally draw people to public transportation. Travel time, reliability, and cost appear to be more important than “flashy” features like Wi-Fi. Additionally, people who are offered pretax transit commuter benefits by their employers are over five times as likely to take transit regularly as employed persons who are not receiving benefits. The large sample size allows for comparisons across geography, age group, quality of local transit, levels of transit use, levels of population density, and other characteristics. We see the most variation across age groups. Behavior changes considerably along the age spectrum, even when controlling for other factors such as employment, household income, and neighborhood type. A central topic of this report is the behavior and attitudes of the Millennial generation as compared to older Americans. Whether the apparent change in travel preferences among Millennials is the result of a true generational change in attitudes—rather than a product of economic or social circumstances—is a topic of fierce debate. We see behavioral evidence to suggest that such a shift is indeed taking place: Parents of school-age children who are under 30 are, it appears, more likely than parents of school-age children over 30 to use public transit, even when controlling for income. In addition to the links between demographics and behavior, the study also explores how attitudes and upbringing affect one’s propensity to use public transportation. Our analysis establishes a connection between deeply held values and travel behavior, contributing to the broad conversation on what motivates an individual’s travel preferences. While the type of neighborhood you live in emerges as the biggest single predictor of mode-choice, personal values and attitudes have a considerable effect on travel preferences. Values influence travel choices directly as well as indirectly, through an effect on neighborhood choice. In an effort to identify distinct “types” of travelers, we use a statistical technique to group the sample into seven distinct groups based on their values and attitudes with respect to transit and housing. In particular, we identify a group of environmentally conscious, outgoing people, largely in their 30s and 40s, who are open to taking transit but find the service inconvenient or inadequate. We conclude that policymakers and transit providers could most easily increase transit ridership by focusing on this group. We also look at the role of upbringing in mode choice. Investigating the childhood circumstances and travel patterns of Millennials (defined in the report as people under 30) and Baby Boomers (over 60) leads us to a paradox: The Millennial generation seems to be defying its sheltered, suburban upbringing by delaying the acquisition of a driver’s license and choosing transit. Meanwhile, Baby Boomers, who grew up using transit and were encouraged to do so, are defying their upbringing by avoiding transit now. Finally, we explore data surrounding each respondent’s neighborhood type. The questionnaire asked a series of questions about the respondent’s current, childhood, and ideal home locations. From this data, we are able to infer that many respondents wish they lived in mixed-use neighborhoods, towns, and suburbs, rather than the residential areas they currently occupy. We draw the conclusion that land-use and housing policy would better serve Americans if it were to favor mixed-use development.

Van Acker, Veronique, Patricia Mokhtarian and Frank Witlox (2011). ***Going soft: on how subjective variables explain modal choices for leisure travel.*** *European Journal of Transport and Infrastructure Research* **11**(2): 115-146. <http://hdl.handle.net/1854/LU-1849426>

Most studies on the link between the built environment and modal choice characterize and model this relationship by objectively measurable characteristics such as density and diversity. Recently, within the debate on residential self-selection, attention has also been paid to the importance of subjective influences such as the individual’s perception of the built environment and his/her residential attitudes and preferences, resulting in models that take account of both the objective and subjective characteristics of the built environment. However, self-selection might occur on other points than residential location as well. Expanding the analysis to also include both objective and subjective characteristics at other model levels (i.e.,

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not only stage of life characteristics but also personal lifestyles; not only car availability but also travel attitudes, not only modal choice but also mode specific attitudes) is the purpose of this paper. To this end, a modal choice model for leisure trips is developed using data on personal lifestyles and attitudes, collected via an Internet survey, and estimated using a path model consisting of a set of simultaneous estimated equations between observed variables. While controlling for subjective lifestyles and attitudes, the effects of the built environment and car availability on modal choice can correctly be determined and thus insights into self-selection mechanisms can be gained. Moreover, we compared the results of a model with and without these subjective influences. The results show that subjective characteristics at various model levels are important decisive factors of modal choices for leisure travel.

Van Acker, Veronique, Patricia Mokhtarian and Frank Witlox (2014). "**Car availability explained by the structural relationships between lifestyles, residential location, and underlying residential and travel attitudes.**"

Transport Policy **35**(0): 88-99. <http://dx.doi.org/10.1016/j.tranpol.2014.05.006>

The majority of land use-travel behaviour studies only considers the direct influence of spatial characteristics on daily travel behaviour. However, this framework should be expanded. A first step is to explore the complex interdependencies of long-term lifestyle decisions, medium-term decisions about residential location and car ownership, and the underlying residential and travel attitudes. Travel behaviour should be considered within a hierarchy of decisions while considering the motivational background of these decisions. Using data from an Internet survey completed by +1800 respondents in Flanders, Belgium, this paper defines car ownership somewhat more broadly as car availability. Results of a structural equation model indicate a significant direct effect of the residential neighbourhood on car availability. However, effects are small compared to the influence of other variables such as stage of life and travel (mode) attitude, the latter referring to travel-related self selection. Moreover, one should keep in mind that residential attitudes remain important in the initial selection of the residential neighbourhood and its spatial characteristics, indicating the need to control for residential self-selection.

Van Acker, Veronique, Bert Van Wee and Frank Witlox (2010). "**When transport geography meets social psychology: Toward a conceptual model of travel behaviour.**" Transport Reviews **30**(2): 219-240.

Many studies model the effects of the built environment on travel behaviour. Usually, results are controlled for socio-economic differences and sometimes socio-psychological differences among respondents. However, these studies do not mention why after all a relationship should exist between travel behaviour and spatial, socio-economic and personality characteristics. Answering this query involves combining and linking theories stemming from transport geography (e.g. time geography, activity-based approach) and social psychology (e.g. Theory of Planned Behaviour, Theory of Repeated Behaviour). Using key-variables from these theories, this paper aims to develop a conceptual model for travel behaviour. Comparable to customary theories in transport geography, this conceptual model considers travel behaviour as derived from locational behaviour and activity behaviour. But the conceptual model adds concepts such as 'lifestyle', 'perceptions', 'attitudes' and 'preferences' which indirectly influence travel behaviour.

Van Wee, Bert, Hans Holwerda and Rick Van Baren (2002). "**Preferences for modes, residential location and travel behaviour: the relevance for land-use impacts on mobility.**" European Journal of Transport and Infrastructure Research **2**(3/4): 305-316.

Nowadays almost all researchers focusing on the impact of land use on travel behaviour examine personal and household variables such as income, age and household type. Still, within 'homogeneous' groups there may be preferences for travel modes (especially car or public transport), and these may have an impact on the influence of land use on travel behaviour – a subject for which available literature is scarce. This paper represents then an endeavour to relay results of empirical research on this matter and also attempts to answer the following questions: 1. Are there preferences for modes? 2. Is there a relationship between preferences and neighbourhood characteristics? 3. Have preferences for modes played a role in residential choices of households? 4. Do preferences for modes add explanatory power to models for travel behaviour that include personal and household characteristics, and land-use variables? Results obtained reveal positive answers to all four questions; but this then confronts us with the following question: Do land-use policies then make no sense? Yes, in our opinion, these policies do make sense, in the least because they allow people who prefer certain modes to live in an area that meets their preferences. However, this does not mean

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that land use alternatives leading to the lowest car use levels should always be recommended. Rather, what is needed is a broad evaluation of all the pros and cons of these alternatives.

Wang, C. H., G. Akar and J. M. Guldmann (2015). "***Do your neighbors affect your bicycling choice? A spatial probit model for bicycling to The Ohio State University.***" *Journal of Transport Geography* **42**: 122-130.

10.1016/j.jtrangeo.2014.12.003 [http://www.scopus.com/inward/record.url?eid=2-s2.0-](http://www.scopus.com/inward/record.url?eid=2-s2.0-84921056479&partnerID=40&md5=b1d79212b1fa9fa6867f22ee01f84d0b)

84921056479&partnerID=40&md5=b1d79212b1fa9fa6867f22ee01f84d0b

Neighborhood social effects have recently become a focus of interest in transportation research, whereby transportation mode choice is not only affected by an individual's characteristics and transportation system conditions, but also by the mode choices of that individual's social neighbors. This study supports the neighborhood social effects argument, using a spatial econometrics approach and data from The Ohio State University (OSU) 2012 Campus Transportation Survey. A spatial probit model of commuters' mode choices (bicycling versus non-bicycling) is estimated, accounting for spatial autocorrelation. The results show that the more OSU-affiliated bicycle riders are residing around an individual OSU commuter, the more attractive bicycling becomes, controlling for other factors such as gender, status, proximity to campus, bicycle infrastructure and attitudes. The results indicate that students and males are more likely to commute by bicycles. The probability of choosing bicycles decreases with distance from campus. In addition, proximity to bicycle infrastructure and physical environment both encourage respondents to bicycle. Feeling of safety, travel cost and concern for the environment also affect bicycling choice. © 2014 Elsevier Ltd.

Wang, Tingting and Cynthia Chen (2012). "***Attitudes, mode switching behavior, and the built environment: A longitudinal study in the Puget Sound Region.***" *Transportation Research Part A: Policy and Practice* **46**(10): pp

1594-1607. <http://dx.doi.org/10.1016/j.tra.2012.08.001>

Carpooling in the US has a storied history. After experiencing a peak 20% mode share in 1980, the current share of carpooling for work trips is about 10% and the majority of these carpooling trips are made by intra-household members. Casting the choice between single occupant vehicles (SOV) and carpool as a social dilemma in which SOV is a noncooperative choice and carpool is a cooperative one, the authors propose to test two hypotheses. First, the switch from SOV to carpool and the reverse choice are attributed to different factors' structural factors, or those factors altering the objective features of a decision scenario such as travel time and travel cost, play a dominant role in the switch from carpool to SOV while psychosocial factors (attitudes and beliefs) play a critical role in the switch from SOV to carpool. Second, the two choices are underlay by different behavioral mechanisms. In particular, the authors expect self-justification by carpool-to-SOV switchers - after they switch from carpool to SOV, they adjusted their attitudes toward carpool accordingly to match their behavior. The analysis of the first three waves of the Puget Sound Transportation Panel supports these two hypotheses. The study results recommend developing programs and policies that aim at influencing people's subjective assessments of carpooling, in addition to the existing ones that mostly focus on incentivizing carpooling, and differentiating between programs seeking to encourage SOV users to switch to carpool and those aiming to maintain existing carpoolers.

Zhao, Jinhua (2011). Subjective Measure of Car Dependence. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2231. Transportation Research Board of the National Academies, Washington, D.C., pp. 44-52 DOI 10.3141/2231-06

A subjective measure of car dependence was developed on the basis of people's own assessment of their reliance on car use. The measure supplements the commonly used objective measure on the basis of actual car use. Structural equation models (SEMs) were estimated to quantify the subjective dependence and to examine its determinants: demographics, socioeconomic, and land use and transit access. The comparison between subjective dependence and actual car use disclosed significant differences between the measures, despite their statistical linkage. The measures also differed significantly in terms of how they were influenced by the determinants. Segmenting the population by both measures revealed 20% of the sample with contrasting subjective and objective measures. After controlling for the determinants, the SEMs examined relations between subjective car dependence (attitude), actual car use (behavior), and the intent to reduce car use (intention). Given the cross-sectional nature of the data, causality could not be proven. Two plausible structural relationships were tested: that actual car use determined subjective car dependence and that no direction of causality was assumed. Subjective car dependence mediates the impact of car use on the intent

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to reduce it: the direct effect of car use on the intent to reduce it is 0.2; the indirect effect through stated car dependence is -0.6; the total effect is -0.4. Actual car use explains approximately 50% of the variation in subjective car dependence, which, together with actual car use, explains approximately 60% of the variation in people's intent to reduce car use.

Zou, F., B. Wu, J. Xiong and L. Li (2013). "**Analyzing public transportation competitiveness based on the theory of planned behavior**". 4th International Conference on Transportation Engineering, ICTE 2013, Chengdu. [^]<http://www.scopus.com/inward/record.url?eid=2-s2.0-84890036126&partnerID=40&md5=8d9b6bb01384f1f5729f9d2d97a9f157>

This paper aims to improve the competitiveness of public transportation by exploring how the psychological factors influencing public transport use behavior based on the theory of planned behavior (TPB). TPB direct variables like intention, attitude, subjective norm, descriptive norm, perceived behavioral control and indirect variables like behavioral beliefs are included in the questionnaires. Firstly, we constructed a ordered logit model with dependent variable intention and other independent variables for the 282 questionnaires of which people who don't have private cars, finding that factors like attitude and subjective norm are significant, but descriptive norm and perceived behavioral control have not entered the model. It is indicated that changing people's attitude towards bus and guiding the residents to choose public transit through family guidance or policy of our country, public transportation competitiveness can be highly improved. Secondly, 111 questionnaires of which people have private cars were analyzed. The results reveal that only attitude is significant in the model, indicating that these people who own private cars are more influenced by subjective attitude instead of objective condition when using buses. Therefore, transferring these potential passengers to public transport by providing them better services is possible. According to the further analysis of behavior beliefs, we find that increasing public transport's punctuality, convenience and speed instead of reducing costs are the key strategies to enhance public transportation competitiveness. © 2013 American Society of Civil Engineers.

4. Hybrid Models to Integrate Attitudes

Bibliography Theme 4: Hybrid Models to Integrate Attitudes

Abou-Zeid, Maya, Moshe Ben-Akiva, Michel Bierlaire, Charisma Choudhury and Stephane Hess. Attitudes and Value of Time Heterogeneity. Presented at 90th Annual Meeting of the Transportation Research Board, Washington, D.C.

There is ample evidence showing a high level of heterogeneity of values of time among travelers. Previous studies have represented this heterogeneity by a distribution such as log-normal whose parameters depend on covariates like income, trip purpose, and mode of travel. We present and demonstrate a model where the distribution of the value of time also depends on attitudes towards travel. Attitudes are latent, or unobservable, and their distribution determines the conditional distribution of the value of time given the observable covariates such as income. We illustrate this model using data from a stated preferences survey. The estimation results show that as expected the median value of time increases with income and that the variability of value of time also increases with income reflecting the greater effect that the attitude towards travel has for high income groups.

Ashok, Kalidas, William R Dillon and Sophie Yuan (2002). "**Extending discrete choice models to incorporate attitudinal and other latent variables.**" Journal of Marketing Research **39**(1): 31-46.

One of the nagging issues in using discrete choice models is how softer attributes, such as attitudes and perceptions, that are not explicitly manipulated within the context of the choice experiment can be accommodated. In many cases, it is reasonable to expect that the choice of a particular alternative may be influenced by non-product-related attributes. For example, latent attitudes and perceptions may play as much of a role in shaping choice as the attributes that have been manipulated and used to define the alternative offerings. In this article, the authors present several full information models that can accommodate latent variables such as attitudes and satisfaction within the context of binary and multinomial choice models. The models proposed are particularly useful when the focus is on understanding how softer attributes can influence choice decisions. The authors accomplish this by integrating structural equation models within the basic framework of binary and multinomial choice models. Two empirical applications are provided. In addition to illustrating the proposed models, these applications provide insights into the circumstances under which the simultaneous factor-choice modeling approach makes a difference.

Barff, R., D MacKay and R. W. Olshavsky (1982). "**A selective review of travel-mode choice models,**" Journal of Consumer Research: pp. 370-380.

Major advances in travel-mode choice modeling are reviewed. These include a shift from aggregate to disaggregate models and a shift from physical and economic variables to cognitive and behavioral variables. Developments in modechoice studies are assessed,

Ben-Akiva, Moshe, Daniel McFadden, Tommy Gärling, Dinesh Gopinath, Joan Walker, Denis Bolduc, Axel Börsch-Supan, Philippe Delquié, Oleg Larichev and Taka Morikawa (1999). "**Extended framework for modeling choice behavior.**" Marketing Letters **10**(3): 187-203.

We review the case against the standard model of rational behavior and discuss the consequences of various "anomalies" of preference elicitation. A general theoretical framework that attempts to disentangle the various psychological elements in the decision-making process is presented. We then present a rigorous and general methodology to model the theoretical framework, explicitly incorporating psychological factors and their influences on choices. This theme has long been deemed necessary by behavioral researchers, but is often ignored in demand models. The methodology requires the estimation of an integrated multi-equation model consisting of a discrete choice model and the latent variable model system. We conclude with a research agenda to bring the theoretical framework into fruition.

Chakraborty, A. and A. McMillan (2015). "**Scenario planning for urban planners: Toward a practitioner's guide.**" Journal of the American Planning Association **81**(1), : 1-12. doi:10.1080/01944363.2015.1038576

Problem, research strategy, and findings: Scenario planning has promise as a planning tool when compared with more common approaches, yet planners have had limited success with scenario planning in part because of the complexities of the scenario-planning process itself. We address these issues by constructing the key building blocks of a scenario process for public sector planners. We review and synthesize 63 articles

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and 25 projects from 2004 to 2014 to construct a planning typology with nine components that capture the important variations in scenario projects, such as the project scope, desired outcomes, and the types of scenario construction and evaluation tools used by planners. Although the typology is based only on a select set of projects from the industrialized world in English, we nevertheless further use our review and synthesis to characterize the key subcomponents or possibilities within each component and discuss the overlaps and connections among them. We then use the typology to code a subset of the reviewed projects to identify the associations among the subcomponents of different components and to explore whether planners should promote or avoid these associations. Finally, we offer some instructions on how planners may use the typology to create a better scenario–planning process. Takeaway for practice: Our typology illustrates the combination of variables that comprise a scenario–planning process and the tradeoffs planners make when choosing one set of factors over another. Planners can use our typology to construct a variety of scenario processes that are participatory, transparent, and future oriented and are an improvement over traditional planning approaches.

Chorus, C. G. and M. Kroesen (2014). "**On the (im-)possibility of deriving transport policy implications from hybrid choice models.**" *Transport Policy* **36**: 217-222. 10.1016/j.tranpol.2014.09.001

[http://www.scopus.com/inward/record.url?eid=2-s2.0-](http://www.scopus.com/inward/record.url?eid=2-s2.0-84907552836&partnerID=40&md5=679dc5ded5d06f428d924ccc27e0dcea)

[84907552836&partnerID=40&md5=679dc5ded5d06f428d924ccc27e0dcea](http://www.scopus.com/inward/record.url?eid=2-s2.0-84907552836&partnerID=40&md5=679dc5ded5d06f428d924ccc27e0dcea)

This paper focuses on hybrid choice models of the type increasingly being used by travel demand modelers, which include latent perception and attitude related variables. We argue that, contrary to current practice, these models do not support the derivation of policies that aim to change travel behavior by means of changing the value of a latent variable. An example of such a policy is a marketing campaign which aims to influence the latent variable 'perceived quality of public transport', and as a consequence mode choice behavior. We argue that this lack of support is due to the combination of two factors: (i) the latent variable is usually to a non-trivial extent endogenous to the travel choice, precluding inference of causality; and (ii) the data are almost without exception cross-sectional as far as the latent variable is concerned, and as such do not allow for claims concerning changes in the variable at the individual level. When data for the latent variables are cross-sectional, and to the extent that endogeneity of the latent variables cannot be ruled out, these variables should best not be used as targets for travel demand management policies—although they may still be used as input for scenario studies that involve changes in the population over time. © 2014 Elsevier Ltd.

Daly, Andrew, Stephane Hess, Bhanu Patruni, Dimitris Potoglou and Charlene Rohr (2012). "**Using ordered attitudinal indicators in a latent variable choice model: a study of the impact of security on rail travel behaviour.**" *Transportation: Planning, Policy, Research, Practice* **39**(2): pp 267-297. <http://dx.doi.org/10.1007/s11116-011-9351-z>

This study investigates the role of latent attitudes in choice behavior by applying jointly estimated attitudinal and choice models to a real-world rail travel study. Findings show a strong impact of two latent variables: (1) concern with privacy, liberty and security; and (2) distrust of business, technology and governmental authority on the desire for rail travel. These variables were significant as explanators for the answers to attitudinal questions put to respondents and also for the propensity to choose an opt-out alternative in the survey. The concern-related variable also showed a significant impact on the sensitivity to the introduction of universal metal detector checks. The authors address several theoretical issues in addition to demonstrating the applicability of the model in applied work. The authors show the equivalence of two different normalizations discussed in the literature and explicitly recognize the repeated choice nature of the data. Replacing the typically used continuous model for attitudinal response by an ordered logit structure more correctly accounts for the ordinal nature of the indicators. The authors conclude that the use of latent attitude models can lead to an improved understanding of stated choice and would be applicable in other practical studies.

Daziano, R. A. (2015). "**Inference on mode preferences, vehicle purchases, and the energy paradox using a Bayesian structural choice mode.**" *Transportation Research Part B: Methodological*, **76**, : pp. 1-26.

Discrete choice modeling is experiencing a reemergence of research interest in the inclusion of latent variables as explanatory variables of consumer behavior. There are several reasons that motivate the

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integration of latent attributes, including better-informed modeling of random consumer heterogeneity and treatment of endogeneity. However, current work still is at an early stage and multiple simplifying assumptions are usually imposed. For instance, most previous applications assume all of the following: independence of taste shocks and of latent attributes, exclusion restrictions, linearity of the effect of the latent attributes on the utility function, continuous manifest variables, and an a priori bound for the number of latent constructs. We derive and apply a structural choice model with a multinomial probit kernel and discrete effect indicators to analyze continuous latent segments of travel behavior, including inference on the energy paradox. Our estimator allows for interaction and simultaneity among the latent attributes, residual correlation, nonlinear effects on the utility function, flexible substitution patterns, and temporal correlation within responses of the same individual. Statistical properties of the Bayes estimator that we propose are exact and are not affected by the number of latent attributes.

Daziano, R. A and Denis Bolduc (2013). **"Incorporating pro-environmental preferences towards green automobile technologies through a Bayesian hybrid choice model"**. *Transportmetrica A: Transport Science* pp. **9 (1)** 74-106.

Using stated data on both vehicle purchase decisions and environmental concerns, we develop, implement and apply the MCMC Gibbs sampler for Bayesian estimation of a Hybrid Choice Model (HCM). Whereas classical estimation of HCMs is fairly complex, we verify the feasibility of the Bayesian estimator as well as the HCM capacity to adapt to practical situations. We show that the Bayesian approach for HCMs is methodologically easier to implement than simulated maximum likelihood because the inclusion of latent variables translates into adding independent ordinary regressions; we also find that, using the Bayesian estimates, forecasting and deriving confidence intervals for willingness to pay measures is straightforward. Our empirical results coincide with a priori expectations, namely that environmentally-conscious consumers are willing to pay more for low-emission vehicles. The model outperforms standard discrete choice models because it not only incorporates pro-environmental preferences but also provides tools to build a profile of environmentally-conscious consumers.

Fleischer, Aliza, Anat Tchetchnik and Tomer Toledo (2012). **"The impact of fear of flying on travelers' flight choice, choice model with latent variables."** *Journal of Travel Research* **51(5)**: 653-663.

Flying is an important part of the tourist experience and a substantial component of its cost. While travelers' decision making regarding air travel has been studied, the role of fear of flying (FOF), a very common phenomenon among air passengers, in the process has not been explicitly addressed. Since airline safety levels are difficult to assess, passengers who have FOF employ other attributes of the itinerary as a means of alleviating their fear. Based on a stated preference experiment and accounting specifically for FOF as a latent variable, we established that the individuals' level of FOF affects the value they place on attributes of flight itineraries. We show that home carriers, scheduled carriers, and nonstop flights are fear-alleviating attributes. We also show that the price elasticities of demand for flights are smaller in absolute terms among people with a high level of FOF compared to their counterparts with low FOF.

Fujii, Satoshi and Tommy Gärling (2003). **"Application of attitude theory for improved predictive accuracy of stated preference methods in travel demand analysis."** *Transportation Research Part A: Policy and Practice* **37(4)**: 389-402. [http://dx.doi.org/10.1016/S0965-8564\(02\)00032-0](http://dx.doi.org/10.1016/S0965-8564(02)00032-0)

Stated preference (SP) surveys are frequently adopted by transport planners for the analysis of the impact of transport policies on travel demand. SP surveys are believed to yield stable preference estimates from stated choices from among hypothetical alternatives, which can then be used in forecasting. However, evidence suggests that preferences derived from SP surveys are contingent on context. The objective of this paper is to outline an alternative conceptual framework for travel demand analysis which draws on attitude theory from social psychology. In line with this theory stated choices are interpreted as behavioral intentions. The theory then explains why behavioral intention sometimes deviates from actual behavior. In an empirical demonstration using panel data obtained from commuters (n=903) before and after the opening of a new subway line in Kyoto, Japan, support is obtained for several predictions about why behavioral intentions are, or are not, implemented.

Glerum, Aurélie, Bilge Atasoy and Michel Bierlaire (2014). **"Using semi-open questions to integrate perceptions in choice models."** *Journal of choice modelling* **10**: 11-33.

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This research investigates the measurement of perceptions by means of adjectives freely reported by respondents in semi-open questions. It involved the use of semi-open responses of 1763 Swiss individuals to develop indicators for a latent variable representing the perception of comfort of public transportation. The indicators are then incorporated into a discrete choice model of revealed mode choices. Perceptions are assumed to impact choice significantly and this research aims at capturing their complexity using adjectives and integrating them into the hybrid choice modeling framework. We exploit a quantification of the adjectives performed by external evaluators. Given the subjectivity that is involved, we analyze the sensitivity of the results across evaluators who rated the adjectives. We observe that the aggregate indicators of demand, such as market shares, elasticities and values of time, are rather robust across evaluators. This is not the case for the disaggregate indicators that may vary substantially across evaluators.

Hensher, D. A., J. M. Rose, W. Leong, A. Tirachini and Z. Li (2013). "**Choosing Public Transport-Incorporating Richer Behavioural Elements in Modal Choice Models.**" *Transport Reviews* **33**(1): 92-106. 10.1080/01441647.2012.760671 <http://www.scopus.com/inward/record.url?eid=2-s2.0-84873163046&partnerID=40&md5=612eae62ad34340ff258cb8750ab486c>

The development of behaviourally richer representations of the role of well-established and increasingly important influences on modal choice, such as trip time reliability and accounting for risk attitude and process rules, has moved forward at a fast pace in the context of automobile travel. In the public transport setting, such contributions have, with rare exception, not been considered. In this paper, we discuss and empirically illustrate the merits of advanced modelling developments aimed at improving our understanding of public transport choice, namely the inclusion of reliability in extended expected utility theoretic forms, to recognize risk attitude and perceptual conditioning, the consideration of passenger crowding and its inclusion in linear additive models, and the role of multiple heuristics in representing attribute processing as a way of conditioning modal choice. We illustrate the mechanics of introducing these behaviourally appealing extensions using a modal choice data set collected in Sydney. © 2013 Copyright Taylor and Francis Group, LLC.

Hess, S and T. Adler (2009). "**An analysis of trends in air travel behaviour using four related SP datasets collected between 2000 and 2005.**" *Association for European Transport*. <http://abstracts.aetransport.org/paper/index/id/3269/confid/15>

An ever growing number of studies are carried out to understand the behaviour of air travellers, and in particular the response to changes in crucial attributes such as air fares, travel time, and frequent flier benefits. Increasingly, these studies make use of data collected through stated choice surveys. However, while the different studies all produce interesting results in their own right, it should be recognised that the results are limited to the context of each specific study. In the present study, we present a novel application in this context, using data from four related surveys carried out between 2000 and 2005. The analysis shows a certain level of consistency in some of the sensitivities, but also highlights trends such as reduced WTP measures, potentially influenced by the growing number of low cost flight options, lack of service differentiation among the carriers, and increased use of online ticketing, which has led to greater fare transparency.

Hess, Stephane, Matthew J. Beck and Caspar G. Chorus (2014). "**Contrasts between utility maximisation and regret minimisation in the presence of opt out alternatives.**"

An increasing number of studies of choice behaviour are looking at random regret minimisation (RRM) as an alternative to the well established random utility maximisation (RUM) framework. Empirical evidence tends to show small differences in performance between the two approaches, with the implied preference between the models being dataset specific. In the present paper, we discuss how in the context of choice tasks involving an opt out alternative, the differences are likely to be more clear cut. Specifically, we hypothesise that when opt out alternatives are framed as a rejection of all the available alternatives, this is likely to have a detrimental impact on the performance of RRM, while the performance of RUM suffers more when the opt out is framed as a respondent being indifferent between the alternatives on offer. We provide empirical support for these hypotheses through two case studies, using the two different types of opt out alternatives. Our findings suggest that analysts need to carefully evaluate their choice of model structure in the presence

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of opt out alternatives, while any a priori preference for a given model structure should be taken into account in survey framing.

Hess, S., T. Ryley, L. Davison and T. Adler (2013). **"Improving the quality of demand forecasts through cross nested logit: A stated choice case study of airport, airline and access mode choice."** *Transportmetrica A: Transport Science* 9(4): 358-384. <http://www.scopus.com/inward/record.url?eid=2-s2.0-84876030467&partnerID=40&md5=3f322419ad5da7ba7bf5a09e351ce2c9>

Airport choice models have been used extensively in recent years to assist the transport planning in large metropolitan areas. However, these studies have typically focused solely on airports within a given metropolitan area, at a time when passengers are increasingly willing to travel further to access airports. This article presents the findings of a study that uses broader, regional data from the East Coast of the United States collected through a stated choice based air travel survey. The study makes use of a cross-nested logit structure that allows for the joint representation of inter-alternative correlation along the three choice dimensions of airport, airline and access mode choice. The analysis not only shows significant gains in model fit when moving to this more advanced nesting structure, but the more appropriate cross-elasticity assumptions also lead to more intuitively correct substitution patterns in forecasting examples. © 2013 Copyright Hong Kong Society for Transportation Studies Limited.

Hess, S. and A. Stathopoulos (2013). **"A mixed random utility - random regret model linking the choice of decision rule to latent character traits."** *Working paper*.

An increasing number of studies are concerned with the use of alternatives to random utility maximisation as a decision rule in choice models, with a particular emphasis on regret minimisation over the last few years. The initial focus was on revealing which paradigm is best for a given dataset, while later studies have looked at variation in decision rules across respondents within a dataset. However, only limited effort has gone towards understanding the potential drivers of decision rules, i.e. what makes it more or less likely that the choices of a given respondent can be explained by a particular paradigm. The present paper puts forward the notion that unobserved character traits can be a key source of this type of heterogeneity and proposes to characterise these traits through a latent variable within a hybrid framework. In an empirical application on stated choice data, we make use of a mixed random utility-random regret structure, where the allocation to a given class is driven in part by a latent variable which at the same time explains respondents' stated satisfaction with their real world commute journey. Results reveal a linkage between the likely decision rule and the stated satisfaction with the real world commute conditions. Notably, the most regret-prone respondents in our sample are more likely to have aligned their real-life commute performance more closely with their aspirational values.

Hess, Stephane, Amanda Stathopoulos and Andrew Daly (2012). **"Allowing for heterogeneous decision rules in discrete choice models: an approach and four case studies."** *Transportation* 39(3): 565-591. 10.1007/s11116-011-9365-6 <http://dx.doi.org/10.1007/s11116-011-9365-6>

The study of respondent heterogeneity is one of the main areas of research in the field of choice modelling. The general emphasis is on variations across respondents in relative taste parameters while maintaining the assumption of homogeneous utility maximising decision rules. While recent work has allowed for differences in the utility specification across respondents in the context of looking at heterogeneous information processing strategies, the underlying assumption that all respondents employ the same choice paradigm remains. This is despite evidence in the literature that different paradigms work differently well on given datasets. In this article, we argue that such differences may in fact extend to respondents within a single dataset. We accommodate these differences in a latent class model, where individual classes make use of different underlying paradigms. We present four applications using three different datasets, showing mixtures between "standard" random utility maximisation models and lexicography based models, models with multiple reference points, elimination by aspects models and random regret minimisation models. In each of the case studies, the behavioural mixing model obtains significant gains in fit over the base structure where all respondents are hypothesised to use the same rule. The findings offer important further insights into the behavioural patterns of respondents. There is also evidence that what is retrieved as taste heterogeneity in standard models may in fact be heterogeneity in decision rules

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Homer, P. M. and L. R. Kahle (1988). " ***A structural equation test of the value-attitude-behavior hierarchy,*** ." *Journal of Personality and Social Psychology*, Vol. 54, (No. 4): pp. 638-646.

The role of values has received limited empirical attention relative to its potential significance, especially within a causal modeling approach. A series of multivariate and structural equation analyses supported the hypotheses that values have internal and external dimensions that influence attitudes. In turn, attitudes were found to influence behaviors, as the final phase in the value-attitude-behavior hierarchy. These analyses were performed on data derived from a survey about natural food shopping. As hypothesized, we found that people who have more internally oriented and less externally oriented value structures like natural foods more than other people, and these attitudes then lead to behaviors appropriate to the structure. Theoretical implications are discussed. (PsycINFO Database Record (c) 2012 APA, all rights reserved)

Hurtubia, Ricardo, My Hang Nguyen, Aurélie Glerum and Michel Bierlaire (2014). "***Integrating psychometric indicators in latent class choice models.***" *Transportation Research Part A: Policy and Practice* 64: 135-146.

Latent class models are a convenient and intuitive way to introduce taste heterogeneity in discrete choice models by relating attributes of the decision makers with unobserved behavioral classes, hence allowing for a more accurate market segmentation. Estimation and specification of latent class models can be improved with the use of psychometric indicators that measure the effect of unobserved attributes in the individual preferences. This paper proposes a method to introduce these additional indicators in the specification of integrated latent class and discrete choice models, through the definition of measurement equations that relate the indicators to attributes of the decision maker. The method is implemented for two mode-choice case studies and compared with alternative methods to introduce indicators. Results show that the proposed method generates significantly different estimates for the class and choice models and provide additional insight into the behavior of each class.

Kamargianni, M. and A. Polydoropoulou (2013). Hybrid choice model to investigate effects of teenagers' attitudes toward walking and cycling on mode choice behavior. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2382. Transportation Research Board of the National Academies, Washington, D.C. pp. 151-161.

The scope of this paper is to develop an advanced stated preferences (SP) survey customized to capture teenagers' behaviors and to estimate models of hybrid mode choices, in which the utilities depend on both the attributes of the mode and the latent variable willingness to walk or cycle. The SP scenarios include four alternative modes for the trip to school-car (escorted by parents), bus, bicycle, and walk-while the attributes are travel time; travel cost; walking time to the bus station; availability of bike paths, sidewalks, and parking places; and weather conditions. The data are drawn from a survey that took place in all the high schools of Cyprus in 2012. The sample consists of 4,174 teenagers (ages 12 to 18) and covers 8.7% of the total high school population. For the model estimations, 8,348 SP observations are used. It was found that the existence of bike paths and wide pavements significantly affect the choice of active transport. The latent variable enters significantly into the specification of the choice model to assure that unobserved variables should be implemented in the choice process. Willingness to walk and to cycle has a positive effect on the choice of those alternatives and a negative effect on the choice of a car. Moreover, parents' level of education and mode use patterns and habits influence the development of attitudes toward mode choice. The results of the study provide insights on policies and campaigns that may help the next generation develop greener travel behavior.

Landau, S.,G. Weisbrod, G. Gosling, C. Williges, M. Pumphrey, and M. Folwer (2015). *ACRP Web-Only Document 22: Passenger Value of Time, Benefit-Cost Analysis, and Airport Capital Investment Decisions: Volume 1 Guidebook for Valuing User Time Savings in Airport Capital Investment Decision Analysis*. www.trb.org/Main/Blurbs/172472.aspx.

This guidebook was prepared as part of Airport Cooperative Research Program (ACRP) 03-19: Passenger Value of Time, Benefit-Cost Analysis and Airport Capital Investment Decisions. The purpose of this research is to provide an up-to-date understanding of how recent airport developments, such as changes in security measures since 9/11, the proliferation of airside passenger amenities, and the adoption of new technology (e.g., Internet, mobile phone, wireless devices, and portable computers), have changed the way travelers value efficient air travel. For example, technology enhancements allow business travelers to conduct business on cell phones or computers while waiting for flights at airport gates. What was once "wasted time" can now become productive time. Similarly, air travelers can now often find a wider array of restaurants, products, and

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services available near gates than in the past. At the same time, security procedures have introduced new sources of uncertainty in time required to get to gates. Altogether, these types of technological and service shifts have the potential to change the way aviation system users value airport services and the airport capital necessary to provide efficient travel. Travel time is often a significant consideration in benefit-cost analysis (BCA) for transportation projects and policies, and in recent years, there has been greater emphasis on use of BCA for airport capital investment. The Federal Aviation Administration (FAA) requires benefit-cost analysis for airport capacity enhancement projects funded through the Airport Improvement Program (AIP). Similarly, US Department of Transportation (USDOT) considers the result of cost-benefit analysis when selecting projects for discretionary funding programs, such as the recent TIGER (Transportation Investment Generating Economic Recovery) Program grant rounds. The Office of Management and Budget (OMB) has also long required the USDOT to estimate the incremental costs and benefits during Regulatory Impact Analysis (RIA) for rulemaking, such as occurred for the 2009 Enhanced Airline Passenger Protections (or "Passenger Bill of Rights") rule. The same need to understand the benefits and costs of investments applies to airport managers. Airports invest billions of dollars in infrastructure and service investments, yet airport owners and operators have relatively limited information on how customers value the impact of these investments. In addressing the question of how to best allocate limited resources, one can ask "would air travelers prefer improvements to the airport access roads, improved security processing times, or a people-mover connection between terminals?" This guidebook provides a method for airport owners and operators to determine how their customers value the travel time impacts of efficiency improvements. The economic values presented in this guidebook are derived from a review of past research studies and a survey of air travelers conducted during the spring of 2013. The survey respondents comprised 1,260 travelers who made flights between 172 distinct origin airports and 148 distinct destination airports throughout the country. The results of the survey provide estimates of how travelers value their time for different segments of an air trip. A detailed description of the data collection methodology and results can be found in *ACRP Web-Only Document 22: Passenger Value of Time, Benefit-Cost Analysis, and Airport Capital Investment Decision, Volume 2: Final Report* at www.trb.org/Main/Blurbs/172473.aspx.

Li, Zheng and David A. Hensher (2013). "***Behavioural implications of preferences, risk attitudes and beliefs in modelling risky travel choice with travel time variability.***" *Transportation: Planning, Policy, Research, Practice* 40(3): pp 505-523. <http://dx.doi.org/10.1007/s11116-012-9445-2>

In this paper, the authors develop an Attribute-Specific Extended Rank-Dependent Utility Theory (AS_ERDUT) model to better understand choice behavior in the presence of time travel variability. The model does so by allowing for a systematic treatment of three key components of decision making—preferences, risk attitudes and beliefs. This study addresses previously unobserved between-individual heterogeneity in these three components. Because risk attitude and belief have been traditionally been overlooked in much of travel time and travel time variability research, the AS_ERDUT framework is determined to be more behaviorally appealing than traditional research in this area.

Maldonado-Hinarejos, R., A. Sivakumar and J. W. Polak (2014). "***Exploring the role of individual attitudes and perceptions in predicting the demand for cycling: a hybrid choice modelling approach.***" *Transportation* 41(6): 1287-1304. [10.1007/s11116-014-9551-4 http://www.scopus.com/inward/record.url?eid=2-s2.0-84911966016&partnerID=40&md5=7a532b3deec79f1c06c88bb2f05f9d1](http://www.scopus.com/inward/record.url?eid=2-s2.0-84911966016&partnerID=40&md5=7a532b3deec79f1c06c88bb2f05f9d1)

Cycling is often promoted as a means of reducing urban congestion and improving health, social and environmental outcomes. However, the quantification of these potential benefits is not well established. This is due in part to practical difficulties in estimating cycling demand and a lack of sound methodologies to appraise cycling initiatives. In this paper we attempt to address this need by developing predictive models of cycle demand, relative to other transport modes, that capture not only the impacts of observed characteristics such as age and travel time but also the role of attitudes and perceptions. Using data from a stated preference survey, we estimate a hybrid choice model for cycle use that incorporates the role of attitudes towards cycling, perceptions of the image associated with cycling, and the stress arising from safety concerns. Model results indicate that the latent attitudes and perceptions explain an important part of the non-observable utility in a simple multinomial logit choice model. We also demonstrate policy analysis using the hybrid choice model, which allows comparisons of 'hard' policies such as the provision of parking facilities against 'soft' measures such as cycle promotion schemes. © 2014, Springer Science+Business Media

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New York.

McFadden, D. L. (1986). **"The choice theory approach to marketing research"** *Marketing Science*, Vol. 5, No. 4: pp. 275–297.

Paulssen, M., D. Temme, A. Vij and J. L. Walker (2013). **"Values, attitudes and travel behavior: a hierarchical latent variable mixed logit model of travel mode choice."** *Transportation*: 1-16.

[http://www.scopus.com/inward/record.url?eid=2-s2.0-](http://www.scopus.com/inward/record.url?eid=2-s2.0-84886734691&partnerID=40&md5=372f2d4397923744146e71988cbebf1)

[84886734691&partnerID=40&md5=372f2d4397923744146e71988cbebf1](http://www.scopus.com/inward/record.url?eid=2-s2.0-84886734691&partnerID=40&md5=372f2d4397923744146e71988cbebf1)

Values lie at the heart of an individual's belief system, serving as prototypes from which attitudes and behaviors are subsequently manufactured. Attitudes and behaviors may evolve over time, but values represent a set of more enduring beliefs. This study examines the influence of values on travel mode choice behavior. It is argued that personal values influence individual attitudes towards different alternative attributes, which in turn impact modal choices. Using data from a sample of 519 German commuters drawn from a consumer panel, the study estimates an integrated choice and latent variable model of travel mode choice that allows for hierarchical relationships between the latent variables and flexible substitution patterns across the modal alternatives. Results from the empirical application support the value-attitude-behavior hierarchical model of cognition, and provide insights to planners and policy-makers on how better to sell public transit as a means of travel. © 2013 Springer Science+Business Media New York.

Temme, Dirk, Marcel Paulssen and Till Dannewald (2008). **"Incorporating Latent Variables into Discrete Choice Models—A Simultaneous Estimation Approach Using SEM Software."** *Business Research* 1(2).

Integrated choice and latent variable (ICLV) models represent a promising new class of models which merge classic choice models with the structural equation approach (SEM) for latent variables. Despite their conceptual appeal, applications of ICLV models in marketing remain rare. We extend previous ICLV applications by first estimating a multinomial choice model and, second, by estimating hierarchical relations between latent variables. An empirical study on travel mode choice clearly demonstrates the value of ICLV models to enhance the understanding of choice processes. In addition to the usually studied directly observable variables such as travel time, we show how abstract motivations such as power and hedonism as well as attitudes such as a desire for flexibility impact on travel mode choice. Furthermore, we show that it is possible to estimate such a complex ICLV model with the widely available structural equation modeling package Mplus. This finding is likely to encourage more widespread application of this appealing model class in the marketing field.

Vij, A., A. Carrel and J. Walker (2013). **"Incorporating the influence of latent modal preferences on travel mode choice behavior."** *Transportation Research Part A: Policy and Practice* 54: 164-178.

[http://www.scopus.com/inward/record.url?eid=2-s2.0-](http://www.scopus.com/inward/record.url?eid=2-s2.0-84883194539&partnerID=40&md5=d7701ec576d714255580883215b2ebb5)

[84883194539&partnerID=40&md5=d7701ec576d714255580883215b2ebb5](http://www.scopus.com/inward/record.url?eid=2-s2.0-84883194539&partnerID=40&md5=d7701ec576d714255580883215b2ebb5)

Latent modal preferences, or modality styles, are defined as behavioral predispositions characterized by a certain travel mode or set of travel modes that an individual habitually uses. They are reflective of higher-level orientations, or lifestyles, that are hypothesized to influence all dimensions of an individual's travel and activity behavior. The objectives of this paper are to understand and quantify different modality styles, and to show how the modality styles construct can be operationalized within the context of traditional models of travel mode choice. We employ the six-week MOBI. DRIVE travel diary and estimate behavioral mixture models in which the modality style provides a behavioral rationale to the way in which unobserved heterogeneity is specified in the travel model. Our analysis consists of two stages: First, we explore the presence and types of modality styles suggested by the data through the means of a descriptive analysis. Next, we develop a model that captures the influence of modality styles on two dimensions of an individual's travel behavior: travel mode choice for work tours and travel mode choice for non-work tours. The modality styles are specified as latent classes; heterogeneity across modality styles include both the modes considered (choice set) and the values of taste parameters. The modality style of an individual then influences all of his/her travel mode choice decisions for work and non-work tours. In addition, error components capture unobserved correlation across travel mode choice decisions made by the same individual. Results indicate the presence of habitual drivers who display a strong bias for using the automobile and multimodal

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individuals who exhibit variation in their modal preferences. Multimodal behavior is further distinguished by those who appear to be sensitive to travel times and those who appear to be insensitive. Estimation results further find that modality styles are strongly correlated with more long-term travel decisions and life-cycle characteristics. © 2013 Elsevier Ltd.

Vij, Akshay and J. Walker (2015). "**Statistical properties of Integrated Choice and Latent Variable models.**"

Integrated Choice and Latent Variable (ICLV) models are an increasingly popular extension to discrete choice models that attempt explicitly to model the cognitive process underlying the formation of any choice. Though the ICLV model has been employed extensively by studies across a wide spectrum of disciplines, the value of the framework has remained unclear. On one hand, ICLV models allow for the proper integration of psychometric data and provide a framework with which to test the influence of latent variables, such as attitudes and perceptions, on observable behavior. On the other, questions have been raised regarding their value to econometricians, practitioners and policy-makers. This study undertakes a systematic evaluation of the statistical properties of the ICLV framework, and how they compare to a reduced form choice model without latent variables. We derive easily generalizable analytical proofs regarding the statistical benefits, or lack thereof, of ICLV models over choice models without latent variables and use synthetic datasets to validate any conclusions drawn from the analytical proofs. In terms of goodness of fit and the consistency of parameter estimates, we find that ICLV models do not offer improvements over reduced form choice models without latent variables. However, ICLV models allow for the identification of structural relationships between observable variables that could not be identified using choice models without latent variables, and parameter estimates from the ICLV model are shown to be potentially more efficient than equivalent estimates from a reduced form choice model without latent variables. Given the limited nature of these practical benefits, we argue that studies that use ICLV models need to show either that the structure imposed by the ICLV model results in a reduced form choice model specification that may not have been considered in the absence of latent variables to guide the process of model development, or that the greater insights into the decision-making process offered by the ICLV model can be used to inform policy and generate forecasts in unobvious ways that would not be possible using choice models without latent variables.

Vredin Johansson, Maria, Tobias Heldt and Per Johansson (2006). "**The effects of attitudes and personality traits on mode choice.**" Transp Res Part A.

We hypothesise that differences in people's attitudes and personality traits lead them to attribute varying importance to environmental considerations, safety, comfort, convenience and flexibility. Differences in personality traits can be revealed not only in the individuals choice of transport, but also in other actions of their everyday lives—such as how much they recycle, whether they take precautions or avoid dangerous pursuits. Conditioning on a set of exogenous individual characteristics, we use indicators of attitudes and personality traits to form latent variables for inclusion in an, otherwise standard, discrete mode choice model. With a sample of Swedish commuters, we find that both attitudes towards flexibility and comfort, as well as being pro-environmentally inclined, influence the individual's choice of mode. Although modal time and cost still are important, it follows that there are other ways, apart from economic incentives, to attract individuals to the, from society's perspective, desirable public modes of transport. Our results should provide useful information to policy-makers and transportation planners developing sustainable transportation systems. © 2005 Elsevier Ltd. All rights reserved.

Walker, J. and M Ben-Akiva (2002) "**Generalized random utility model.**" Mathematical Social Sciences **43303-343**.

Researchers have long been focused on enriching Random Utility Models (RUMs) for a variety of reasons, including to better understand behavior, to improve the accuracy of forecasts, and to test the validity of simpler model structures. While numerous useful enhancements exist, they tend to be discussed and applied independently from one another. This paper presents a practical, generalized model that integrates many enhancements that have been made to RUM. In the generalized model, RUM forms the core, and then extensions are added that relax simplifying assumptions and enrich the capabilities of the basic model. The extensions that are included are: • Flexible Disturbances in order to allow for a rich covariance structure and enable estimation of unobserved heterogeneity through, for example, random parameters; • Latent Variables in order to provide a richer explanation of behavior by explicitly representing the formation and effects of

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latent constructs such as attitudes and perceptions; • Latent Classes in order to capture latent segmentation in terms of, for example, taste parameters, choice sets, and decision protocols; and • Combining Revealed Preferences and Stated Preferences in order to draw on the advantages of the two types of data, thereby reducing bias and improving efficiency of the parameter estimates. The paper presents a unified framework that encompasses all models, describes each enhancement, and shows relationships between models including how they can be integrated. These models often result in functional forms composed of complex multidimensional integrals. Therefore, an estimation method consisting of Simulated Maximum Likelihood Estimation with a kernel smooth simulator is reviewed, which provides for practical estimation. Finally, the practicality and usefulness of the generalized model and estimation technique is demonstrated by applying it to a case study.

5. Environmental Motivations and Strategies

Bibliography Theme 5: Environmental Motivations and Strategies

Abrahamse, Wokje, Linda Steg, Robert Gifford and Charles Vlek (2009). "**Factors influencing car use for commuting and the intention to reduce it: A question of self-interest or morality?**" Transportation Research Part F: Traffic Psychology and Behaviour **12**(4): 317-324. <http://dx.doi.org/10.1016/j.trf.2009.04.004>

Car use for commuting contributes to various environmental and traffic problems, such as pollution and congestion. Policies aimed at reducing commuter car use will be more effective when they target important determinants of car use and willingness to reduce it. This study examined whether variables reflecting self-interest (from the theory of planned behavior [Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhl & J. Beckmann (Eds.), *Action control: From cognition to behavior* (pp. 11–39). Berlin: Springer]) and variables reflecting moral considerations (from the norm-activation model [Schwartz, S. H. (1977). Normative influences on altruism. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 10, pp. 221–279). New York: Academic Press]) were able to explain self-reported car use for commuting and intentions to reduce it in a sample of Canadian office workers. Car use for commuting was mostly explained by variables related to individual outcomes (perceived behavioral control and attitudes) whereas the intention to reduce car use was mostly explained by variables related to morality (personal norms). The study also found that perceived behavioral control moderated the relation between personal norms and behavioral intentions: stronger personal norms were associated with stronger behavioral intentions, but only when perceived behavioral control was low. Some issues evoked by these results are discussed.

de Groot, Judith and Linda Steg (2007). "**General beliefs and the theory of planned behavior: The role of environmental concerns in the TPB.**" Journal of Applied Social Psychology **37**(8): 1817-1836.

This study tested whether the theory of planned behavior (TPB; Ajzen, 1985) could explain people's intention to use a park-and-ride facility (transferium) in Groningen, The Netherlands. We extended the TPB by including egoistic, altruistic, and biospheric concerns. A questionnaire study was conducted among 218 respondents who regularly visit the center of Groningen for work or shopping. Environmental concerns were directly related to attitudes toward using the transferium. However, the 3 types of concerns were not directly related to intention to use the transferium. Furthermore, positive attitudes, positive subjective norms, and high perceived behavioral control toward the use of the transferium were related to stronger intention to use the transferium. Limitations and practical implications of the study are discussed

de Groot, Judith and Linda Steg (2010). "**Relationships between value orientations, self-determined motivational types and pro-environmental behavioural intentions.**" Journal of Environmental Psychology **30**(4): 368-378.

<http://dx.doi.org/10.1016/j.jenvp.2010.04.002> <http://www.sciencedirect.com/science/article/pii/S0272494410000472>

We examined the predictive power of egoistic, altruistic and biospheric value orientations and six types of self-determined motivations (i.e. intrinsic motivation, integrated regulation, identified regulation, introjected regulation, external regulation, and amotivation) toward acting pro-environmentally for explaining two types of pro-environmental intentions in two questionnaire studies among student samples (N = 304 and N = 520). The two pro-environmental intentional measures included choosing a car based on environmental performance and donating to an environmental organisation. Values were more predictive of pro-environmental intentions than were self-determined motivational types, although these differences were not always statistically significant. Furthermore, we explored how value orientations are related to self-determined motivational types. The more respondents were altruistically and biospherically oriented, the more they were self-determined to act pro-environmentally. When respondents endorsed egoistic values, they were less self-determined towards acting in a pro-environmental way. When altruistic and especially biospheric values were important predictors of pro-environmental intentions, stronger types of self-determined motivations were also important to explain intentions. And, when egoistic values contributed uniquely to the explanation of pro-environmental intentions, amotivation and external regulation (i.e. less self-determined motivational types) were most relevant for explaining intentions.

Grob, Alexander (1995). "**A structural model of environmental attitudes and behaviour.**" Journal of Environmental Psychology **15**(3): 209-220. [http://dx.doi.org/10.1016/0272-4944\(95\)90004-7](http://dx.doi.org/10.1016/0272-4944(95)90004-7)

5. Environmental Motivations and Strategies

The multivariate relationship between environmental attitudes and pro-environmental behaviour was examined. In two studies a structural model linking environmental awareness, emotions, personal-philosophical values, perceived control and behaviour was proposed and tested. The main questions investigated were (a) whether, to what extent, and in which constellation personal belief systems affect environmental behaviour, and (b) the generalizability of the model from two known groups. New instruments were created to measure the model's constructs. Using LISREL VII, Study I confirmed the proposed model. The strongest effect on environmental behaviour stemmed from personal-philosophical values and emotions. No effects on environmental behaviour stemming from factual knowledge were found. Thirty-nine per cent of the variance in environmental behaviour was explained by the attitudinal components. Study II showed the extent to which persons differ in their environmental behaviour depending on their membership in a 'green' drivers' association, compared with traditional drivers.

Haustein, Sonja and Marcel Hunecke (2013). "**Identifying target groups for environmentally sustainable transport: assessment of different segmentation approaches.**" Current Opinion in Environmental Sustainability 5(2): 197-204. <http://dx.doi.org/10.1016/j.cosust.2013.04.009>

Recently, the use of attitude-based market segmentation to promote environmentally sustainable transport has significantly increased. The segmentation of the population into meaningful groups sharing similar attitudes and preferences provides valuable information about how green measures should be designed and promoted in order to attract different user groups. This review highlights advances in the understanding of mode choice from a psychological perspective, taking into account behavioural theories of car use and car-use reduction. In this contribution, attitudinal, socio-demographic, geographical and behavioural segmentations are compared regarding marketing criteria. Although none of the different approaches can claim absolute superiority, attitudinal approaches show advantages in providing starting-points for interventions to reduce car use.

Hess, Stephane, Jeremy Shiresy and Ann Jopson (2013). "**Accommodating underlying pro-environmental attitudes in a rail travel context: application of a latent variable latent class specification.**" Transportation Research Part D: Transport and Environment.

Using data from a stated preference survey conducted in the United Kingdom, we show how the willingness to reduce greenhouse gas emissions and accept longer travel time varies strongly as a function of underlying attitudes towards the environment. We specify a latent class structure that allocates respondents to two classes with substantially different valuations of greenhouse gas emissions, and show how the allocation of a given respondent to either class is a function of underlying attitudes that also drive the answers to a number of attitudinal questions. We also show how these underlying attitudes are a function of a number of socio-demographic characteristics, with female respondents, older respondents, and respondents with a university degree having a stronger pro-environmental attitude, with the opposite applying to respondents with regular car access.

Kaiser, Florian G, Sybille Wölfling and Urs Fuhrer (1999). "**Environmental attitude and ecological behaviour.**" Journal of Environmental Psychology 19(1): 1-19.

This paper establishes environmental attitude as a powerful predictor of ecological behaviour. Past studies have failed in this enterprise because they did not consider three shortcomings that limit the predictive power of environmental attitude concepts: . 1 the lack of a unified concept of attitude, 2.the lack of measurement correspondence between attitude and behaviour on a general level, and 3. the lack of consideration of behaviour constraints beyond people's control. Based on Ajzen's theory of planned behaviour, the present study uses a unified concept of attitude and a probabilistic measurement approach to overcome these shortcomings. Questionnaire data from members of two ideologically different Swiss transportation associations are used. This study confirmed three measures as orthogonal dimensions by means of factor analysis: . 1 environmental knowledge, . 2 environmental values, and 3. ecological behaviour intention. One other measure, general ecological behaviour, is established as a Rasch-scale that assesses behaviour by considering the tendency to behave ecologically and the difficulties in carrying out the behaviours, which depend on influences beyond people's actual behaviour control. A structural equation model was used to confirm the proposed model: environmental knowledge and environmental values explained 40 per cent of the variance of ecological behaviour intention which, in turn, predicted 75 per cent

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of the variance of general ecological behaviour.

Lauper, E., S. Moser, M. Fischer, E. Matthies and R. Kaufmann-Hayoz (2015). **"Psychological predictors of eco-driving: A longitudinal study."** *Transportation Research Part F: Traffic Psychology and Behaviour* **33**: 27-37.

10.1016/j.trf.2015.06.005 <http://www.scopus.com/inward/record.url?eid=2-s2.0-84936753527&partnerID=40&md5=e12297e8e7fbd2a648ceae2c7b4df653>

Eco-driving has well-known positive effects on fuel economy and greenhouse-gas emissions. Moreover, eco-driving reduces road-traffic noise, which is a serious threat to the health and well-being of many people. We investigated the psychological predictors of the adoption of eco-driving from the perspective of road-traffic noise abatement. The data came from 890 car drivers who participated in a longitudinal survey over four months. Specifically, we tested the effects of the intention to prevent road-traffic noise, variables derived from the theory of planned behavior (social norm, perceived behavioral control, and attitude), and variables derived from the health action process approach (implementation intention, maintenance self-efficacy, and action control) on the intention to practice eco-driving and on eco-driving behavior. The intention to prevent road-traffic noise was not linked to the intention to practice eco-driving. The strongest predictors of the intention to practice eco-driving were attitude and perceived behavioral control. The strongest predictor of eco-driving behavior was action control. The link between behavioral intention and behavior was weak, indicating that drivers have difficulties putting their intention to practice eco-driving into action. Therefore, intervention efforts should directly address and support the transition from intention to behavior. This could be accomplished by providing reminders, which help to maintain behavioral intention, and by providing behavior feedback, which helps car drivers to monitor their behavior. © 2015 Elsevier Ltd.

Line, Tilly, Kiron Chatterjee and Glenn Lyons (2010). **"The travel behaviour intentions of young people in the context of climate change."** *Journal of Transport Geography* **18**(2): 238-246.

<http://dx.doi.org/10.1016/j.jtrangeo.2009.05.001>

This article examines the factors influencing the future travel behaviour intentions of young people (aged 11–18), with specific attention given to how climate change considerations affect these. Overall it is found that the participants' travel behaviour intentions are dominated by a desire to drive and that their values relating to identity, self-image, and social recognition (at the expense of their environmental values), as well as their affective attitudes towards transport modes, are key influences on this. Although they are aware of climate change, the participants' understanding of the link between transport and climate change was weak. At the same time, they illustrated an apathy towards climate change – in part due to the timing and intangibility of its associated impacts and their lack of self-efficacy with respect to tackling this issue. However, despite claiming that their current environmentally friendly travel behaviours (such as walking or cycling to school) are not influenced by the issue of climate change, a number are accepting of the idea of enforced travel behaviour change – away from use of the car, towards more 'environmentally friendly' modes. This acceptance was in part due to their belief that such action would remove the influence of the 'social dilemma', where their own efforts to tackle climate change may be rendered worthless by the inaction of others.

Nordlund, Annika M and Jörgen Garvill (2002). **"Value structures behind proenvironmental behavior."** *Environment and Behavior* **34**(6): 740-756.

The purpose of the study was to test a hierarchical model of the effects of general values, environmental values, problem awareness, and personal norms on general proenvironmental behavior. The model starts with the effects of the relatively stable structures of general values and moves toward effects of more specific environmental values, environmental problem awareness, and personal norms. A personal norm was expected to mediate the effects of values and problem awareness on proenvironmental behavior. Survey data from a Swedish sample of 1,400 individuals were used in a path analysis to test the model, which was supported, and the results showed that the personal norm could be seen as derived from self-transcendent and ecocentric values and activated by problem awareness. The personal norm mediated the effects from general values, environmental values, and problem awareness on proenvironmental behavior.

Poortinga, Wouter, Linda Steg and Charles Vlek (2004). **"Values, Environmental Concern, and Environmental Behavior: A Study into Household Energy Use."** *Environment and Behavior* **36**(1): 70-93.

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10.1177/0013916503251466 <http://eab.sagepub.com/content/36/1/70.abstract>

In this study, the role of values in the field of household energy use is investigated by using the concept of quality of life (QOL). Importance judgments on 22 QOL aspects could be summarized into seven clearly interpretable value dimensions. The seven value dimensions and general and specific environmental concern contributed significantly to the explanation of policy support for government regulation and for market strategies aimed at managing environmental problems as well as to the explanation of the acceptability of specific home and transport energy-saving measures. In line with earlier research, home and transport energy use were especially related to sociodemographic variables like income and household size. These results show that it is relevant to distinguish between different measures of environmental impact and different types of environmental intent. Moreover, the results suggest that using only attitudinal variables, such as values, may be too limited to explain all types of environmental behavior.

Rasouli, Soora and Harry Timmermans (2013). The Effect of Social Adoption on the Intention to Purchase Electric Cars: A Stated Choice Approach. Presented at 92nd Annual Meeting of the Transportation Research Board, Washington, D.C.

The use of stated choice experiments in travel behaviour research has increased dramatically over the last decade. Although considerable progress has been made, over-prediction of market shares of new choice alternatives is often reported. This study is based on the contention that such over-prediction is partly due to the fact that experimental designs do not incorporate conditions that reflect how new alternatives are received in the market: social adoption is not experimentally varied. The aim of this paper is to show how social adoption can be incorporated in the design and analysis of stated choice experiments. The intention to buy an electric car is used for illustration. This paper discusses the design of the choice experiment and summarizes the main findings of the analyses. Results indicate that although social influence plays a less significant role than attributes of electric cars in the buying process, different elements of social networks do exert an influence on people's buying decisions. These effects vary between friends, relatives, colleagues and the larger peer group. Moreover, the effects are non-linear, the particular form of the part-worth utility function depending on the element of the social network. The latent decision to buy a car also depends on socio-demographic variables. The results of this novel approach have implications for the design of stated choice experiments, which are discussed in the last section of the paper

Schuitema, G., J. Anable, S. Skippon and N. Kinnear (2013). "***The role of instrumental, hedonic and symbolic attributes in the intention to adopt electric vehicles.***" *Transportation Research Part A: Policy and Practice* **48**: 39-49. <http://www.scopus.com/inward/record.url?eid=2-s2.0-84873726441&partnerID=40&md5=3af833784d38af8660ad1b6d7489a8f1>

The aim is to understand how private car drivers' perception of vehicle attributes may affect their intention to adopt electric vehicles (EVs). Data are obtained from a national online survey of potential EV adopters in the UK. The results indicate that instrumental attributes are important largely because they are associated with other attributes derived from owning and using EVs, including pleasure of driving (hedonic attributes) and identity derived from owning and using EVs (symbolic attributes). People who believe that a pro-environmental self-identity fits with their self-image are more likely to have positive perceptions of EV attributes. Perceptions of EV attributes are only very weakly associated with car-authority identity. © 2012 Elsevier Ltd.

Steg, Linda, Jan Willem Bolderdijk, Kees Keizer and Goda Perlaviciute (2014). "***An integrated framework for encouraging pro-environmental behaviour: The role of values, situational factors and goals.***" *Journal of Environmental Psychology* **38**: 104-115.

Many environmental behaviours involve a conflict between hedonic and gain goals versus normative goals; people often need to incur some costs to benefit the environment. Based on this assumption, we propose an integrated theoretical framework for understanding behaviour change that identifies two routes to encourage pro-environmental behaviour. First, the conflict between goals can be reduced by decreasing the (hedonic and gain) costs of pro-environmental choices. Although this route is important when pro-environmental choices are very costly, it may not result in sustained pro-environmental actions. Second, normative goals can be strengthened. This strategy may encourage pro-environmental actions, even when it is somewhat costly. We propose that the strength of normative goals depends on values and situational

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factors that influence the accessibility of these values. We discuss theoretical implications of our reasoning, and indicate how the integrated framework adopted in this paper may advance theory development and environmental policy making.

Steg, Linda and Charles Vlek (2009). "**Encouraging pro-environmental behaviour: An integrative review and research agenda.**" *Journal of Environmental Psychology* **29**(3): 309-317. <http://dx.doi.org/10.1016/j.jenvp.2008.10.004>

Environmental quality strongly depends on human behaviour patterns. We review the contribution and the potential of environmental psychology for understanding and promoting pro-environmental behaviour. A general framework is proposed, comprising: (1) identification of the behaviour to be changed, (2) examination of the main factors underlying this behaviour, (3) design and application of interventions to change behaviour to reduce environmental impact, and (4) evaluation of the effects of interventions. We discuss how environmental psychologists empirically studied these four topics, identify apparent shortcomings so far, and indicate major issues for future research.

Steg, Linda, Charles Vlek and Ton Rooijers (1995). "**Private car mobility. Problem awareness, willingness to change, and policy evaluation: A national interview study among Dutch car users.**" *Studies in Environmental Science*, Elsevier.

This paper reports on a field study, based on personal interviews with 539 car users. Problem awareness appears to be an important condition for any attempts to make people voluntarily reduce car use. Problem awareness also is an prerequisite for the acceptance of policy measures aimed at reducing car use. Problem awareness is higher the more people are confronted with the problems of car use. The provision of information in a brochure did not influence respondents' problem awareness.

van der Werff, Ellen, Linda Steg and Kees Keizer (2013). "**The value of environmental self-identity: The relationship between biospheric values, environmental self-identity and environmental preferences, intentions and behaviour.**" *Journal of Environmental Psychology* **34**(0): 55-63. <http://dx.doi.org/10.1016/j.jenvp.2012.12.006>

Biospheric values and environmental self-identities are considered to be important antecedents of environmental preferences, intentions, and behaviour. Although various authors suggest a relationship between values and self-identity, this has rarely been studied empirically. This paper aimed to clarify the relationship between biospheric values and environmental self-identity and to study how both are related to environmental preferences, intentions, and behaviour. We hypothesized that biospheric values are related to environmental self-identity, and that self-identity is in turn related to preferences, intentions, and behaviour. Results of three studies including a wide range of environmental preferences, intentions, and behaviour support our reasoning and show that biospheric values are related to environmental self-identity, even when measured months before. Moreover, we found that the relationship between biospheric values and environmental preferences, intentions and behaviour was fully mediated by environmental self-identity, indicating that biospheric values are related to preferences, intentions, and behaviour via one's environmental self-identity. This suggests that values need to be linked to the self in order to be influential in choices made.

6. Information Technologies and the Productivity of Time

Bibliography Theme 6: Information Technologies and the Productivity of Time

Dong, Zhi, Patricia L Mokhtarian and Giovanni Circella (2013). "***Estimation of Changes in Rail Ridership Through Onboard Survey: Did Free Wi-Fi Make a Difference to Amtrak's Capitol Corridor Service?***"

Amtrak launched free Wi-Fi service on the California Capital Corridor (CC) on November 28, 2011. To study the impact of free Wi-Fi on ridership, an on-board survey was conducted in March, 2012. Through the descriptive analysis, several conventional factors (trip frequency in 2011, trip purpose, station to station distance and employment) as well as Wi-Fi are found to have some impact on the expected trip frequency in 2012. A linear regression model based on the specification of three market segments was built to better understand the impact of selected variables on the expected number of CC trips in 2012. According to the model results, past trip frequency is the most important predictor of future frequency. The impact of free Wi-Fi on 2012 trip frequency is statistically significant and positive for the two (lower-frequency and higher-frequency) continuing rider segments, albeit modest in magnitude. Using the estimated parameters from the model, the number of trips the sample expects to make in 2012 is 1.3% higher than would have been the case without free Wi-Fi. Furthermore, the effect clearly differs among the three segments: lower-frequency continuing riders (those using CC less than once a week in 2011) expect to make 8.5% more trips than if Wi-Fi were not available, whereas the corresponding number for higher-frequency continuing riders (using CC once a week or more in 2011) is 0.7%. Wi-Fi has no statistically significant impact on the expected 2012 trip frequency for new riders.

Dziekan, Katrin (2004). "***Customer perceptions and behavioural responses to IT-based public transport information.***" KTH Infrastructure, Stockholm, Sweden.

A considerable amount of money is spent on IT-based applications such as real-time, at-stop displays on public transport, but actual knowledge about the behavioural effects these have on customers or potential customers in real life is quite sparse. This paper presents a review of relevant literature, focusing specially on user response to public transport information via telephone, mobile devices, the Internet and at-stop displays. This paper also presents the findings of a questionnaire returned by a number of specially selected experts on how information delivered via IT applications influences the behaviour of people in reality. The experts commented on the "efficiency" of a journey, whether or not the IT systems matched customer needs, customer perceptions of reliability and trust in the system, and changes in the numbers of travellers. Both the literature review and the opinions of the experts show that more evaluation studies need to be done that include customer perspectives. The main conclusion that can be drawn from this paper is twofold—the effect of public transport information delivered via IT-based applications on modal split should not be overestimated, nor should its potential effect be underestimated.

Dziekan, Katrin (2008). "***What do people know about their public transport options?***" Transportation **35**(4): 519-538.

This paper studies the memory representations of residents regarding the public transport system in their city. Telephone interviews were conducted with a representative sample of 204 inhabitants in a selected residential inner-city area in Stockholm. Route knowledge questions, recognition tasks, free-recall tasks and estimations of service frequency were used to explore memory representations. The results showed that, in general, residents in metropolitan areas have good knowledge of the public transport options along well-known transport corridors. The memory representation of lesser-known transport corridors tends to be of a poorer quality. In the results presented here, the variables gender, age, employment status, level of education and car availability had no correlation with the quality of the memory representation, but experience increased knowledge. Although frequent users of public transport had a more detailed representation of the system, the less frequent users also had a considerable- and good-memory representation. An explorative hierarchy for representation of public transport lines in the memory is proposed. It is hypothesised that memory representations of a transport line can be affected by the following three factors: the extent to which a line is visible in the urban area, the straightness of the routes and whether or not stops are labelled, for example, by destination area. Simply put, these factors determine

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how well a person knows a line. It was found that people first remember a commuter train and a trunk bus line, followed by metro lines and suburban buses and finally normal inner-city buses with the poorest anchorage in memory.

Ettema, Dick, Margareta Friman, Tommy Gärling, Lars E. Olsson and Satoshi Fujii (2012). "**How in-vehicle activities affect work commuters' satisfaction with public transport.**" *Journal of Transport Geography* 24(0): 215-222. <http://dx.doi.org/10.1016/j.jtrangeo.2012.02.007>

Research has recently questioned the commonly held opinion that travel time is valued as negative, arguing that engagement in activities during travel may make these trips more enjoyable or productive. Satisfaction with travel has to date been assessed using utility-based models or measures of productivity of the trip. The present study is the first to assess the influence of activities performed during travel on public transport users' subjective well-being. To this end, a survey was conducted in Sweden in 2010 in which activities during the work commute by public transport were recorded and subjective well-being during travel was measured retrospectively using the Satisfaction with Travel Scale (STS). Results show that talking to other passengers has the strongest positive effect on STS, whereas activities related to entertainment and relaxation lead to lower STS, possibly since engaging in these activities reflect unsuccessful attempts to abate boredom. In addition, it is found that activities during travel may have a more positive effect on the commute back home, suggesting that the mindset related to the destination influences travel satisfaction.

Kenyon, S. and G. Lyons (2003). "**The value of integrated multimodal traveller information and its potential contribution to modal change.**" *Transportation Research Part F Traffic Psychology and Behaviour*: 1-21. [http://dx.doi.org/10.1016/S1369-8478\(02\)00035-9](http://dx.doi.org/10.1016/S1369-8478(02)00035-9)

This paper reports on research that introduced the concept of Integrated Multimodal Traveller Information to mixed mode and mixed socio-demographic groups of travellers. Travellers were shown information about travel by car, coach and train for a journey with which they were familiar. Different levels of information were shown at different times, ranging from simple financial cost and journey duration information to information incorporating comfort and convenience factors. The research illustrates that the majority of travellers do not consider their modal choice for the majority of journeys. Rather, this choice is automatic and habitual, based upon subconscious perceptions of the viability and desirability of travel by modes other than the dominant mode. Thus, information about alternative modes is rarely consulted and travellers can be unaware of viable modal alternatives for their journeys. Results suggest that presentation of a number of modal options for a journey in response to a single enquiry could challenge previous perceptions of the utility of non-car modes, overcoming habitual and psychological barriers to consideration of alternative modes. Where the information presented incorporates comfort and convenience factors, in addition to cost and duration, it may challenge travellers' concerns about alternative modes and could persuade a modal change.

Le Vine, S., Latinopoulos, C., Polak, J. (2014). Establishing the Links between Online Activity and Car Use: Evidence from a Combined Travel Diary and Online-Activity Pseudo-Diary Data Set. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2405. Transportation Research Board of the National Academies, Washington, D.C.

The linkages between online activity and physical mobility are of wide and growing interest to researchers, practitioners and policymakers. This paper presents results from analysis of Scottish Household Survey microdata, a unique large-scale, nationally-representative dataset that includes both a travel diary instrument and a pseudo-diary of online activity participation. Multivariate regression models were estimated to relate people's online-activity profiles with their car driving mileage. The models include demographic and spatial characteristics to control for potential confounding effects. It was found that, net of other effects, Internet usage is positively associated with car use. The marginal effect of time spent online was, however, found to be negative. The paper concludes with a discussion of further research needs to advance this line of enquiry.

Le Vine, S., Latinopoulos, C., Polak, J (2014). "**What is the relationship between online activity and driving-licence-holding amongst young adults?**" *Transportation*. DOI: 10.1007/s11116-014-9528-3.

There is growing interest amongst both practitioners and researchers in the correlates of young adults' driving-licence-acquisition. One aspect of the ongoing scholarly debate is whether taking part in online (i.e. virtual) activities may be associated with young adults feeling less need to drive and hence to acquire a

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driving licence. This paper addresses this issue by drawing on analysis of two distinct datasets. Both contain rich pseudo-diary instruments in which people indicate detailed characteristics of their unique online-activity profile. This includes both indicators of the types of online activities in which respondents participate, and a separate metric of internet-use intensity. The latter is defined in one dataset as the amount of time per week spent online, and in the other dataset the frequency of their internet use. On the basis of a set of multivariate regression analyses, a positive (i.e. complementary) cross-sectional relationship between young adults' online activity and licence-holding was found. We find that young adults who use the internet are, net of confounding effects, more likely to hold a driving licence than otherwise identical young adults who do not use the internet. Both datasets show this type of effect, and it is robust across a range of model specifications, including multi-stage estimations to address cross-correlation between indicators of internet usage. In addition to the positive net statistical association, we also report several other noteworthy effects. Of the six effects associated with online-activity types that are directly comparable between the two datasets, we find that the correlation in the parameter estimates across the two datasets is 0.63. This suggests similar types of relationships across the two datasets. Also, in several (but not all) of our analyses we found an inverted 'U' shaped ceteris paribus relationship between intensity-of-internet-use and licence-holding. The positive net statistical association between internet use and licence-holding is a different relationship than previously reported in the literature, and therefore further research is needed to reconcile the differences (which are likely due at least in part to different methodological approaches and data resources). Further research is also needed to continue to resolve between the relative saliency of other hypothesised determinants of licence-holding (e.g. economic and socio-demographic explanators, as well as licence-acquisition regimes that vary by time and place).

Schwieterman, J and L. Fischer (2011). "***Variations in the Rates of Passenger Usage of Portable Technology on Intercity Buses, Trains and Planes: Implications for Transportation Planning.***" Journal of Transportation Law, Logistics and Policy **78**(1).

In recent years, the use of portable electronic devices by passengers on intercity transportation services has risen markedly. Transportation providers support the use of such devices by installing Wi-Fi systems, power outlets, and cellular telephone signal boosters for passenger use. To fill a void in research about the effects of portable electronic technology on intercity travel behavior, this study evaluates newly collected data for 7,028 passengers on 96 bus, train, and air trips in 14 states. The paper explores how usage differs by mode and time of day as well as the implications that these differences have on various sectors of the U.S. transportation system. Interpreted broadly, the research findings suggest that the ability to use portable electronics may be a factor offsetting the longer travel times associated with certain bus and train trips, and provides a new incentive for travelers to use transportation services that operate to and from the downtown areas of major cities.

Schwieterman, J and L Fischer (2011). "***Privacy Invades Public Space: The Growing Use of Portable Electronic Technology on Intercity Buses, Trains & Planes between 2009 and 2010.***" DePaul University

Travelers on intercity buses, trains, and planes increasingly are using portable electronic devices while en route. The use of these devices appears to serve two purposes at once: They enable the passenger to remain in touch with the world outside the vehicle while insulating the passenger from the noise, distractions or just plain boredom normally experienced in the interior. Whether for work or leisure, many travelers engage in intensive digital activities that would have been almost inconceivable a decade ago. In doing so they are profoundly changing the way private individuals inhabit and experience public space. To clarify the implications of this phenomenon, this study evaluates data from 19,000 unique passenger observations on intercity trips, primarily in the United States but also on selected Canadian and Western European routes. Among the notable results are: 1. Usage of portable electronic devices rose markedly among travelers on all modes of intercity transportation in the United States between the 4th quarters of 2009 and 2010 (Table A). 2. Opportunities for using portable electronic technology continue to give passenger trains and "curbside" bus service an important competitive edge over personal automobiles and air travel. 3. Travelers on all modes are rapidly shifting toward more sophisticated devices, especially those with built-in LCD screens and Internet capability. 4. High-speed trains offer travelers particularly advantageous environments for technology usage, but even conventional trains are congenial to the practice because their generous interior dimensions offer the electronics user more personal space than the interior of a bus or airliner. 5. Use of

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portable electronic devices is making significant gains on commercial airlines but still lags the rate of the other modes surveyed. 6. As buses and airplanes become more crowded, consumers are less apt to use portable technology, perhaps due to concerns over privacy or lack of adequate personal space needed to manipulate devices.

7. Application of Market Segmentation Techniques

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Anable, Jillian (2005). "**Complacent Car Addicts' or 'Aspiring Environmentalists'? Identifying travel behaviour segments using attitude theory.**" *Transport Policy* **12**(1): 65-78. <http://dx.doi.org/10.1016/j.tranpol.2004.11.004>

Using an expanded version of a psychological theory of attitude-behaviour relations, namely the theory of planned behaviour (TPB), scores on factor analysed multi-dimensional attitude statements were used to segment a population of day trip travellers into potential 'mode switchers' using cluster analysis. Six distinct psychographic groups were extracted, each with varying degrees of mode switching potential. Each group represents a unique combination of preferences, worldviews and attitudes, indicating that different groups need to be serviced in different ways to optimise the chance of influencing mode choice behaviour. Socio-demographic factors had little bearing on the travel profiles of the segments, suggesting that attitudes largely cut across personal characteristics. The evidence clearly shows that the same behaviour can take place for different reasons and that the same attitudes can lead to different behaviours. The paper asserts that commonly used a priori classifications used to segment populations based on demographic variables or simple behavioural measures may oversimplify the structure of the market. Cluster analysis is rarely used in studies of travel behaviour but this study demonstrates its utility in providing a way of extracting naturally occurring, relatively homogenous and meaningful groups to be used in designing targeted hard and 'soft' transport policies.

Ayvalik, Cemal, Kimon Prossaligou, Ryan Greene-Roesel and Chris Wornum (2008). "**TOD Choices Study - Market Segmentation Results**" Metropolitan Transportation Commission. MTC Library

Most service providers understand that not all their customers are the same. The private sector has long used market research to investigate customer attitudes and preferences in order to develop and target products and service at specific market segments. This study extends private market research techniques to identify the market segments for all those looking for an apartment or house. This research starts with a survey of Bay Area households that have recently moved or are planning to move. By surveying the attitudes of these "movers", it is possible to divide them into market segments, each with distinct attitudes and preferences. The segmentation will ultimately give public agencies critical information regarding public amenities and policies that can make Transit Oriented Developments (TOD) a more attractive choice to specific market segments. Market segmentation is a multi-step process. This document describes each of the steps, which are: 1. Gathering of information on the attitudes of the target group (new movers). 2. Analysis of the attitudes to identify underlying attitudinal dimensions or "factors", which represent combinations of attitudinal statements. This step includes both exploratory and confirmatory factor analysis. 3. Structural Equations Modeling (SEM), which links each factor with a set of related socioeconomic characteristics. 4. Cluster analysis, which defines unique market segments based on respondents socioeconomic characteristics and the importance they attach to each factor.

Bhat, Chandra R (1997). "**An endogenous segmentation mode choice model with an application to intercity travel.**" *Transportation Science* **31**(1): 34-48.

This article uses an endogenous segmentation approach to model mode choice. This approach jointly determines the number of market segments in the travel population, assigns individuals probabilistically to each segment, and develops a distinct mode choice model for each segment group. The author proposes a stable and effective hybrid estimation approach for the endogenous segmentation model that combines an Expectation-Maximization algorithm with standard likelihood maximization routines. If access to general maximum-likelihood software is not available, the multinomial-logit based Expectation-Maximization algorithm can be used in isolation. The endogenous segmentation model, and other commonly used models in the travel demand field to capture systematic heterogeneity, are estimated using a Canadian intercity mode choice dataset. The results show that the endogenous segmentation model fits the data best and provides intuitively more reasonable results compared to the other approaches.

Budd, Thomas, Tim Ryley and Stephen Ison (2014). "**Airport ground access and private car use: a segmentation analysis.**" *Journal of Transport Geography* **36**: 106-115.

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The increasing scale of, and demand for, civil air transport world-wide has resulted in a greater volume of people travelling to and from airports. The vast majority of these journeys are made by private cars, which has led to traffic congestion and raised levels of air pollution in and around airports. Subsequently, airports are re-evaluating their approach to ground access mode choice and considering how to reduce the reliance on private cars. Based on a survey of passengers at Manchester Airport in the UK, attitude statements pertaining to psychological constructs from the Theory of Planned Behaviour and the Norm-Activation Theory, combined with key factors relating to the passenger's trip, are used to identify eight behaviourally distinct groups of passengers with varying potential to reduce their private car use. Two of these groups, described as the Conflicted Greens and the Pessimistic Lift Seekers, are identified as having the greatest potential to reduce private car use to airports. Analysis reveals the need for decision makers to address the existing attitude-behaviour 'gap' that can prevent positive environmental attitudes being translated into the use of more sustainable modes, as well as tackling the perceived difficulty some passengers associate with using these modes.

Campbell, Margaret, Matthew Coogan and Tom Adler Latent Class Cluster Analysis of New England Driver Attitudes Toward Risky Driving: Is There a Rural Culture of Unsafe Driving Attitudes and Behavior? Presented at 90th Annual Meeting of the Transportation Research Board, Washington D.C.

The vastly higher rate of highway death experienced by rural residents, compared to urban and suburban residents, could be at least partially explained by the presence of a 'rural culture' characterized by bad attitudes towards dangerous driving behaviors. This paper describes the application of a method of behavioral analysis borrowed from the field of market research, designed to apply a statistically-based model to the task of segmenting the driving population based on the similarities of driver' attitude and beliefs structures. A survey of over 1,000 residents of Maine, New Hampshire, Vermont, New York and Massachusetts was conducted. The purpose of the survey was to study the driving behaviors and attitudes of New England residents. The study explored the frequencies of risky driving behaviors and attitudes to better understand the driving culture of the targeted areas. The work described in this paper used latent class cluster analysis to identify segments of the driving population which exhibit distinct patterns of attitudes and behavior. The analysis identified four distinct segments, two of which correspond with extremes of attitudes, behaviors and outcomes and two of which are more nuanced. However, rural residents tend to fall more predominantly in the segments that exhibit the attitudes, behaviors and outcomes associated with safe driving. Thus, the analysis decidedly does not find evidence of a rural culture of unsafe driving. If anything, this study finds the reverse; that is, rural residents tend toward segments that exhibit attitudes and behaviors that support safer driving and have better self-reported outcomes.

Clifton, Kelly, Jenny Liu and Roger Chen (2013). "***Understanding Market Segments for Current and Future Residential Location and Travel Choices***"

This project aims to examine the connections between residential location choices and travel at the household level with an emphasis on identifying current residents' preferences for their future housing, neighborhood and transportation choices (collectively referred to as lifestyle choices) that can be used in scenario planning exercises. The goal is to understand how future lifestyle aspirations relate to current choices. This work builds on a current project, funded by the Oregon Department of Transportation (ODOT), that employs data from the recent Oregon Household Activity Survey (OHAS) to define discrete market segments of lifestyle choices based upon the revealed preferences for housing, neighborhoods and travel. In this proposed second phase, a sample of people in each of these market segments will participate in this study, which relies upon experimental survey techniques and visualization tools to see how these lifestyle preferences may change over the life course and may differ from currently held assumptions about these preferences. Understanding the changes in preferences is key to improving the presentation of residential locations choices in integrated land use and travel demand models. As communities struggle to address challenges related to public infrastructure provision, climate change preparation, energy and natural resource consumption, and the creation of a livable future given present economic uncertainty and constraint, land use and transportation plans have become predicated on certain assumptions about the market for various housing types, residential environments and travel modes. If planners lack faith in the estimates from these models, the long range supply of housing, mix of uses, and other land use characteristics will be insufficient to meet future demands. This research will inform these assumptions and

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contribute to a more robust understanding of the public's desires and how they may be accommodated in future scenarios.

Collum, K. K. and J. J. Daigle (2015). "**Combining attitude theory and segmentation analysis to understand travel mode choice at a national park.**" *Journal of Outdoor Recreation and Tourism* **9**: 17-25. 10.1016/j.jort.2015.03.003 <http://www.scopus.com/inward/record.url?eid=2-s2.0-84928950899&partnerID=40&md5=dddd68a7042cb793afc7cc516b7e6b54>

Transportation management is one of the most salient challenges facing managers of national parks and public lands. In order to determine strategies to increase voluntary use of alternative transportation modes, this study explores the factors that influence travel mode choice in recreation settings. We combine the theory of planned behavior and segmentation analysis to determine distinct segments of national park visitors in regard to their beliefs about transportation. Using cluster analysis, we identify three distinct segments of visitors to a popular national park in Colorado, USA. The segments are statistically similar in regards to sociodemographic variables, yet significantly different in terms of attitudes, subjective norms, perceived behavioral control and intentions to use shuttles. This study demonstrates the utility of combining segmentation analysis and attitude theory to inform messaging for travel information sources, such as intelligent transportation system (ITS) technologies. Combining attitude theory and segmentation analysis allows researchers and managers to identify specific types of visitor groups for targeted marketing campaigns in the context of nature tourism. Management implications This research can help managers design alternative transportation systems to alleviate congestion caused by private automobiles. Our research found that: Alternative transportation must be frequent, dependable, and provide ample space to attract loyal users. Direct routes between parking and popular attractions as well as special opportunities such as pick-up/drop-off for one-way treks may increase alternative transportation use. Promotional materials and messaging should focus on the ability of alternatives to enhance sightseeing opportunities, reduce stress caused by driving, and simplify parking. When incentives fail to increase voluntary alternative transportation use, mandatory systems may be necessary at the most popular visitor attractions. © 2015 Elsevier Ltd. All rights reserved.

Coogan, Matthew, Margaret Campbell, Tom Adler and Sonja Forward (2014). "**Examining Behavioral Differences Among Groups in their Traffic Safety Culture: Application Latent Class Cluster Analysis and Multi-Group Structural Equation Modeling**" *Transp Res Part F Traffic Psychol Behav*.

The paper explores the concept that, for a given population, there is not a single "traffic safety culture," but rather a set of alternative cultures in which the individual driver might belong. There are several different cultures of dangerous driving behavior and each might need a separate strategy for intervention or amelioration. First, the paper summarizes the over-arching theory explored in the research, which applies Multi-group Structural Equation Modeling (MSEM) in a modification of the Theory of Planned Behavior (TPB) in the explanation of Risky Driving Behavior, based on ten observed explanatory factors. Second, we apply Latent Class Cluster (LCC) segmentation to the full sample, revealing four segments: one cluster reflecting a "Low Risk Driving Safety Group" and three clusters describing three different groups of problematic drivers. We first apply MSEM to two groups; the "Low Risk Driving Safety Group," and the "High Risk Driving Safety Group," defined as the members of the three problematic clusters together, revealing how a "Low Risk" culture differs from the "High Risk" culture, with the relative importance of the TPB explanatory factors varying sharply between the two groups. Finally, the three problematic clusters are profiled for demographics and their mean scores for the ten observed explanatory factors. Each of the clusters is reviewed in terms of responses to selected survey questions. Three separate and distinct dangerous traffic safety cultures emerge: first, a culture of risky driving dominated by excitement seeking and optimism bias; a second dominated by denial of societal values; and a third characterized by its propensity to find rational justifications for its speeding behavior. The paper applies two research methods together: LCC segmentation divides our sample into meaningful subgroups, while MSEM reveals both within-group analysis of variance and between-group differences in safety attitudes and outcomes. The paper concludes that the combination of the segmentation powers of the LCC and the analysis powers of the MSEM provides the analyst with an improved understanding of the attitudes and behaviors of the separate groups, all tied back to the over-arching theory underlying the research.

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Elmore-Yalch, Rebecca (1998). *TCRP Report 36: A Handbook: Using Market Segmentation to Increase Transit Ridership*. TRB, National Research Council, Washington, D.C.

This handbook will be of interest to transit managers, marketing professionals, planners, and others interested in the potential implementation of market segmentation strategies to increase transit ridership. Market segmentation is the identification of groups of people--or market segments--that have similarities in characteristics or needs who are likely to exhibit similar purchase behavior and/or responses to changes in the marketing mix. This handbook provides an overview of market segmentation--what it is and why it is relevant to public transit agencies. It serves as an introduction for managers to the basic concepts and approaches of market segmentation and provides steps and procedures for marketers or market researchers who have the responsibility for implementing a market segmentation program. The handbook places special emphasis on issues that must be addressed when using market segmentation, procedures and terminology that one may encounter in connection with segmentation, problems likely to arise in implementing segmentation studies, ways to encourage the use of market segmentation at transit agencies, and methods to translate segmentation findings into strategy. Private and public sector examples of market segmentation analyses are used extensively throughout the handbook to illustrate concepts presented. In addition, the handbook provides the results of market segmentation analyses performed as part of this project at three demonstration transit agencies: Boise Urban Stages, the Milwaukee County Transit System, and the Washington Metropolitan Area Transit Authority. As a result of these demonstrations, key market segments are identified and reported in the handbook.

Haustein, Sonja (2012). "**Mobility behavior of the elderly: an attitude-based segmentation approach for a heterogeneous target group.**" *Transportation* 39(6): 1079-1103. 10.1007/s11116-011-9380-7
<http://dx.doi.org/10.1007/s11116-011-9380-7>

The western population is ageing. Based on the assumption that the elderly are a quite heterogeneous population group with an increasing impact on the transport system, mobility types of the elderly were identified. By means of 1,500 standardized telephone interviews, mobility behavior and possible determinants including infrastructural, sociodemographic and attitudinal variables, were assessed. The most important factors, identified by five regression analyses, served as type-constituent variables in a series of cluster analyses. The final cluster solution resulted in four segments of the elderly named Captive Car Users, Affluent Mobiles, Self-Determined Mobiles, and Captive Public Transport Users. The groups showed distinct mobility patterns as well as significant differences in infrastructural, sociodemographic and attitudinal variables. The study provides a more comprehensive understanding of the diverse lifestyles, attitudes, travel behavior and needs of the elderly. Furthermore, it identifies starting points for the reduction of car use.

Hensher, D.A (1976). "**Market Segmentation as a Mechanism in Allowing for Variability of Traveller Behavior**" *Transportation*, 5(3), : 257-284.

A major problem with aggregate transport planning models is the accounting of variability in traveller behaviour when the basic unit of analysis is the geographical traffic zone. In an attempt to allow for this variance, recent attention has been given to the role of socio-economic (user and household) characteristics in systematically identifying a homogeneous grouping of travellers with respect to the issue under study rather than restricting the grouping definition according to physical geographical criteria alone. This homogeneous grouping criterion combined eventually with a necessity to represent travel demand in a spatial context, can assist in improving our ability to explain real travel patterns by the development of an improved aggregation condition. The emphasis is on modelling homogeneous groups of travellers separately, and then relating the individual sets of results to each other to obtain an aggregate prediction of behaviour via a knowledge of the representativeness of each group contained in the total sample. This paper presents a technique to identify the relative homogeneity of travellers in accordance with a specified criterion, and illustrates its use with individual household data for the Sydney Metropolitan Area. The paper concludes with a discussion of the advantages of segmentation in operational transport planning, in particular with reference to the "aggregation" of disaggregate behavioural travel choice models, or movement from a micro-model of individual choice behaviour to an aggregate model of travel demand.

Hunecke, Marcel, Sonja Haustein, Susanne Böhrer and Sylvie Grischkat (2010). "**Attitude-Based Target Groups to Reduce the Ecological Impact of Daily Mobility Behavior.**" *Environment and Behavior* 42(1): 3-43.

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10.1177/0013916508319587 <http://eab.sagepub.com/content/42/1/3.abstract>

This study analyzes the usefulness of an attitude-based target group approach in predicting the ecological impact of mobility behavior. Based on a survey of 1,991 inhabitants of three large German cities, constructs derived from an expanded version of the Theory of Planned Behavior were used to identify distinct attitude-based target groups. Five groups were identified, each representing a unique combination of attitudes, norms, and values. The groups differed significantly from each other with regard to travel-mode choice, distances traveled, and ecological impact. In comparison with segmentations based on sociodemographic and geographic factors, the predictive power of the attitude-based approach was higher, especially with regard to the use of private motorized modes of transportation. The opportunities and limits of reducing the ecological impact of mobility behavior on the basis of an attitude-based target group approach are discussed.

Karash, Karla, Matthew Coogan and Tom Adler (2007). Exploring Market Support for New Products and Services for Transit and Walking: New Market Research Approach. *Transportation Research Record: Journal of the Transportation Research Board*, No. 2034. Transportation Research Board of the National Academies, Washington, D.C.
<http://trb.metapress.com/content/bp477203p1514627/>

This paper concerns the relationship between mobility products and services and the propensity to change travel behavior. In an online panel survey, 501 respondents answered questions about their attitudes toward increasing their use of transit and walking. The questions first established base conditions for variables specified by the theory of planned behavior. Respondents were then exposed to seven products and services. A follow-up set of questions revealed shifts in key attitudes. New products and services may influence the traveler's personal inclination to change modal behavior, belief that a change in modal behavior might be socially acceptable, and belief or self-confidence that he or she can change modal behavior. These three attitudinal categories were examined for four market segments, two more positive and two more negative. The positive segments included the transit loyalists, who were already heavy users of transit, and the environmental mode changers, who were not heavy transit users but who wanted to help the environment. Both positive segments significantly shifted their ratings of the social acceptability of transit with the improvements. However, the segments differed in terms of what factors were associated with the improved social acceptability. For the environmental mode changers, the strongest association was with concern about being lost or stranded on public transportation, whereas for the transit loyalists, the strongest association was with being able to depend on public transportation to be timely. However, it is unclear from this research which products and services contribute to improved social acceptability.

Rhindress, Mindy, Frank Lynch, Susan Bregman, Rose E Reichman, Nancy J Coopersmith and John A Dunning (2008). *TCRP Report 122: Understanding How to Motivate Communities to Support and Ride Public Transportation*. Transportation Research Board of the National Academies, Washington, D.C.
<http://www.trb.org/Publications/Blurbs/159756.aspx>

TCRP Report 122: Understanding How to Motivate Communities to Support and Ride Public Transportation provides a comprehensive discussion on the methods and strategies used by public transportation agencies in the United States and Canada to enhance their public images and motivate the support and use of public transportation. Additionally, the report identifies and describes methods and strategies used by other industries (comparable to public transportation) to enhance their public image and to motivate the support and use of their products and services. Also, this report examines the perceptions, misperceptions, and use of public transit, and the extent to which these affect support. Finally, the report identifies effective communication strategies, campaigns, and platforms for motivating individuals to action in support of public transportation, and it recommends ways to execute those communication strategies, campaigns, and platforms. This report will be helpful to transit agencies; elected officials; community leaders; business leaders; and federal, state, and local funding agencies in both the United States and Canada.

Ripplinger, David, Jeremy Mattson and Del Peterson (2012). "**An Application of Attitudinal Structural Equation Modeling to Intercity Transportation Market Segmentation**"

Travel behavior information is valuable to transportation policymakers, planners, and service providers. While aggregate data is helpful, segmenting a market into smaller groups allows for more targeted planning, promotion, operation, and evaluation. In this study, intercity market segments based on traveler attitudes are

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identified using Structural Equation Modeling (SEM). The study focuses on rural and small urban areas, using survey data for residents of North Dakota and northwest Minnesota. Attitudes toward travel time, flexibility, and privacy are found to have the strongest explanatory power. The socioeconomic profile of each market segment is identified. Individuals living in the study's upper Midwest market area are assigned to market segments based on their socioeconomic characteristics to determine market segment size. Mode shares for automobile, air, intercity bus, intercity rail, and van service are estimated for each market segment under varying conditions.

Shiftan, Yoram, Maren Outwater and Yushuang Zhou (2008). **"Transit market research using structural equation modeling and attitudinal market segmentation."** *Transport Policy* **15**(3): 186-195.

<http://dx.doi.org/10.1016/j.tranpol.2008.03.002> <http://www.sciencedirect.com/science/article/pii/S0967070X08000206>

This paper presents a comprehensive approach for identifying potential transit markets and for developing strategies to increase public transport ridership. The approach uses structural equation modeling (SEM) to identify simultaneously travelers' attitudes, travel behavior, and the causal relationships between a traveler's socioeconomic profile and his/her attitude toward travel. Travel attitudes are also used to identify distinct market segments and to develop plans that best serve the needs of each segment and increase transit ridership. The approach is demonstrated with a case study from the Utah Transit Authority.

Vermunt, Jeroen K and Jay Magidson (2005). **"Factor analysis with categorical indicators: A comparison between traditional and latent class approaches."** *New developments in categorical data analysis for the social and behavioral sciences*: 41-62.

The linear factor analysis (FA) model is a popular tool for exploratory data analysis or, more precisely, for assessing the dimensionality of sets of items. Although it is well known that it is meant for continuous observed indicators, it is often used with dichotomous, ordinal, and other types of discrete variables, yielding results that might be incorrect. Not only parameter estimates may be biased, but also goodness-of-fit indices cannot be trusted. Magidson and Vermunt (2001) presented a nonlinear factor-analytic model based on latent class (LC) analysis that is especially suited for dealing with categorical indicators, such as dichotomous, ordinal, and nominal variables, and counts. The approach is called latent class factor analysis (LCFA) because it combines elements from LC and traditional FA. This LCFA model is one of the LC models implemented in the Latent GOLD program (Vermunt & Magidson, 2000, 2003).

Wirthlin-Worldwide and FJCandN (2000). *TCRP 63: Enhancing the Visibility and Image of Transit in the United States and Canada*. TRB, National Research Council, Washington, D.C.

As population increases, streets and highways become more congested, and natural resources grow more precious, it will become increasingly important to realize the full economic and environmental efficiencies of transit (defined as publicly sponsored bus and rail transit services) in order to maintain a high level of mobility and livability in communities. To achieve full potential, public support for and use of transit are essential. Currently, transit has an image problem, and unless the general public's perception of transit is improved, the necessary public support for and use of transit is in question. In response to this concern, transit organizations at the national, regional, and local levels are contemplating the development of campaigns to enhance the visibility and image of transit. To date, significant research has been completed to define the general public's perceptions of transit, to better understand the reasons for these perceptions, and to identify major motivators and barriers to using transit. In order to develop potential visibility and image campaigns, additional research was needed to develop effective messages that build an emotional connection with key target markets, and to develop a series of strategic approaches and tactics that could be implemented nationally, regionally, or locally by transit systems of various sizes as part of such campaigns. Under TCRP Projects B-20 and B-20A, research was undertaken by Wirthlin Worldwide and FJCandN to provide guidance to national, regional, and local organizations interested in initiating campaigns to enhance the visibility and image of transit through value shifts that will improve the perceptions of transit among the general public, and appropriate target audiences.

Zhou, Yushuang, Krishnan Viswanathan, Yasasvi Popuri and Kimon E Proussaloglou (2004). *Transit District Customers in San Mateo County, California: Who, Why, Where, and How*. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1887. Transportation Research Board of the National Academies, Washington, D.C.

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pp. 183-192.

In the face of declining transit market share and an increase in population and jobs, transit agencies have to go beyond the traditional approach of trying to balance between maximizing ridership and meeting the needs of those who are most dependent on transit. Innovative approaches that account for customer perceptions and attitudes towards transit need to be undertaken in an effort to make transit a more attractive option for customers. This study reports the efforts of the San Mateo County Transit District (SamTrans) to understand customer attitudes and perceptions and create market segments that reflect and account for traveler attitudes. The study uses a Structural Equation Modeling (SEM) approach along with cluster analysis to identify market segments in the population that can be targeted for new services to be offered by SamTrans. In addition, the results of the market segmentation are applied spatially so that SamTrans can customize their response to address individual market areas. The results of the market segmentation were applied based on a mode choice model that determines the market share for competing auto, bus and enhanced transit modes. This study provides SamTrans with the means of identifying the spatial and modal distribution of their service market based on customer needs. This approach allows SamTrans to design transit services that compete more effectively in the target geographic markets addressing the needs of individual market segments.

Technical Appendix: The ICLV/Hybrid Model Development

TECHNICAL APPENDIX: ICLV AND HYBRID MODEL DEVELOPMENT

This technical appendix provides a full description of the NCRRP ICLV/Hybrid Model summarized in Chapter 5 of *NCRRP Report 4*. This text was significantly shortened for use in Chapter 5 and this version should be used by those wanting a more complete description of the model.

Introduction

The gap between discrete choice models and behavioral theory has encouraged different developments that attempt to enrich behavioral realism by explicitly modeling one or more components of the respondents' decision-making process (e.g., accounting for attitudes and perceptions). The most general framework proposed is the integrated choice and latent variable (ICLV) methodology (Ben-Akiva et al., 1999a; Ashok et al., 2002; Ben-Akiva et al., 2002; Bolduc et al., 2005), with some examples of recent applications given in Abou-Zeid et al. (2010), Glerum et al. (2014) and Hess et al. (2013). This hybrid modeling approach integrates latent variable and latent class models with discrete choice methods to model the influence of latent variables and classes on the choice process. Latent variable models capture the formation and measurement of latent psychological factors, such as attitudes and perceptions, which explain unobserved individual heterogeneity.

In other words, hybrid choice models allow the joining of models that can analyse both “hard” concepts like travel times, costs, comfort, frequency, etc. with “softer” concepts like how attitudes and values influence choice making. Most of the work to date has been academic with small samples and little effort on understanding important policy implications.

In this study for NCRRP, we demonstrate how attitudes and values (beyond simply times and costs) can influence demand and mode choice for two major US intercity corridors: the Northeast Corridor (NEC) and the Cascade Corridor. The NEC in particular is the biggest intercity corridor in the US and is in desperate need for infrastructure investment, which will cost many billions of dollars (NY Times). In this study, we obtained over 6,000 respondents—a very large dataset for such an effort—to use hybrid choice models to better understand the demand for these two major US intercity rail corridors. As far as we know from the literature, this is the largest scale study of its kind using hybrid choice techniques. This is important due to the immense needs of the NEC, in particular, and the necessary investment that needs to be made. Billions will need to be spent, so understanding demand for intercity rail and what influences it is critical to spend wisely to maximize the value of the investments being considered (Northeast Corridor Commission).

For this NCRRP study, respondents live in the larger metropolitan area of Boston, New York, Philadelphia, or Washington, D.C. (for NEC participants) or Portland, Seattle, or Vancouver (for Cascade participants) and made at least one intercity trip to other cities within their respective corridor. The total sample size is roughly 5,500 respondents from the NEC recruited through an online sample and a previous study of auto users in the NEC. And 500 respondents obtained from an online sample for the Cascade sample. Not only is this sample size much larger than in most typical studies using ICLV studies, but we also work extensively on disentangling pure random heterogeneity from that which can be linked to underlying latent attitudes. This takes into account the criticisms in Daly et al. (2012) and Vij & Walker (2015), and should at least in part avoid issues where the overall degree of heterogeneity is understated and/or the share of heterogeneity that can be linked to latent attitudes is overstated.

The remainder of this technical appendix is organized as follows. We first look at the survey work and model specification, before turning to model results, application and finally present some conclusions.

Technical Appendix: The ICLV/Hybrid Model Development

Survey Work and Data Processing

The survey work comprised an online stated preference questionnaire that was designed to reduce respondent burden and increase respondent participation (Dillman). An example stated preference scenario is shown below. Note that party costs were calculated versus individual costs. Costs and times were developed based on respondent's previous answers as well as network data on the two corridors. The scenarios tested concepts of different future expected times and costs on both the NEC and Cascade.

Below are 4 different travel options for your 2 day trip from your home to Seattle/Portland. Assume that none of the options require a transfer or connection. Assume that none of the options require a transfer or connection. If the options below are the only options available for your trip, which would you prefer? Highlighted information will vary from screen to screen.

Option 1: Rental Car	Option 2: Bus	Option 3: Air	Option 4: Train
Time to & waiting at station: 30 min	Time to & waiting at station: 30 min	Time to & waiting at airport: 2 hr 30 min	Time to & waiting at station: 50 min
On-board travel time: 2 hr 50 min	On-board travel time: 2 hr 50 min	Time in plane: 1 hr 5 min	On-board travel time: 2 hr 30 min
Destination station to final destination: 25 min	Destination station to final destination: 25 min	Airport to destination: 1 hr 15 min	Destination station to final destination: 35 min
Total Travel Time: 3 hr 35 min	Total Travel Time: 3 hr 45 min	Total Travel Time: 4 hr 50 min	Total Travel Time: 3 hr 55 min
Total one-way cost for your party of 2 (including rental car fee and parking for 2 nights): \$182	Total one-way cost for your party of 2: \$16	Total one-way cost for your party of 2: \$212	Total one-way cost for your party of 2: \$20
I prefer this option: <input type="radio"/>	I prefer this option: <input type="radio"/>	I prefer this option: <input type="radio"/>	I prefer this option: <input type="radio"/>

FIGURE 1 Stated Preference Experiment from the Survey.

The field of experimental design has seen substantial developments over recent years, moving away from the use of orthogonal designs, and turning to efficient designs which rely on prior information about the likely sensitivities of respondents to the individual attributes (see e.g., Rose and Bliemer, 2014). Making use of this prior information leads to more meaningful trade-offs that increase the information content in the data. In practice, this leads to substantially lower standard errors. The designs produced for this study allowed for uncertainty in our priors by using Bayesian D-efficient designs. We worked with wide regions, using normally distributed priors, with standard deviations that are 50% of the mean values. The priors were based on an extensive review of values obtained in past studies. Different designs were produced across purposes and for different journey lengths (i.e., different reference values), with a total of 108 designs produced for this study. In addition to the stated preference experiments, a number of attitudinal batteries were included in the questionnaire to understand the attitudes and values of respondents. These attitudinal statements were based on the Theory of Planned Behaviour (TPB) (Aizen, 1991) to understand the responses that were used as the indicator variables in the hybrid choice model described below. The TPB aims to understand behavioral beliefs (i.e., one's attitude toward intercity rail), normative beliefs (i.e., how friends and family and those one respects feel about intercity rail), and perceived behavioral control (i.e., the ability for the respondent to take intercity rail).

Responses were collected online. Nearly all responses were used, though about 600 overall were eliminated for a variety of reasons (inability to generate a valid trip time from google maps, speed-through respondents, straight-line answers to all attitude questions, and any radically large/small rail and bus and air access times and costs).

After data cleaning, a final sample of 6,564 respondents was retained for modeling (this is slightly more than the 6,000 responses above due to the ability to model some respondents across different trip purposes, as they could choose more than one). Data coding and model building was undertaken by the Research Team using Ox, a software package (Doornik, 2001).

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Model Specification

Separate models were estimated for four different segments:

- work, composed of business and attending a conference, with a total of 1,043 respondents;
- vacation, with a total of 2,062 individuals;
- visiting friends and relatives (VFR), with a total of 2,724 individuals; and
- other purposes, with a total of 735 individuals.

A common specification was used as the starting point for all segments, and this was refined by excluding attributes that did not show a significant and meaningful influence in a given segment. We will now describe the individual components of the overall model structure, looking in turn at the role of explanatory variables, latent attitudes, modal constants and attitudinal indicators.

Key Explanatory Variables

We focus first on the components of utility related to explanatory variables, which are travel time (access time, in-vehicle time, and egress time), and travel cost. For air, bus and rail, travel cost was defined as the per person cost, while, for car, we recognized that the driver often pays a larger share, and thus multiplied the total cost by $\frac{1}{1+\log(1+party\ size)}$. For car, access time and egress time were set to zero.

To capture random heterogeneity in sensitivities across respondents, we defined the individual coefficients to follow a log-uniform distribution, i.e., allowing for different time and cost sensitivities across respondents. This distribution has a similar shape to a lognormal distribution (being the exponential of a uniform rather than a normal distribution), but with a less extreme tail, and initial tests showed it to obtain not only more meaningful results, but also slightly better fit. Separate coefficients were used for travel time on different modes and also for access and egress time, allowing us to capture differences in the perceived onerousness of different time components. Using the example of car in-vehicle time, we would have that the sensitivity for respondent n is given by: $\beta_{car-IVT,n} = -e^{a_{\log(-\beta_{car-IVT})} + b_{\log(-\beta_{car-IVT})} \zeta_{car-IVT,n}}$ (1)

where $\zeta_{car-IVT,n}$ is a standard Uniform variate (between 0 and 1), distributed across respondents, where $a_{\log(-\beta_{car-IVT})}$ and $b_{\log(-\beta_{car-IVT})}$ relate to the lower bound and spread of the uniform distribution for the logarithm of the negative of the car in-vehicle time coefficient.

For cost, we used a similar approach, but additionally captured interactions with income. A complication arises as a share of respondents does not report income. Rather than making an arbitrary assumption that these respondents had an average income, we used a separate mean effect for the random cost coefficient for these respondents, but kept the level of the underlying heterogeneity for the uniform distribution (i.e., the log of the negative of the coefficient) the same. In this way, we have:

$$\beta_{cost,n} = -x_{reporter} \cdot e^{a_{\log(-\beta_{cost}),reporter} + b_{\log(-\beta_{cost})} \zeta_{cost,n}} \left(\frac{inc_n}{inc}\right)^{\lambda_{inc}} - x_{non-reporter} \cdot e^{a_{\log(-\beta_{cost}),non-reporter} + b_{\log(-\beta_{cost})} \zeta_{cost,n}} \quad (2)$$

where $x_{reporter}$ and $x_{non-reporter}$ are dummy variables to identify income reporters and income non-reporters, and where $\zeta_{cost,n}$ is again a Uniform variable, distributed between 0 and 1. The additional parameter λ_{inc} is an estimated income elasticity on the cost sensitivity.

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Latent Attitudes

The latent attitude specification used in these models follows on from earlier factor analysis work carried out on the same data. In particular, we define four latent variables α_l , with $l=1, \dots, L$, where $L=4$. These are hereafter referred to as:

- attitude toward cars;
- attitude toward information technology;
- attitude toward urbanism/sociability; and
- attitude toward privacy.

Each of these latent attitudes is defined to have a deterministic and a random component, with latent attitude l for person n being:

$$\alpha_{l,n} = \gamma_l z_n + \xi_{l,n} \quad (3)$$

where the estimates of γ_l capture the impact of a range of sociodemographic characteristics of person n (z_n) on the latent attitude, and where ξ_l is a standard Normal variate (mean of 0, standard deviation of 1), distributed across respondents, capturing the random element of the latent attitude. The sociodemographic terms tested for effects on the latent attitudes were:

- gender (female dummy);
- age (using 5 categories of which 35-45 served as base);
- education: dummy for respondents without a graduate degree; and
- employment: dummy for respondents who are not employed.

Modal Constants

The mode specific constants for respondent n were specified to follow a Normal distribution across respondents, allowing for differences across individual travelers in their baseline preferences for different modes. We then have:

$$\delta_{j,n} = \mu_{\delta_j} + \gamma_j z_n + \omega_j w_n + \sigma_{\delta_j} \xi_{j,n} + \sum_{l=1}^L \tau_{j,l} \alpha_{l,n} \quad (4)$$

We will initially focus on the three first components above, before turning our attention to the $\sum_{l=1}^L \tau_{j,l} \alpha_{l,n}$ component. In the above specification, we have that μ_{δ_j} is an estimated mean, σ_{δ_j} is an estimated standard deviation, $\xi_{j,n}$ is a standard Normal variate (mean of 0, standard deviation of 1) distributed across respondents, and γ_j and ω_j are vectors of estimated parameters that measure the impact of respondent (z_n) and trip (w_n) characteristics captured in z_n , which are specified in the paragraphs below.

For identification purposes, the mean and standard deviation were set to zero for bus, on the basis of tests showing that the level of random heterogeneity was lowest for bus. Identification was also ensured for the effects of sociodemographic and trip characteristics by setting, for a given characteristic $z_{n,k}$ to zero for at least one j . The same applies to w_n and $\omega_{j,k}$.

The characteristics included in the vector z_n for interactions with constants included:

- gender (female dummy): tested for the non-car modes;
- age (using 5 categories of which 35-45 served as base): interacted with the non-car modes;
- education: dummy for respondents without a graduate degree, interacted with the constant for non-car modes (with degree as base);

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- employment: dummy for respondents who are not employed, interacted with the constant for non-car modes (employed as base);
- households with fewer cars than adults: dummy interacted with the car constant (one or fewer cars per adult); and
- households with more cars than licenses: dummy interacted with the car constant (one or fewer cars per license);

while, for w_n , they were:

- frequency: daily service frequency, interacted with the constant for non-car modes. Note that this was included here as opposed to being listed as an explanatory variable above as it was not included as a variable in the survey, i.e., it was not explicitly shown to respondents. The aim behind including this is to test whether respondents in corridors with higher frequency of service for a given mode are more likely to choose that mode also in the hypothetical scenarios;
- West Coast dummy: interacted with the constant for non-car modes (East Coast as base);
- party size: terms for one other person and two plus other people, interacted with the constant for non-car modes (single person as base);
- trip length: terms of overnight, two nights and three plus nights, interacted with the constant for non-car modes (day trip as base); and
- distance effects for air: dummy terms for trips under 200 miles and trips over 400 miles, interacted with the air constant (200-400 miles as base);

The combined utility specification now includes:

- the impacts of the explanatory variables, with randomly distributed time and cost coefficients, where the latter is also interacted with income;
- the mode specific constants, which include a deterministic component as well as a random part; and
- an impact on the modal constants by the latent attitudes, which again include a deterministic and random component.

Two important points need to be made here.

Firstly, the sociodemographic terms included in the modal constants explained above relate to person as well as trip characteristics, while those sociodemographic terms mentioned earlier for the latent attitudes related only to person characteristics. This reflects the assumption that attitudes are stable for each person across different trips.

Secondly, all respondent characteristics included in the deterministic component of the latent attitude have also been included in the modal constant as well, thus avoiding a situation where a sociodemographic effect is erroneously captured as relating to attitudes when it may just relate to underlying modal preferences, or vice versa. As an example, it may well be the case that younger respondents travel less by car for reasons unrelated to their attitude toward cars. If age was included as a covariate only on the latent attitude toward cars but not separately on the modal constants, this inherent modal preference may erroneously be captured as an attitudinal differences. In very much the same way, the modal constants now include a random component that relates to the latent attitudes (through the inclusion of $\sum_{l=1}^L \tau_{j,l} \alpha_{l,n}$ in Equation [4]) while a separate random component ($\sigma_{\delta_j} \xi_{j,n}$) relates to random variations in preferences for modes which cannot be linked to latent attitudes, for example due to uncaptured journey specific effects.

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This brings us to an important point. The specification of an alternative specific constant (except for bus) now includes two separate random terms, both following a Normal distribution, and both with deterministic interactions on the mean, some of which relate to the same underlying sociodemographic variables. In the current form, this would be an overspecification, with two parameters capturing the same effect. What allows us to separately identify the two components is that one of them, namely the latent variable component, is also used in a separate measurement model, which we will turn our attention to next.

Measurement Model

We have four latent attitudes in our model, and these are used in the measurement model component of our overall framework to explain the answers that respondents give to a number of attitudinal questions and one question about their habits. In particular, we follow the segmentation developed in the earlier factor analysis work, with the groupings summarized in Table 1.

With the exception of the smart technology ownership question, all questions use a 7-level Likert scale. We now use the four latent attitudes to explain the answers to the attitudinal questions. With I_s used to refer to a given attitudinal question, and letting α_l be the associated latent attitude, we use an ordered logit model to explain the likelihood of the actual observed value of I_s for respondent n as:

$$LI_{S,n} = \sum_{p=1}^7 x_{I_s,n,p} \left(\frac{e^{t_{I_s,p} - \zeta_{I_s} \alpha_l}}{1 + e^{t_{I_s,p} - \zeta_{I_s} \alpha_l}} - \frac{e^{t_{I_s,p-1} - \zeta_{I_s} \alpha_l}}{1 + e^{t_{I_s,p-1} - \zeta_{I_s} \alpha_l}} \right) \quad (5)$$

where $x_{I_s,n,p}=1$ if and only if respondent n chooses answer p for question s . The $t_{I_s,p}$ parameters are thresholds that are to be estimated, with the normalisation that $t_{I_s,0} = -\infty$ and $t_{I_s,7} = +\infty$. The estimated parameter ζ_{I_s} measures the impact of the latent variable α_l on I_s . A significant estimate for ζ_{I_s} thus shows us that the latent attitude α_l has a statistically significant impact on the answers provided to the attitudinal question I_s .

The above specification is used directly with the latent car attitude, the latent urbanism attitude and the latent privacy attitude on the three indicators associated with each one (cf. Table 1). For the latent information technology attitude, this specification is used for the two associated attitudinal questions. For the question relating to ownership of smart technology, the binary nature of the answer to that question means that a binary response model is used instead, specified as:

$$LI_{6,n} = x_{I_6,n,0} \frac{1}{1 + e^{t_{I_6} + \zeta_{2,6} \alpha_2}} + x_{I_6,n,1} \frac{e^{t_{I_6} + \zeta_{2,6} \alpha_2}}{1 + e^{t_{I_6} + \zeta_{2,6} \alpha_2}} \quad (6)$$

where $x_{I_6,n,0}$ is 1 if respondent n does not own smart technology (and 0 if he/she does), with the opposite applying for $x_{I_6,n,1}$. This indicator is explained through the second latent variable, and t_{I_6} is an estimated constant that explains the average rate of respondents owning smart technology in our data, while $\zeta_{2,6}$ captures the impact of the latent attitude on ownership of smart technology.

Joint Specification

The four latent variables are a function of the respondent characteristics z , while the utilities of the four alternatives are a function of respondent characteristics z , trip characteristics w and mode characteristics x . The four latent attitudes are used to explain the values of twelve indicators and also contribute to the utility of the modal alternatives in the choice model (with a normalization). These utilities are then used to explain the choices observed in the data.

With $i_{n,t}$ being the alternative chosen by respondent n in task t (out of $T=8$), we have that the likelihood of the observed choices and answers to attitudinal questions for respondent n is given by:

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$$L_n = \int_{\alpha} \int_{\beta} \int_{\delta} \prod_{t=1}^T \frac{e^{v_{in,t}}}{\sum_{j=1}^4 e^{v_{j,t}}} \prod_{s=1}^{12} LI_{s,n} f(\alpha) f(\beta) f(\delta) d\delta d\beta d\alpha \quad (7)$$

where we use a Logit kernel for the choice model component, and where $LI_{s,n}$ is defined as above. Both the component relating to the choices (i.e. the Logit kernel) and the component relating to the attitudinal questions are a function of the vector of latent variables α , while the choice model component is also a function of the random components used in the marginal utility coefficients (β) and the random components used in the alternative specific constants (δ). This is why the entire likelihood function is integrated over the distribution of α , β and δ . For estimation, we work with the log-likelihood function (the logarithm of Equation 7) and approximate this using numerical simulation, i.e. maximizing the simulated log-likelihood. In this process, we need to take draws (where we rely on 250 MLHS draws per person, see Hess et al., 2006) for 7 normally distributed random terms (the random components for the car, rail and air constants, and the random components for the four latent attitudes), as well as 7 uniformly distributed random terms (the random components for the log-uniformly distributed access time, egress time, travel cost, and four mode specific in-vehicle time coefficients). All models were coded in Ox (Doornik, 2001), and the standard errors reported in the results are obtained with the sandwich method (Huber, 1967).

The above likelihood is a function of a large number of parameters to be estimated, namely:

- the lower bounds (a) and ranges (b) for the underlying Uniform distributions used for the log-uniformly distributed time and cost coefficients
- the means (μ) and standard deviations (σ) for the mode specific constants
- the impact of income (λ_{inc}) on the cost sensitivity
- the impact (γ) of the sociodemographic characteristics on:
 - the mode constants; and
 - the latent variables
- the impact (ω) of the trip characteristics on the mode constants
- the threshold parameters (t) for the eleven ordered logit measurement model and the constant for the binary logit measurement model
- the impacts of the latent variables on the indicators (ζ)

Model Results

The modeling effort undertaken for this work was substantial, with a total of 160 different parameters used across the different models. The results are in turn very detailed and are presented across a number of different tables at the end of this Appendix. We will now look at the different parts of the results in turn.

Model Fit Statistics and Headline VTT Measures

The overall model fit statistics and headline value of travel time (VTT) are presented in Table 2, where we present the VTT measures for a mean income of \$125K per year (this is a high mean, but is not surprising due to the fact these are intercity travelers in two major US corridors making discretionary or business trips), and where we report the mean and standard deviation of the distribution resulting from the ratio between the negative log-uniform distributions for the time and cost coefficients.

The overall model fits are not directly comparable across purposes, not only given the differences in sample size, but also due to the use of different numbers of indicators across segments in the measurement models (details on this are given later on). After estimation, it is possible to factor out the component of the overall log-likelihood relating to the stated choices alone, and the calculation of the ρ^2 measures shows very similar performance across segments, where the high values show the relative ease

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of explaining mode choices for intercity travel, especially after accounting for random heterogeneity and the role of attitudes. (These measures are unadjusted for the number of parameters as it is not immediately clear how many degrees of freedom should be used, but with the overall data size, any adjustment would have a very minor impact only.)

Turning to the VTT measures, we can see that, with the exception of access time (where VFR is very similar to work), the measures are higher for work trips than for all other purposes. Even when remembering that these are calculated for a given income of \$125K, this is still not surprising given the different time pressures faced on work trips. Egress time is valued substantially lower than access time for all purposes except work trips, where the opposite applies, potentially as a result of these trips being presented as outbound and respondents being more sensitive to the part of their journey relating to getting to their work location after exiting the main-mode station.

Major differences exist across modes in the way travel time is valued, and the orderings differ across purposes. We see that, while for work trips, car IVT is valued the least highest, this is not the case for the three remaining purposes, where the least onerous type of IVT applies to air for vacation, and rail for VFR and other purposes. The highest VTT generally applies to bus, which is clearly a comfort factor, except for *other* purposes, where the VTT for air is marginally higher than that for bus. Overall, rail IVT is valued the least highest. Finally, the standard deviations show that there exists extensive variation across individual travellers in how they value travel time.

The actual values of time are calculated from the results in Table 2 which show that, with a few exceptions (access time for work, egress time, car travel time for work and air travel time for work), the estimates for the variance parameters are statistically significant, showing substantial heterogeneity, especially for the travel cost sensitivity. We also see that, across all four purposes, the sensitivity to travel cost is higher for income non-reporters than for a respondent at the mean income of \$125K. The impact of income on cost sensitivity is strongest for work travel, and lowest for vacation and VFR travel.

Mode Constants

We next move to the constants for the four modes, with results shown in Table 3 where this excludes the impacts of the latent attitudes, which are looked at later on.

We start by looking at the mean values of the modal constant, i.e., studying the underlying preference for different modes, all else being equal (i.e., same time, cost, etc.). Remembering that these estimates relate to a respondent in the base sociodemographic group (aged between 35 and 44, with a degree and in employment, traveling alone on an East Coast day trip between 200 and 400 miles), we see that:

- male respondents on work trips prefer rail ahead of air, car and then bus (the base), where, for female respondents, the difference between car and bus becomes negligible;
- male respondents on vacation trips prefer rail, ahead of bus, air and car, where, for female respondents, air is ranked second;
- both male and female respondents on VFR trips prefer rail, ahead of air, car and bus; and
- both male and female respondents with other purposes prefer rail, ahead of car, bus and air.

Numerous shifts in the modal constants are also observed, as follows:

- Age has impacts for bus and air, where:
 - on vacation trips, the likelihood of traveling by bus is higher for respondents under 35; and
 - the likelihood of traveling by air reduces for VFR purposes in the two highest age groups, but increases in the highest age group for other purposes.

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- Having more vehicles than licenses in a household increases the probability of traveling by car for work trips.
- Compared to respondents with a graduate degree, those without are:
 - more likely to use bus on VFR and other trips; and
 - more likely to use air on VFR trips than those with a degree
- Compared to respondents in firm employment, those not are:
 - more likely to travel by bus for work reasons;
 - less likely to travel by air for other reasons.
- Compared to respondents on day trips, we see that:
 - those with an overnight stay are less likely to use bus or rail for VFR trips;
 - those with one or more nights away are less likely to use bus for other trips; and
 - those with three or more nights away are more likely to use air for vacation trips and less likely to use rail for other trips.
- Compared to respondents traveling alone, we see that:
 - those traveling with one other person are less likely to use bus, air or rail for vacation trips, less likely to use rail or air for VFR trips, or air for work trips; and
 - those traveling with two or more people are more likely to use bus for work trips, less likely to use air or rail for vacation and VFR trips, and less likely to use air for other trips.
- Increases in service frequency increases the likelihood of choosing bus for vacation and VFR trips, and air for VFR and other trips.
- Compared to the East Coast, travellers on the West Coast are less likely to travel by bus for vacation, air for other purposes, or rail for work and vacation.
- Across all purposes, respondents on trips below 200 miles are less likely to use air, than those traveling between 200 and 400 miles, where, above 400 miles, they are even more likely to travel by air.

Attitude Toward Cars

The results in Table 3 relate to the latent attitude toward cars. Looking first at the signs of the ζ parameters, we see that those respondents with a more positive latent attitude are more likely to agree with the statements “Rather than owning a car, I would prefer to borrow, share, or rent a car just for when I need it” and “I feel I am less dependent on cars than my parents are/were”, and to disagree with the statement “I love the freedom and independence I get from owning one or more cars”. This thus identifies this latent attitude as an *anti-car attitude*, or at the very least as a reduced car lover attitude.

Looking at the γ parameters, we can see that these anti-car respondents are less likely to be female for non-work trips (perhaps due to personal security issues), are more likely to be young (as expected given the changes in car attitudes across generations), are more likely to be less educated (other than for vacation trips where there is no effect) and are less likely to be employed (for VFR trips only), where this is likely to be an income effect too, which the main income effect on cost fails to capture completely.

Looking finally at the impacts of this latent attitude on mode choice behavior, the τ parameters show us that respondents with a less positive car attitude (i.e., a more positive value for this latent attitude) are less likely to choose car (not surprisingly), but there is also a reduced probability of choosing air for work and VFR trips, possibly due to environmental considerations, though again possibly also due to some confounding with income effects. We finally also see a reduced probability of choosing rail for VFR trips (with bus being the base), reinforcing the earlier point that for VFR, there are possibly confounding effects with income for this latent attitude.

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Attitude Toward Information Technology

The results in Table 3 relate to the latent attitude toward information technology, where this was only included for VFR and *other* purposes after no impact on mode choice behavior was found for work and vacation. This may be seen as surprising for work especially, but could be the result of a relatively homogeneous group of work travelers, who all have a heightened use of information technology, making it hard to find an impact on mode choice.

Looking first at the signs of the ζ parameters, we see that those respondents with a more positive latent attitude are more likely to agree with the statements “It would be important to me to receive e-mail or text message updates about my bus or train trip” and “Being able to freely perform tasks, including using a laptop, tablet, or smartphone is important to me”. This thus identifies this latent attitude as a *pro-information technology attitude*. Looking at the γ parameters, we can see that, for VFR trips, these respondents are more likely to be female, highly educated, or employed and are more likely to be younger (for both VRT and *other* purposes).

Looking finally at the impacts of this latent attitude on the mode choice behavior, the τ parameters show us that respondents with a more positive attitude toward information technology are less likely to choose car for VRT and *other* purposes, while, for *other* trips, they are also more likely to choose air. While the former effect is as expected, the latter is somewhat surprising as the use of information technology is less easy during air travel than for bus or rail, although that is starting to change with more abundant in-plane Wi-Fi, the ability to keep devices on during take-off and landing, etc.

Attitude Toward Urbanism

The results in Table 3 relate to the latent attitude toward urbanism, which was found to have an effect only for the *other* purposes segment. Looking first at the signs of the ζ parameters, we see that those respondents with a more positive latent attitude are more likely to agree with the statements “I enjoy being out and about and observing people”, “I like to live in a neighborhood where I can walk to a commercial or village center” and “If everyone works together, we could improve the environment and future for the earth”, identifying them as *more sociable respondents*.

Looking at the γ parameters, we can see that these respondents are more likely to be female and to have a graduate degree. Looking finally at the impacts of this latent attitude on the mode choice behaviour, the τ parameters show us that respondents with a more positive social latent attitude are more likely to choose air and rail than those with a less positive attitude, compared to car and bus.

Attitude Toward Privacy

The results in Table 3 relate to the latent attitude toward privacy, where this has an effect on mode choice behavior in all four trip-purpose segments. Looking first at the signs of the ζ parameters, we see that those respondents with a more positive latent attitude are more likely to agree with the statement “I don't mind traveling with people I do not know” and less likely to agree with the statements “The idea of being on a train or a bus with people I do not know is uncomfortable” and “The thought of sharing a car with others for such a trip seems unpleasant to me”. This thus shows that respondents with a more positive value for this latent attitude are *less concerned about privacy*.

Looking at the γ parameters, we can see that these respondents are more likely to be female for *other* purposes, are more likely to be older and less likely to be less educated (for work, vacation and VFR) or to be unemployed (for all purposes other than work).

Looking finally at the impacts of this latent attitude on the mode choice behavior, the τ parameters show us that respondents who are less concerned about privacy are less likely to choose car or air (for all purposes other than work), while, for work trips, they are more likely to choose rail. The negative coefficient of the latent attitude on the probability of choosing rail for *other* purposes needs to be

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put into the context that the impact is even more negative on car and air, showing simply that these respondents are more likely to choose bus than others, which is a reasonable result.

Strength of Impact of Latent Attitudes

A key aspect of our modeling approach was to include pure random heterogeneity not linked to the latent attitudes in addition to that attributed to the latent attitudes. This means that the total random variation in the mode constants for car, air and rail is a combination of the random heterogeneity in the constants and the random heterogeneity introduced by the latent attitude. It is then of interest to see what share of this random heterogeneity can be linked to the latent attitudes. This is the approach used in Table 4, where we compute the total random variance in a modal constant (given by $\sigma_{\delta_j}^2 + \sum_{l=1}^L \tau_{j,l}^2$) and then report the share of that variance that can be attributed to the different subparts.

Looking first at car, we can see that the share of random heterogeneity that can be attributed to the latent attitudes is only one-fifth for work trips and one quarter for vacation. However, for VFR and *other*, it is more than half, with the biggest share, in line with expectations, due to the attitude toward cars. For rail, the share of random heterogeneity linked to the latent attitudes is small except for *other* purposes, where the vast majority of the random heterogeneity can be attributed to the latent variables. For air, the picture is more varied, showing for the first time a case where, for work, the latent attitudes contribute the largest part to the random variation in the mode constants. For vacation, there is no impact by any of the latent variables, while, for VFR and *other*, the share is around one-third and one-fifth, respectively.

Finally, Table 5 looks at the role of key sociodemographic variables in influencing mode choice, comparing the direct impact (i.e., through inclusion in the definition of mode constants) with the indirect impact through the latent variables. The latter are calculated in interaction with the τ parameters and summed across latent variables, while, for the former, we renormalized the values to use bus as the base for all effects, in common with the latent variable impacts.

An interesting picture emerges when studying these results. Firstly, we can see that overall, more of the sociodemographic characteristics are able to manifest an impact on mode choice through the latent variables than through direct inclusion in the definition of the mode choice constants. This in itself is not surprising as the latent attitude effects benefit from calibration on more observations, including not just choice data but also the indicator variables.

Additionally, however, and with no exception, where a sociodemographic variable has both a direct and an “indirect” impact on the mode constants, the former is always larger, sometimes substantially so. No immediate reason arises for this, but overall, our extensive exercise has been much more successful than previous studies in capturing an effect of socio-demographics on behavior through the latent variables. This is somewhat contrary to the statement in Ben-Akiva et al. (1999b) that it can be difficult to find good causal variables for the latent variables. A possible reason is that much of the previous work on latent variables has failed to follow the guidance in Vij & Walker (2015) to attempt to disentangle the role of heterogeneity caused by latent variables from that unrelated to latent variables, which we do.

One important aspect of the project that made it unique from most academic efforts to date is that once the model was estimated, we then applied it to understand the impacts of various demographic and policy shifts. This is important to allow the model to actually become useful for decision-making and policy work.

To apply the model, we used sample enumeration, meaning we took the 6,000 respondents in our sample and applied the model to each of them. Once we implemented the model and checked that it accurately reported base mode shares from the sample (it does), then we used the application to play with a number of what-if scenarios and the resulting changes in mode shares.

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There is debate in the academic literature about endogeneity and causality in hybrid choice models. For example, there is concern about assuming that attitudes toward urbanism increase by 10%, as it is hard to tell whether an urban attitude is developed which causes the choice in mode or if by choosing a particular mode it affects your attitude toward urbanism due to “cognitive dissonance,” meaning the way we rationalize our decisions.

Therefore, the table below simply shows potential demographic shifts by saying, “What if all the males in the sample were female, etc.” and the resulting changes in share for the rail mode based on these changes. We are not presenting here direct shifts in attitudes, which can also be played with, as the demographic shifts are more tangible and less prone to endogeneity concerns.

Note that in Table 6, the biggest changes affecting rail share is when the sample is assumed to be all young people under 35. You can see that the anti-car attitude of young people has a major effect on the rail share. Also interesting is the privacy variable. Young people have MORE concern about privacy than older people; thus when everyone is made young, some of the rail increase is mitigated by young people’s desire for more privacy (though the car attitude is still much stronger). The reverse is true for those over 65.

Summary and Conclusions

The Technical Appendix for ICLV/Hybrid Model Development demonstrates that the results obtained in this study have the ability to help formulate real policy implications using advanced (and formerly only academic) modeling techniques in a real-world setting. The results have been applied in a way to make them easy to interpret and use for policy makers. This indicates that studies that can obtain a significant sample and which can then estimate and apply complex models in reasonable ways to the policy implications clear to decision makers is a worthwhile and possible outcome. As shown in the paper, to measure and estimate both hard and soft attributes means that a relatively complex model is necessary to describe these complex behaviours. Yet, as demonstrated in the model application section, this complexity can then be simplified to generate good clear policy implications that are useful and tangible. This example shows how this can be accomplished for hybrid choice models, but the study is also a model of how this could be done for other applications where the state of the art is put into the state of the practice.

Technical Appendix: ICLV/Hybrid Choice Model Development**TABLE 1 Attitudinal Indicators**

car attitude	“Rather than owning a car, I would prefer to borrow, share, or rent a car just for when I need it”
	“I love the freedom and independence I get from owning one or more cars”
	“I feel I am less dependent on cars than my parents are/were”
technology attitude	“It would be important to me to receive e-mail or text message updates about my bus or train trip”
	“Being able to freely perform tasks, including using a laptop, tablet, or smartphone is important to me”
	Respondent owns smart technology (at least one smartphone, tablet, GPS device or laptop)
urbanism attitude	“I enjoy being out and about and observing people”
	“I like to live in a neighborhood where I can walk to a commercial or village center”
	“If everyone works together, we could improve the environment and future for the earth”
privacy attitude	“The idea of being on a train or a bus with people I do not know is uncomfortable”
	“I don't mind traveling with people I do not know”
	“The thought of sharing a car with others for such a trip seems unpleasant to me”

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TABLE 2 Model Fit Statistics, VTT Measures at Income of \$125k per Year, Impact of Explanatory Variables and Mode Constants

	WORK		VACATION		VFR		OTHER		
Respondents	1,043		2,062		2,724		735		
Log-likelihood (total)	-15,827.00		-30,867.10		-48,659.70		-20,354.90		
Log-likelihood (choice)	-5,065.95		-9,803.58		-12,041.90		-2,879.41		
ρ^2 for choice model only	0.56		0.57		0.60		0.65		
	mean	std. dev.	mean	std. dev.	mean	std. dev.	mean	std. dev.	
value of access time (\$/hr)	50.10	39.37	38.71	50.73	49.19	102.06	41.60	84.31	
value of egress time (\$/hr)	58.37	98.27	25.86	28.70	14.75	47.36	18.02	45.89	
value of car IVT (\$/hr)	44.15	34.61	23.48	28.75	27.39	32.15	27.93	32.19	
value of bus IVT (\$/hr)	61.33	61.81	48.28	54.84	40.24	47.94	34.02	37.03	
value of air IVT (\$/hr)	49.35	130.69	20.72	58.81	29.01	34.30	36.65	38.72	
value of rail IVT (\$/hr)	46.08	43.81	22.96	21.96	23.96	23.58	26.31	29.20	
	est	t-rat	est	t-rat	est	t-rat	est	t-rat	
access time	$a_{\log(-\beta)}$	-3.9150	-10.13	-2.8467	-22.11	-2.8057	-19.56	-7.9529	-10.32
	$b_{\log(-\beta)}$	-0.1875	-0.20	-3.0618	-7.71	-2.4337	-4.74	6.0773	6.79
egress time	$a_{\log(-\beta)}$	-6.9454	-2.84	-5.7072	-6.89	-6.6600	-3.08	-2.3157	-9.06
	$b_{\log(-\beta)}$	4.6302	1.95	2.1882	1.69	3.6599	1.48	-9.0141	-1.60
IVT (car)	$a_{\log(-\beta)}$	-4.0950	-10.85	-3.4560	-55.37	-5.3063	-19.14	-3.1642	-38.99
	$b_{\log(-\beta)}$	-0.0784	-0.12	-2.6874	-8.63	1.5739	3.36	-2.2307	-6.44
IVT (bus)	$a_{\log(-\beta)}$	-4.8138	-35.11	-5.1620	-40.62	-5.0798	-40.00	-5.0285	-24.46
	$b_{\log(-\beta)}$	1.7660	4.16	2.3066	14.20	2.1105	14.66	1.9725	6.95
IVT (air)	$a_{\log(-\beta)}$	11.7700	-1.20	13.5680	-6.67	-3.6075	-9.74	-3.0383	-14.21
	$b_{\log(-\beta)}$	10.0540	0.97	11.3470	5.08	-2.2287	-2.52	-1.8133	-2.85
IVT (rail)	$a_{\log(-\beta)}$	-3.4296	-26.15	-3.8837	-42.42	-3.6779	-28.87	-3.2838	-13.47
	$b_{\log(-\beta)}$	-1.5006	-10.27	-1.4875	-8.22	-1.4840	-6.27	-2.0560	-4.35

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		$a_{\log(-\beta)}$ (income reporters)	-4.9485	-19.87	-4.7051	-48.61	-4.3928	-51.55	-4.4786	-24.89
	cost	$a_{\log(-\beta)}$ (income non-reporters)	-5.6919	-5.98	-4.8481	-23.44	-5.1859	-23.68	-4.7184	-9.44
		$b_{\log(-\beta)}$	2.8859	11.02	2.9076	20.95	2.4727	18.45	3.0380	10.48
		income elasticity (λ_{inc})	-0.3200	-3.25	-0.1027	-2.35	-0.1251	-2.63	-0.1810	-3.80
	μ_{δ_j}	mean	0.8204	1.00	-0.8155	-1.39	1.7003	3.67	1.7623	2.99
	car	σ_{δ_j}	standard deviation	-2.8398	-10.48	-2.7435	-19.92	-2.1138	-9.29	-2.4398
	constant	γ_j	more vehicles than licenses in household	1.2058	2.10					
		μ_{δ_j}	mean	0	-	0	-	0	-	0
		σ_{δ_j}	standard deviation	0	-	0	-	0	-	0
		γ_j	female	0.7791	1.91			0.3534	1.78	1.4077
			aged under 35			0.8485	2.10			
			no graduate degree					1.6069	8.22	1.0314
	bus		not employed	0.9090	1.20					
	constant		overnight trip			-0.7617	-2.22			
			one or more nights away						-1.2603	-3.85
		ω_j	one or more other people in party			-1.8521	-3.66			
			two or more other people in party	1.0473	3.33					
			frequency of service			0.0096	2.80	0.0091	3.43	
			West coast			-1.6929	-4.70			
		μ_{δ_j}	mean	2.1196	2.03	-0.7797	-0.92	2.2816	3.25	-0.3916
		σ_{δ_j}	standard deviation	1.5479	1.45	2.1333	9.68	2.3069	9.87	1.4371
			female			1.3593	3.29			
			aged between 55 and 64					-0.5811	-1.11	
	air	γ_j	aged 65 or over					-0.8950	-2.28	2.9667
	constant		no graduate degree					1.0246	3.26	
			not employed							-1.2695
			three or more nights away			0.9820	2.27			
		ω_j	one other person in party	-0.6674	-1.47	-2.2473	-5.03	-0.9228	-3.27	
			two or more other people in party			-2.8939	-5.06	-1.8685	-5.56	-1.1443

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		distance under 200 miles	-1.3584	-3.38	-1.5424	-2.65	-1.6538	-4.78	-1.5062	-3.17
		distance over 400 miles	2.2162	2.29	2.1668	4.46	1.0978	2.51	0.5217	0.63
		frequency of service					0.0325	1.41	0.1325	4.07
		West coast							-2.8008	-3.70
	μ_{δ_j}	mean	2.4121	4.09	0.7658	1.71	2.6482	7.44	1.8148	2.95
	σ_{δ_j}	standard deviation	1.6040	8.78	-0.4448	-1.94	0.9862	5.55	1.6237	7.28
	γ_j	female			0.1405	0.88				
		overnight trip			-0.5962	-1.67				
		three or more nights away							-1.6014	-3.74
		one other person in party			-1.6532	-4.14	-0.5459	-2.79		
		two or more other people in party			-2.2215	-5.56	-1.1882	-6.10		
		West coast	-0.5172	-1.06	-0.7450	-2.09				
rail										
constant	ω_j									

Technical Appendix: ICLV/Hybrid Choice Model Development

TABLE 3 Formation and role of attitudes

	ATTITUDE TOWARDS CARS	WORK		VACATION		VFR		OTHER	
		est	t-rat	est	t-rat	est	t-rat	est	t-rat
γ_l	female			-0.2193	-3.44	-0.1639	-2.68	-0.2075	-2.32
	aged under 35	0.5038	1.95	0.2325	1.63			0.9432	5.73
	aged between 45 and 54	-0.3996	-2.15	-0.4035	-4.44	-0.3929	-5.24		
	aged between 55 and 64	-0.5256	-2.95	-0.5740	-5.11	-0.7531	-9.27		
	aged 65 and over	-0.5715	-2.78	-0.7918	-7.03	-0.8867	-8.34	-0.2905	-2.02
	not a graduate	-0.2466	-2.25			-0.1382	-2.11	-0.3530	-3.25
	not employed					0.1972	2.69		
$\tau_{j,l}$	impact on utility of car	-1.4274	-3.82	-0.9658	-6.25	-2.1502	-9.76	-2.0074	-7.58
	impact on utility of air	-0.4972	-1.04			-1.0998	-5.76		
	impact on utility of rail					-0.7620	-5.99		
"Rather than owning a car, I would prefer to borrow, share, or rent a car just for when I need it"	$\zeta_{l,s}$	1.4209	9.12	1.2817	14.91	1.2889	18.06	1.0385	7.92
	$t_{l,s,1}$	-2.8212	-10.56	-2.7423	-18.40	-2.9712	-21.67	-2.1196	-13.10
	$t_{l,s,2}$	-1.3212	-5.41	-1.2173	-9.63	-1.4694	-12.83	-0.5597	-4.32
	$t_{l,s,3}$	-0.5792	-2.43	-0.4568	-3.75	-0.6748	-6.29	0.1011	0.82
	$t_{l,s,4}$	0.3791	1.58	0.5171	4.26	0.2937	2.89	1.1651	8.78
	$t_{l,s,5}$	0.9369	3.84	1.2863	10.26	0.9754	9.54	1.6324	11.50
"I love the freedom and independence I get from owning one or more cars"	$\zeta_{l,s}$	-1.3647	-9.39	-1.1748	-14.04	-1.2836	-15.55	-1.7967	-9.37
	$t_{l,s,1}$	-3.7261	-13.07	-3.7698	-20.90	-3.5752	-23.40	-4.5916	-11.88
	$t_{l,s,2}$	-3.1936	-12.17	-3.0738	-20.21	-2.6962	-21.75	-3.9447	-11.60
	$t_{l,s,3}$	-2.5118	-10.22	-2.5962	-18.68	-2.2404	-19.84	-3.3174	-11.33
	$t_{l,s,4}$	-1.5595	-6.89	-1.5760	-13.04	-1.2376	-12.38	-2.0700	-9.30
	$t_{l,s,5}$	-0.2125	-0.96	-0.3931	-3.51	-0.1820	-1.91	-0.8658	-4.65
"I feel I am less dependent on cars than	$\zeta_{l,s}$	1.5275	6.32	1.4001	11.39	1.5926	14.90	1.0509	5.72
	$t_{l,s,1}$	1.7313	9.32	1.8284	14.11	1.6630	17.02	1.7576	9.45
		-2.0500	-6.42	-1.8646	-9.44	-2.1162	-15.12	-1.0587	-5.42

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My parents are/were"	$t_{I_s,2}$	-0.3465	-1.19	-0.2243	-1.31	-0.4727	-3.85	0.4023	2.21
	$t_{I_s,3}$	0.5098	1.78	0.6788	4.02	0.4302	3.51	1.2695	6.84
	$t_{I_s,4}$	1.2436	4.34	1.4735	8.68	1.2988	10.15	2.0399	9.72
	$t_{I_s,5}$	2.1221	7.20	2.4754	13.77	2.2659	16.15	2.8938	11.60
	$t_{I_s,6}$	3.1273	9.95	3.8838	17.54	3.4159	20.15	4.0424	12.39
	ATTITUDE TOWARDS INFORMATION TECHNOLOGY			WORK	VACATION		VFR		OTHER
					est	t-rat	est	t-rat	
	female				0.1741	2.63			
	aged between 45 and 54				-0.2133	-2.65	-0.1977	-1.42	
γ_l	aged between 55 and 64				-0.5013	-5.18	-0.4943	-3.73	
	aged 65 and over				-0.8184	-7.41	-0.8722	-5.09	
	not a graduate				-0.0956	-1.32			
	not employed				-0.1308	-1.72			
	$\tau_{j,l}$	impact on utility of car			-0.5772	-2.12	-1.2915	-6.74	
		impact on utility of air					2.1968	9.15	
		$\zeta_{l,s}$			1.3723	11.70	1.0909	7.85	
"It would be important to me to receive e-mail or text message updates about my bus or train trip"	$t_{I_s,1}$				-4.9150	-23.08	-4.3277	-14.93	
	$t_{I_s,2}$				-3.7676	-21.39	-3.3221	-13.66	
	$t_{I_s,3}$				-3.2105	-19.94	-2.8478	-13.17	
	$t_{I_s,4}$				-1.8515	-14.02	-1.5464	-8.79	
	$t_{I_s,5}$				-0.3459	-3.09	-0.2304	-1.50	
	$t_{I_s,6}$				1.6264	13.24	1.5908	9.93	
		$\zeta_{l,s}$			1.3627	12.48	1.3074	8.91	
"Being able to freely perform tasks, including using a laptop, tablet, or smartphone is important to me"	$t_{I_s,1}$				-5.2905	-23.71	-5.5909	-12.86	
	$t_{I_s,2}$				-3.9949	-21.85	-4.0694	-13.36	
	$t_{I_s,3}$				-3.2259	-19.88	-3.0776	-11.87	
	$t_{I_s,4}$				-1.8991	-14.29	-1.7347	-8.22	
	$t_{I_s,5}$				-0.5586	-4.88	-0.5008	-2.80	
	$t_{I_s,6}$				1.3549	11.65	1.2747	7.22	
ATTITUDE TOWARD URBANISM			WORK	VACATION		VFR		OTHER	
							est	t-rat	

Technical Appendix: ICLV/Hybrid Choice Model Development

γ_l	female							0.3617	3.26
	not a graduate							-0.2253	-2.06
$\tau_{j,l}$	impact on utility of air							1.2629	4.83
	impact on utility of rail							0.5292	2.99
"I enjoy being out and about and observing people"	$\zeta_{l,s}$							1.1813	8.48
	$t_{I_s,1}$							-5.0410	-13.48
	$t_{I_s,2}$							-4.1311	-15.44
	$t_{I_s,3}$							-3.1033	-14.95
	$t_{I_s,4}$							-2.0236	-12.96
	$t_{I_s,5}$							-0.4778	-3.83
	$t_{I_s,6}$							1.5659	11.01
"I like to live in a neighborhood where I can walk to a commercial or village center"	$\zeta_{l,s}$							0.9229	7.45
	$t_{I_s,1}$							-3.8221	-15.60
	$t_{I_s,2}$							-2.8778	-15.58
	$t_{I_s,3}$							-2.0316	-13.82
	$t_{I_s,4}$							-1.2632	-9.88
	$t_{I_s,5}$							-0.0810	-0.74
	$t_{I_s,6}$							1.3224	11.05
"If everyone works together, we could improve the environment and future for the earth"	$\zeta_{l,s}$							1.4226	7.59
	$t_{I_s,1}$							-4.8139	-12.74
	$t_{I_s,2}$							-4.1706	-14.31
	$t_{I_s,3}$							-3.7071	-14.05
	$t_{I_s,4}$							-2.7650	-12.87
	$t_{I_s,5}$							-1.3056	-8.08
	$t_{I_s,6}$							0.6032	4.05
γ_l	ATTITUDE TOWARDS PRIVACY								
		WORK			VACATION		VFR		OTHER
		est	t-rat	est	t-rat	est	t-rat	est	t-rat
	female							0.2065	1.86
	aged between 55 and 64	0.2962	2.62	0.1913	2.20			0.2462	1.49
	aged 65 and over	0.5004	3.19	0.4041	4.00	0.3524	4.60	0.5450	3.50
	not a graduate	-0.5850	-4.36	-0.3099	-4.40	-0.1688	-2.53		

Technical Appendix: ICLV/Hybrid Choice Model Development

	not employed			-0.0865	-1.10	-0.1947	-2.91	-0.4732	-3.60
$\tau_{j,l}$	impact on utility of car			-1.1976	-6.25	-0.7277	-4.73	-1.6770	-6.45
	impact on utility of air			-1.0411	-4.89	-0.5819	-2.65	-2.5531	-7.65
	impact on utility of rail	1.4259	7.33					-0.5487	-2.14
“The idea of being on a train or a bus with people I do not know is uncomfortable”	$\zeta_{l,s}$	-1.4550	-7.93	-1.7859	-14.49	-1.7989	-15.61	-1.6129	-8.51
	$t_{l,s,1}$	-2.2301	-12.06	-2.7850	-18.98	-2.4584	-21.02	-2.7330	-10.88
	$t_{l,s,2}$	-0.1512	-1.28	-0.4803	-4.94	-0.1746	-2.24	-0.5418	-2.76
	$t_{l,s,3}$	0.6267	5.29	0.5066	5.02	0.8564	10.30	0.4542	2.36
	$t_{l,s,4}$	1.7855	11.97	1.7337	14.03	2.0993	19.87	1.6867	8.04
	$t_{l,s,5}$	2.9063	14.87	3.0485	19.66	3.4794	24.39	3.1367	12.38
	$t_{l,s,6}$	4.2639	15.24	4.5268	21.51	4.6240	25.56	4.1860	13.49
“I don't mind traveling with people I do not know”	$\zeta_{l,s}$	1.0128	8.13	1.1832	13.65	1.4419	15.93	1.5671	8.32
	$t_{l,s,1}$	-3.5739	-18.10	-3.6891	-24.50	-3.9863	-27.70	-3.9006	-12.29
	$t_{l,s,2}$	-2.5355	-17.32	-2.3661	-22.08	-2.8443	-26.27	-2.6732	-10.86
	$t_{l,s,3}$	-1.5207	-13.28	-1.3536	-15.46	-1.7684	-20.36	-1.5305	-7.53
	$t_{l,s,4}$	-0.5239	-5.48	-0.2703	-3.65	-0.6019	-8.55	-0.2730	-1.50
	$t_{l,s,5}$	0.4945	5.23	0.8456	11.27	0.6204	8.93	1.0450	5.46
	$t_{l,s,6}$	2.4524	16.64	2.9431	25.26	2.8805	26.80	3.2882	12.50
“The thought of sharing a car with others for such a trip seems unpleasant to me”	$\zeta_{l,s}$	-0.5084	-5.49	-0.6565	-9.51	-0.6797	-10.95	-0.5455	-4.56
	$t_{l,s,1}$	-2.6219	-20.85	-2.5018	-28.28	-2.4289	-32.24	-2.3753	-15.92
	$t_{l,s,2}$	-1.2451	-15.02	-1.1030	-18.16	-1.0356	-20.53	-0.8579	-8.49
	$t_{l,s,3}$	-0.5286	-7.13	-0.3937	-7.03	-0.3023	-6.47	-0.2227	-2.32
	$t_{l,s,4}$	0.3628	4.93	0.4967	8.76	0.6163	12.76	0.7708	7.99
	$t_{l,s,5}$	1.2602	14.81	1.3513	20.62	1.5306	26.78	1.6225	14.54
	$t_{l,s,6}$	2.6287	21.14	2.6230	28.08	2.8671	33.24	3.0780	17.28

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TABLE 4 Different Sources of Random Heterogeneity in Mode Constants (Share of Variance)

		WORK	VACATION	VFR	OTHER
car	pure random variation	0.80	0.76	0.45	0.41
	car attitude	0.20	0.09	0.47	0.28
	information technology attitude			0.03	0.12
	privacy attitude		0.15	0.05	0.19
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air	pure random variation	0.91	0.81	0.77	0.14
	car attitude	0.09		0.18	
	information technology attitude				0.32
	urbanism				0.11
	privacy attitude		0.19	0.05	0.43
<hr/>					
rail	pure random variation	0.56	1.00	0.63	0.82
	car attitude			0.37	
	urbanism				0.09
	privacy attitude	0.44			0.09

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TABLE 5 Comparison of Direct and Indirect Impact of Socio-Demographics (Impacts of Socio-Demographics on Modal Constants)

		WORK		VACATION		VFR		OTHER	
		direct	through LV	direct	through LV	direct	through LV	direct	through LV
CAR	female	-0.78			-0.21	-0.35	-0.25	-1.41	-0.07
	aged under 35		0.72	-0.85	0.22				1.89
	age between 45 and 54		-0.57		-0.39		-0.97		-0.26
	aged between 55 and 64		-0.75		-0.33		-1.91		-0.23
	aged 65 and over		-0.82		-0.28		-2.12		-0.80
	no graduate degree		-0.35		-0.37	-1.61	-0.48	-1.03	-0.71
	not in employment	-0.91			-0.10		0.21		-0.79
AIR	female	-0.78		1.36		-0.35	-0.18	-1.41	0.98
	aged under 35		0.25	-0.85					
	age between 45 and 54		-0.20				-0.43		-0.43
	aged between 55 and 64		-0.26		0.20	-0.58	-0.83		-0.46
	aged 65 and over		-0.28		0.42	-0.90	-0.77		-0.52
	no graduate degree		-0.12		-0.32	-0.58	-0.25	-1.03	-0.28
	not in employment	-0.91			-0.09		0.10	-1.27	-1.21
RAIL	female	-0.78		0.14		-0.35	-0.12	-1.41	0.30
	aged under 35			-0.85					
	age between 45 and 54						-0.30		
	aged between 55 and 64		0.42				-0.57		0.14
	aged 65 and over		0.71				-0.68		0.30
	no graduate degree		-0.83			-1.61	-0.11	-1.03	-0.12
	not in employment	-0.91					0.15		-0.26

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TABLE 6 How Demographics affect the share of Rail Trips in the Model

% change in rail trips	Anti-car	Pro	Pro Urbanism	Less concerned privacy	All at once
		Technology			
Shift female to male attitude	2.30%	-0.41%	-0.30%	-0.40%	1.20%
Shift male to female attitude	-1.80%	0.30%	0.20%	0.40%	-1.00%
Shift age groups to under 35 attitude	17.95%	2.50%	0.00%	-3.40%	16.40%
Shift under 35 to 35-44 attitude	-1.70%	0.00%	0.00%	0.00%	-1.70%
Shift age groups to over 65 attitude	-11.90%	-3.40%	0.00%	10.40%	-5.70%
Shift no college to college attitude	1.20%	0.10%	0.10%	2.70%	4.20%
Shift college to no college attitude	-3.60%	-0.30%	-0.20%	-7.50%	-11.40%
Shift no job to employed attitude	-0.60%	0.20%	0.00%	1.30%	0.90%
Shift employed to no job attitude	1.20%	-0.40%	0.00%	-2.50%	-1.70%

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Technical Appendix: The Scenario Analysis Tool

TECHNICAL APPENDIX: MODEL APPLICATION FOR SCENARIO ANALYSIS

This technical appendix to *NCRRP Report 4* now presents the full description of the scenario testing tool, which takes the form of a Workbook of spreadsheets in Microsoft® Excel format. Chapter Six presented a shortened, edited version of this full description of the scenario testing tool.

1. Introduction

The mode choice models with latent attitudinal variables, described in Technical Appendix: Documentation for the Structural Equation Models, have been implemented in an Excel workbook in order to provide results for user-defined scenario changes. The implementation uses the *sample enumeration* method. Under this method, the appropriate model parameters are applied for each member of a sample of individual travelers, and the predicted mode shares are expanded and added across the sample to arrive at a total predicted number of trips made using each mode alternative for each travel segment (trip purpose). The resulting predictions can then be compared against a base scenario to determine the change in mode usage that is expected due to the change in the scenario inputs.

2. Excel workbook contents

The Excel workbook will be accessible to the public on the TRB website in June 2016 (by searching for “NCRRP Web-Only Document 2”). It contains the following worksheets:

Scenario: This is the only sheet that most users interact with. It has cells to define scenario changes, and tables to view the scenario results. This sheet is described in much more detail later in this Appendix.

TripData: This sheet contains the reported data for the 5,626 survey respondents for this project who completed the mode choice SP exercise. The data fields in the worksheet for each respondent are:

- Hhsize: number of persons in the respondent’s household
- Hhadults: number of adults age 18+ in the household
- Hhkids: number of children under age 18 in the household
- Hhworkers: number of employed persons in the household
- Hhlic: number of licensed drivers in the household
- Hhveh: number of vehicles owned by the household
- Income: household income category
- Age: respondent age group
- Gender: respondent gender
- Education: highest education level completed
- Employ: current employment status
- ODpair: origin-destination city pair for respondents actual reference trip
- Purpose: main destination purpose for actual reference trip
- Triplength: nights away from home category for actual reference trip

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- Psize: travel party size for actual reference trip, including the respondent
- Mode: the mode used for the actual reference trip (car, bus, rail or air)

All other variables on the sheet are variables used directly in the models that are derived from the variables above. (For example, a “female” 0/1 variable derived from the Gender variable)

Los_data_base: For each of the 5,626 respondents, this page has the average mode time and cost variable levels across the SP scenarios seen in the survey. The data fields for each respondent are:

- Carparkandrent: Car parking and rental cost, if applicable, in dollars
- cargascost: Car fuel cost, in dollars
- carpartycost: Car total cost for the travel party, in dollars
- busaccdur: Bus access time to the station, in minutes
- busdur: Bus in-vehicle travel time, in minutes
- busegrdur: Bus egress time to the destination, in minutes
- busppcost: Bus fare per person, in dollars
- railaccdur: Rail access time to the station, in minutes
- rairdur: Rail in-vehicle travel time, in minutes
- railgrdur: Rail egress time to the destination, in minutes
- railppcost: Rail fare per person, in dollars
- airaccdur: Air access time to the airport, in minutes
- airdur: Air in-vehicle travel time, in minutes
- airegrdur: Air egress time to the destination, in minutes
- airppcost: Air fare per person, in dollars
- airfreqserv: Air origin-destination frequency of service, in departures per day
- railfreqserv: Rail origin-destination frequency of service, in departures per day
- busfreqserv: Bus origin-destination frequency of service, in departures per day
- cbc_carmiles: The distance by car from the origin to the destination, in miles

Because the SP experiment levels were customized based on the respondents’ reported trip origins and destinations, they provide a realistic distribution near current service levels. In the future it would be possible to replace the OD-specific levels for fares, in-vehicle times, and service frequencies with values representing specific future operating scenarios. (The access and egress times would be more difficult to specify precisely, as they depend on the exact trip end locations.) However, the focus of the scenarios is on indicative results rather than precise forecasts, so using exact times and costs in the scenarios is not seen as a high priority.

Randuniform: This worksheet has 10 randomly generated uniformly distributed numbers in the range 0.0 to 1.0 for each person in the sample. The numbers were generated using Excel functions.

Rand_normal: This worksheet has 10 randomly generated normally distributed numbers for each person in the sample, generated with mean 0 and standard deviation of 1.0. The numbers were generated using Excel functions

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Coeffs: This worksheet has all model coefficients for each person in the sample. These were copied from the “original coefficient table” sheet, using the coefficients corresponding to each person’s reference trip purpose. Since the coefficients do not change across scenarios, they are pre-copied rather than specified using look-up functions in order to speed up the scenario calculations.

Los_data_scenario: This sheet calculates the scenario-specific time and cost values, based on the input data in the **Los_base_data** sheet and any scenario user inputs that change travel times or costs.

Attitudes: This sheet contains the calculations that determine the 4 latent attitudinal variables for each person in the sample, based on the input data sheets and the user’s scenario input changes.

Mode choice: This is the most calculation-intensive sheet in the workbook. It contains the calculation of the utility functions for the 4 travel modes, and the calculation of the resulting logit model probabilities. It then converts those into a numbers of trips for each mode. It also uses scenario inputs for demographic changes to calculate adjusted expansion factors.

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3. Sample expansion and initial model calibration

Because we are using only a partial sample of trips in the Northeast and Cascade Corridors, it was useful to first check the numbers of trips by mode and corridor against similar numbers from other corridors. Two sources were used: the Northeast Corridor Intercity Travel Summary Report (RSG 2015a), which has estimates of annual trips by mode and city pair in the NE Corridor; and the output from the rJourney national long-distance passenger travel demand model (RSG 2015b), which has synthetic estimates of annual trips by mode, trip purpose and city pair in both the NE and Cascade Corridors. Because these two sources use different definitions of geographic areas, and because the SP survey used fairly vague city area definitions, the numbers are not exactly comparable between any of the estimates. The purpose of the scenarios is not to provide precise forecasts, but to begin with a reasonable representation of the current traveling population, so an approximate overall sample expansion was deemed acceptable.

Using an expansion factor of 6,000 annual trips per survey respondent gave a reasonable match against “observed” trips in total and by trip purpose. Compared to the observed data, the initial mode share was skewed a bit toward bus and away from rail, so slight changes were made to the mode constants in the models to better match the data.

The resulting initial expanded trips for the “base scenario” (no user-supplied changes) are shown in Table 1. Note that the overall rail and bus mode shares are near 14%, which is higher than for the NE Corridor in total because our sample and the resulting models focus on trips with both ends near the major cities (Boston, New York, Philadelphia, Washington), while the entire corridor also contains areas that are relatively distant from those city centers and thus tend to be more car-oriented.

Table 1: Base Scenario Total Trips by Purpose and Mode

RESULTS		BASE SCENARIO				
Predicted trips (1000/year)		Business	Vacation	Visit	Other	Total
Car		6,114	19,891	19,765	7,641	53,411
Bus		1,812	6,130	2,900	697	11,539
Rail		3,290	4,260	3,551	1,189	12,290
Air		1,887	2,341	2,213	517	6,958
Total		13,104	32,622	28,428	10,044	84,198
Mode share		Business	Vacation	Visit	Other	Total
Car		46.7%	61.0%	69.5%	76.1%	63.4%
Bus		13.8%	18.8%	10.2%	6.9%	13.7%
Rail		25.1%	13.1%	12.5%	11.8%	14.6%
Air		14.4%	7.2%	7.8%	5.2%	8.3%

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4. Changing the demographic distributions

One way that the user can define future scenarios is to adjust the population distribution by gender, age group, education level, employment status and/or income level. Table 2 shows the base scenario distributions that result from the expanded sample of respondents.

The user can change the percentages in any of the green shaded rows, and the percentage in the “base” category (white unshaded row) automatically adjusts to maintain the total at 100%. In the model calculations, the expansion factor for each respondent are adjusted using the new scenario percentage divided by the base scenario percentage along for the relevant category for each demographic variable. (For example, if the gender balance for Business trips were adjusted to be 50%/50%, then the expansion factors for Business trips made by females would be multiplied by $0.500/0.411$, while the expansion factors for Business trips made by males would be multiplied by $0.500/0.589$.)

Table 3 shows the resulting changes in rail trips for five different scenario changing the demographic distribution of the traveling population: (1) a shift towards more females, (2) a shift towards more senior citizens, (3) a shift towards fewer non-college graduates, (4) a shift toward fewer non-employed adults, and (5) a shift towards the extremes of the income range and away from the center. The shifts are all fairly modest, at 10% of the initial population share, and the resulting changes in rail trips in Table 3 are also modest, all below 1.5% change in total trips. (The scenarios assume no changes in attitudes within each demographic category.)

Table 2: Base Scenario Demographic Distributions

Demographics	BASE SCENARIO			
	Business	Vacation	Visit	Other
GENDER				
Female	41.1%	57.1%	55.4%	56.4%
Male (base, do not edit)	58.9%	42.9%	44.6%	43.6%
Total	100.0%	100.0%	100.0%	100.0%
AGE				
Under 35	20.7%	24.1%	21.3%	12.6%
35-44 (base, do not edit)	22.0%	19.9%	16.4%	12.9%
45-54	24.0%	18.5%	17.2%	24.7%
55-64	21.7%	18.8%	21.7%	20.8%
65 and older	11.6%	18.7%	23.4%	29.0%
Total	100.0%	100.0%	100.0%	100.0%
EDUCATION				
Not a college graduate	22.8%	33.9%	28.1%	35.8%
College graduate (base, do not edit)	77.2%	66.1%	71.9%	64.2%
Total	100.0%	100.0%	100.0%	100.0%
EMPLOYMENT				
Not employed	14.5%	32.0%	34.2%	41.9%
Employed (base, do not edit)	85.5%	68.0%	65.8%	58.1%
Total	100.0%	100.0%	100.0%	100.0%
INCOME				
	Business	Vacation	Visit	Other

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Under \$25,000	5.6%	6.3%	6.9%	8.9%
\$25,000 to \$49,999	10.4%	15.3%	14.0%	12.9%
\$50,000 to \$74,999	12.3%	16.9%	16.2%	15.3%
\$75,000 to \$99,999	19.0%	20.5%	20.5%	21.3%
\$100,000 to \$149,999 (base, no ed)	23.7%	24.3%	22.3%	21.6%
\$150,000 to \$199,999	12.7%	9.0%	9.3%	10.3%
\$200,000 and up	16.3%	7.7%	10.8%	9.7%
Total	100.0%	100.0%	100.0%	100.0%

Table 3: Change in rail trips by purpose for selected changes in demographic distributions

	Business	Vacation	Visit	Other	Total
Female share up 10%, male share down to compensate	-0.6%	-1.2%	-0.5%	-2.2%	-0.9%
Age over 65 share up 10%, under 35% down 5%	-0.1%	1.1%	-0.1%	-0.9%	0.1%
Not college grad share down 10%, college grad share up to compensate	1.4%	1.0%	1.5%	1.9%	1.4%
Not employed share down 10%, employed share up to compensate	0.4%	-0.6%	0.5%	1.5%	0.3%
Income shares below 50k up 10%, income shares above 150k up 10%, incomes 50-100 k down 10%	-0.4%	-0.5%	0.4%	0.7%	-0.1%

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5. Changing the mode travel times and costs

Table 4 shows how the user can adjust the travel times or costs for specific scenarios. The changes are quite general and are applied in the same percentage to each person in the sample (with the exception of cost changes, which can be specified separately for business trips and non-business trips to represent changes in business or economy fares separately). The base scenario values are given an index of 100, so entering a value of 110 would increase the value by 10% for every person, while entering a value of 90 would decrease the value by 10% for every person.

Tests were done increasing each of the values in Table 2 by 10% (entering an index of 110, one cell at a time). The largest influence was seen when increasing the rail non-business fare by 10% with a change in number of trips of -8.2% (a direct fare elasticity of -0.82). The second largest change is when increasing rail in-vehicle time, with a direct travel time elasticity of -0.64. The cross-mode effect for a 10% increase in car in-vehicle time is the third largest with an increase of 5.5% in rail trips (a cross-elasticity of 0.55). In general, the cross-elasticities for changes in car times and costs are larger than for the other modes because of the larger base shares for car.

Table 4: User input for changes in travel times or costs

Time and Cost Indices (Base=100)	Car	Bus	Rail	Air
Main mode travel time	100	100	100	100
Access travel time		100	100	100
Egress travel time		100	100	100
Service frequency		100	100	100
Business trip cost	100	100	100	100
Non-business trip cost	100	100	100	100

Table 5: Change in total rail trips when increasing each time and cost variable by 10%

	Car	Bus	Rail	Air
Main mode travel time	5.5%	2.7%	-6.4%	0.3%
Access travel time		0.5%	-2.8%	0.8%
Egress travel time		0.3%	-1.4%	0.4%
Service frequency		-0.4%	0.0%	-0.2%
Business trip cost	0.7%	0.2%	-2.0%	0.4%
Non-business trip cost	3.1%	0.8%	-8.2%	1.7%

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6. Changing the attitudinal variables

The spreadsheet also allows the user to simulate predefined shifts in the four latent attitudinal variables, where one or more groups defined by age, gender, education and/or employment status take on the attitudes of another group along that demographic dimension. Such a shift is simulated by entering a value greater than 0 in the cell for any of the four attitudes, as shown in Table 6.

Table 6: User input for specific pre-defined shifts in attitudes

	Car-oriented	Technology	Urbanism	Privacy
Shift all ages to under 35 attitude	0	0	0	0
Shift under 35 to 35-44 attitude	0	0	0	0
Shift all ages to over 65 attitude	0	0	0	0
Shift all ages one group younger	0	0	0	0
Shift female to male attitude	0	0	0	0
Shift male to female attitude	0	0	0	0
Shift no college to college attitude	0	0	0	0
Shift college to no college attitude	0	0	0	0
Shift no job to employed attitude	0	0	0	0
Shift employed to no job attitude	0	0	0	0

Table 7: Change in total rail trips when shifting attitudes, on at a time and all at once

	Car-oriented	Technology	Urbanism	Privacy	All at once
Shift all ages to under 35 attitude	17.9%	2.5%	0.0%	-3.4%	16.4%
Shift under 35 to 35-44 attitude	-1.7%	0.0%	0.0%	0.0%	-1.7%
Shift all ages to over 65 attitude	-11.9%	-3.4%	0.0%	10.4%	-5.7%
Shift all ages one group younger	6.1%	1.4%	0.0%	-2.5%	4.9%
Shift female to male attitude	2.3%	-0.4%	-0.3%	-0.4%	1.2%
Shift male to female attitude	-1.8%	0.3%	0.2%	0.4%	-1.0%
Shift no college to college attitude	1.2%	0.1%	0.1%	2.7%	4.2%
Shift college to no college attitude	-3.6%	-0.3%	-0.2%	-7.5%	-11.4%
Shift no job to employed attitude	-0.6%	0.2%	0.0%	1.3%	0.9%
Shift employed to no job attitude	1.2%	-0.4%	0.0%	-2.5%	-1.7%

The results of the attitudinal change for each the cells above, in terms of total rail trips, are shown in Table 7. The final column also shows the result if all four attitudinal variables are shifted at once. The age variables tend to have the largest effect. If all age groups were to adopt the current attitudes of the “Millennials” (under 35), then rail trips would increase by 16%, with the largest effect from a shift away from the “car-oriented” attitude, plus a positive effect from the technology aspect of being able to use devices in the train, but an offsetting negative effect from the relative lack of privacy in the train. On the other hand, if all age groups were to adopt the attitudinal tendencies of the current age 65+ group, rail

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trips would decrease by almost 6%, due to opposite offsetting effects as described for the shift to “younger” attitudes. The most realistic future trend in attitudes by age may be the “shift all ages one group younger”. This would be the situation 10-15 years from now if attitudes for any given person stay the same and go together with the age cohorts, rather than changing with age. The result for that test is a 5% increase in total rail trips.

Other than age, the largest effect would be if all persons adopted the “no college education” attitude, regardless of education level. This would result in an 11% decrease in rail trips, but seems like a very unlikely scenario.

7. Four illustrative scenarios

Finally, combinations of the attitudinal shifts above were run to represent four possible future scenarios. Only the trends with age are varied – the attitudinal differences related to gender, education and employment are assumed not to change in these scenarios. The most optimistic scenario for rail is that people will keep their current attitudes toward auto orientation and technology as they age (“Go with cohort” below) and that the next generation will have the same attitudes as current Millennials, but that all age groups will adopt the current attitudes toward privacy of the current age 65+ group. The most pessimistic scenario for rail is that each age cohort will adopt the attitudes toward auto orientation and technology that the previous cohort had at that age (“Current trend with age” below) that the next Generation Z will not reflect the current Millennials but will reflect the current post-Millennial 35-44 age group, and that the cohorts will keep their same attitudes toward privacy as they age. The “Mixed A” and “Mixed B” have different combinations of those assumptions.

Table 8: Definitions of four scenarios, relative to the Base scenario

Name	1 Pessimistic for Rail	2 Mixed A	3 Mixed B	4 Optimistic for Rail
Change in Values				
Age effects on auto orientation	Current trends with age Gen Z same as current 35-44	Current trends with age Gen Z same as current 35-44	Go with cohort Gen Z same as Millennials	Go with cohort Gen Z same as Millennials
Age effects on technology orientation	Current trend with age	Go with cohort	Current trend with age	Go with cohort
Age effects on privacy attitude	Go with cohort	All adopt Over 65	Go with cohort	All adopt Over 65
Gender, employment, education effects on all attitudes	Current trends	Current trends	Current trends	Current trends

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Table 9: Change in rail trips under the four scenarios, relative to the Base scenario

Name	1 Pessimistic for Rail	2 Mixed A	3 Mixed B	4 Optimistic for Rail
<i>Change in Rail Trips</i>				
Business	-5%	13%	3%	22%
Vacation	-4%	8%	2%	14%
Visit Friends/relatives	-2%	9%	4%	15%
Other	-11%	14%	9%	35%
Total	-4%	10%	4%	18%

The results are that the pessimistic scenario results in a 4% drop in total rail trips, while the optimistic scenario results in an 18% increase. The mixed scenarios result in a 10% and 4% increase in rail trips respectively. The “Other” trip segment, which is the smallest segment, is the most volatile, while the other trip purposes all show fairly similar trends across the scenarios.

References

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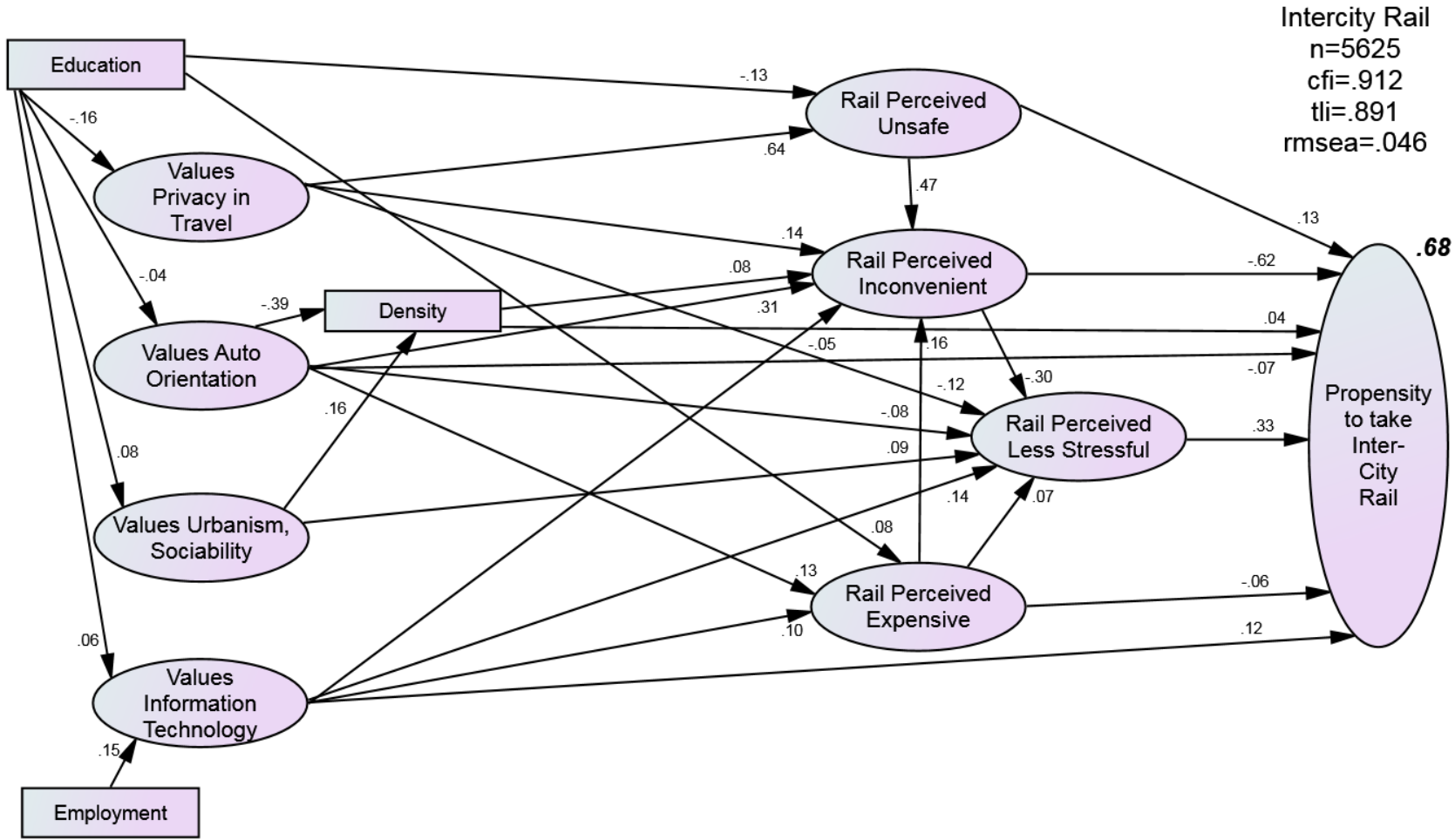
Technical Appendix: Documentation for the Structural Equation Models

TECHNICAL APPENDIX: DOCUMENTATION FOR THE STRUCTURAL EQUATION MODELS

Introduction

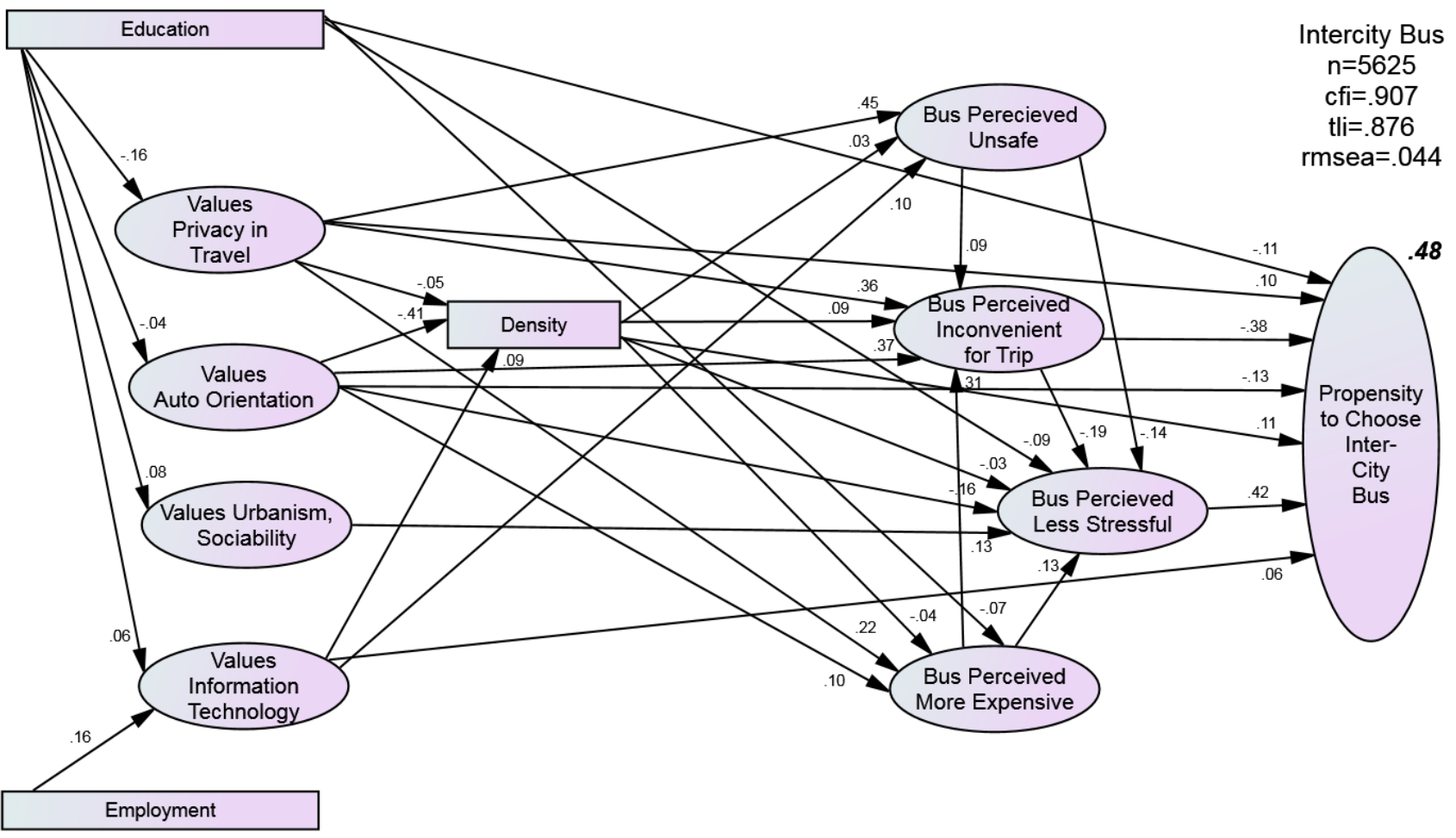
This final technical appendix for *NCRRP Report 4* presents a series of backup documentation to support the three Attitudinal Models (Rail, Bus, and Rural) and the Theory of Planned Behavior Model. First each model is presented here in ‘landscape’ page layout format. Then, tables of data are provided in ‘portrait’ page layout format, providing the backup data for the full sample for the three Attitudinal Models, and a full sample, Millennials Only, and Older Groups only for the Theory of Planned Behavior Models.

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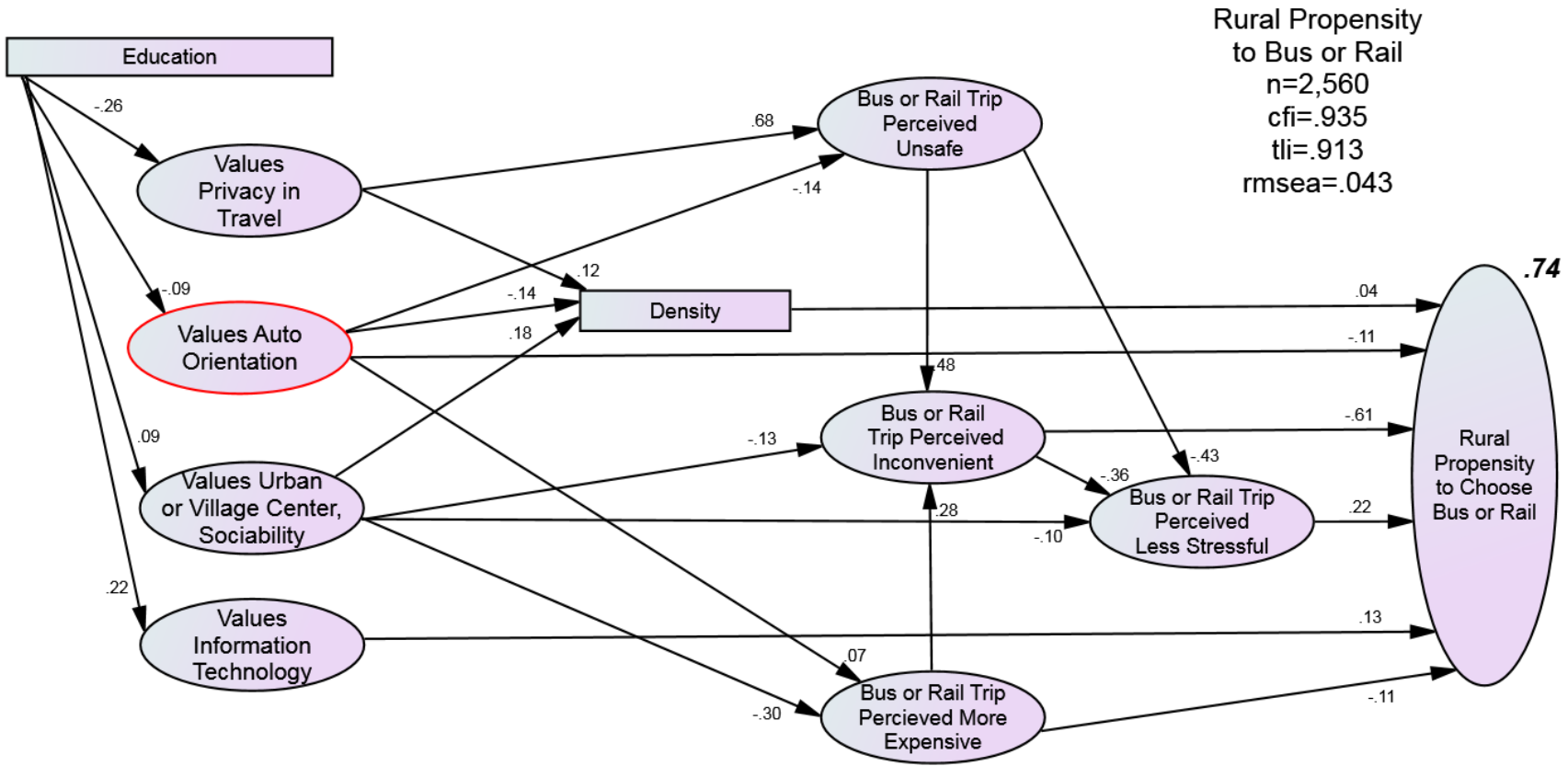


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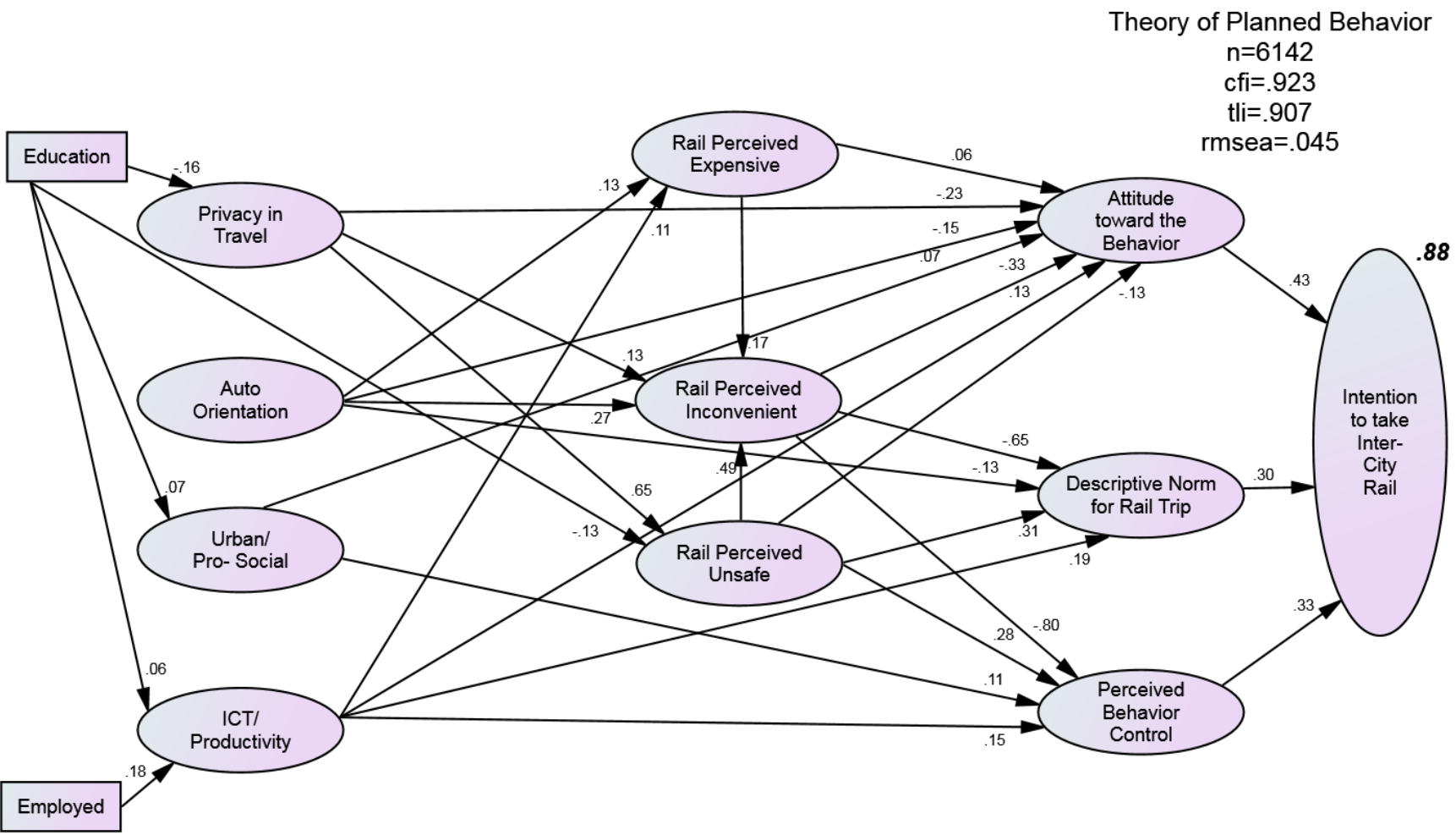
Technical Appendix: Documentation for the Structural Equation Models



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The Rail Model							
			Estimate	S.E.	C.R.	P	St. Estimate
Privacy	<---	Education	-0.347	0.033	-10.452	***	-0.158
ICT	<---	Education	0.1	0.026	3.769	***	0.062
Auto Orientation	<---	Education	-0.052	0.021	-2.454	0.014	-0.039
Urbanism	<---	Education	0.103	0.021	4.909	***	0.085
Unsafe	<---	Education	-0.272	0.026	-10.471	***	-0.131
Expensive	<---	Education	0.184	0.034	5.407	***	0.078
ICT	<---	Employment	0.14	0.015	9.279	***	0.151
Paramters between Latent Factors							
Unsafe	<---	Privacy	0.608	0.021	28.642	***	0.643
Inconvenience	<---	Privacy	0.083	0.015	5.697	***	0.144
Stressful	<---	Privacy	-0.129	0.023	-5.547	***	-0.123
Expensive	<---	Auto Orientation	0.236	0.031	7.569	***	0.133
Density	<---	Auto Orientation	-0.268	0.012	-21.65	***	-0.393
Inconvenience	<---	Auto Orientation	0.295	0.022	13.192	***	0.312
Stressful	<---	Auto Orientation	-0.145	0.033	-4.43	***	-0.084
RailPropensity	<---	Auto Orientation	-0.13	0.042	-3.135	0.002	-0.074
Density	<---	Urbanism	0.123	0.013	9.804	***	0.164
Stressful	<---	Urbanism	0.179	0.041	4.315	***	0.094
Inconvenience	<---	ICT	-0.041	0.015	-2.816	0.005	-0.052
Stressful	<---	ICT	0.201	0.029	6.92	***	0.139
Expensive	<---	ICT	0.143	0.026	5.387	***	0.096
RailPropensity	<---	ICT	0.181	0.026	6.891	***	0.123
Inconvenience	<---	Density	0.116	0.024	4.815	***	0.083
RailPropensity	<---	Density	0.102	0.042	2.426	0.015	0.039
Inconvenience	<---	Expensive	0.084	0.009	9.289	***	0.156
RailPropensity	<---	Expensive	-0.064	0.016	-3.897	***	-0.064
Inconvenience	<---	Unsafe	0.288	0.016	17.773	***	0.474
RailPropensity	<---	Unsafe	0.144	0.03	4.863	***	0.127
Stressful	<---	Inconvenience	-0.546	0.047	-11.627	***	-0.3
RailPropensity	<---	Inconvenience	-1.165	0.074	-15.785	***	-0.625
Stressful	<---	Expensive	0.071	0.015	4.645	***	0.073
RailPropensity	<---	Stressful	0.343	0.019	18.223	***	0.334
Loadings from Factor to Observed Variable							
how likely	<---	RailPropensity	1				0.732
would consider	<---	RailPropensity	0.88	0.015	57.291	***	0.704
railtaken	<---	RailPropensity	0.098	0.003	29.497	***	0.473
rail from sp study	<---	RailPropensity	0.866	0.024	36.49	***	0.636
with people I do not know	<---	Privacy	-0.604	0.021	-29.476	***	-0.527
uncomfortable with strangers	<---	Privacy	1				0.858
freedom and indpedence	<---	Auto Orientation	1				0.579
less dependent than parents	<---	Auto Orientation	-1.284	0.045	-28.598	***	-0.58
prefer to share or borrow car	<---	Auto Orientation	-1.402	0.047	-29.845	***	-0.693
walk to town center	<---	Urbanism	1.273	0.053	23.813	***	0.636
enjoy observing people	<---	Urbanism	1				0.602
together could improve	<---	Urbanism	0.17	0.008	21.115	***	0.423
perform tasks, laptop	<---	ICT	1				0.709
to receive emails	<---	ICT	0.909	0.038	23.978	***	0.626
own smartphone or tablet	<---	ICT	0.256	0.013	19.991	***	0.376
unsafe by train	<---	Unsafe	0.963	0.017	58.079	***	0.867
crime unruly behavior	<---	Unsafe	1				0.827
personal safety	<---	Unsafe	0.831	0.018	45.258	***	0.684
need car at destination	<---	Inconvenience	1.54	0.056	27.311	***	0.599
difficult from destination	<---	Inconvenience	1.565	0.053	29.625	***	0.694
flexibility of schedules	<---	Inconvenience	1				0.523
perceived expensive	<---	Expensive	1				0.921
less stressful	<---	Stressful	1.12				0.918

Technical Appendix: Documentation for the Structural Equation Models

The Bus Model							
			Estimate	S.E.	C.R.	P	St. Estimate
Demographic							
Privacy	<---	Education	-0.351	0.033	-10.692	***	-0.162
ICT	<---	Education	0.098	0.026	3.709	***	0.062
Auto Orientation	<---	Education	-0.058	0.023	-2.576	0.01	-0.041
Expensive	<---	Education	-0.187	0.037	-5.083	***	-0.072
Urbanism	<---	Education	0.104	0.022	4.818	***	0.084
Auto OrientationStress	<---	Education	-0.214	0.034	-6.231	***	-0.087
BusPropensity	<---	Education	-0.055	0.007	-8.076	***	-0.113
ICT	<---	Employment	0.143	0.015	9.472	***	0.155
Paramters between Latent Factors							
Density	<---	Privacy	-0.02	0.006	-3.121	0.002	-0.047
Unsafe	<---	Privacy	0.506	0.023	21.829	***	0.449
Inconvenience	<---	Privacy	0.185	0.015	12.444	***	0.359
Expensive	<---	Privacy	0.264	0.021	12.402	***	0.219
BusPropensity	<---	Privacy	0.023	0.005	4.409	***	0.104
Density	<---	AutoOrientation	-0.259	0.012	-21.406	***	-0.409
Expensive	<---	AutoOrientation	0.183	0.035	5.239	***	0.101
Inconvenience	<---	AutoOrientation	0.285	0.021	13.362	***	0.367
Stress	<---	AutoOrientation	-0.278	0.04	-6.872	***	-0.163
BusPropensity	<---	AutoOrientation	-0.043	0.008	-5.173	***	-0.127
Stress	<---	Urbanism	0.26	0.037	7.026	***	0.132
Density	<---	ICT	0.053	0.009	6.005	***	0.093
Unsafe	<---	ICT	0.153	0.025	6.009	***	0.1
BusPropensity	<---	ICT	0.019	0.005	3.687	***	0.062
Unsafe	<---	Density	0.088	0.037	2.411	0.016	0.033
Expensive	<---	Density	-0.124	0.046	-2.7	0.007	-0.043
BusPropensity	<---	Density	0.057	0.009	6.428	***	0.107
Inconvenience	<---	Density	0.116	0.024	4.945	***	0.095
Stress	<---	Density	-0.093	0.044	-2.126	0.034	-0.035
Inconvenience	<---	Unsafe	0.041	0.01	4.028	***	0.09
Stress	<---	Unsafe	-0.142	0.016	-8.711	***	-0.141
Stress	<---	Inconvenience	-0.422	0.064	-6.581	***	-0.192
BusPropensity	<---	Inconvenience	-0.164	0.014	-11.564	***	-0.377
Inconvenience	<---	Expensive	0.134	0.009	15.318	***	0.312
Stress	<---	Expensive	0.122	0.018	6.795	***	0.129
BusPropensity	<---	Stress	0.083	0.003	24.495	***	0.418
Loadings from Factor to Observed Variable							
Intend to take bus	<---	BusPropensity	1				0.738
Bus taken on last trip	<---	BusPropensity	0.507	0.017	29.669	***	0.554
Bus chosen in SP	<---	BusPropensity	4.615	0.129	35.707	***	0.712
with people I do not know	<---	Privacy	-0.621	0.025	-25.144	***	-0.534
uncomfortable with strangers	<---	Privacy	1				0.843
freedom and indpedence	<---	AutoOrientation	1				0.622
less dependent than parents	<---	AutoOrientation	-1.272	0.043	-29.331	***	-0.618
prefer to share or borrow car	<---	AutoOrientation	-1.248	0.047	-26.659	***	-0.664
perform tasks, laptop	<---	ICT	1				0.705
to receive emails	<---	ICT	0.916	0.04	23.177	***	0.627
own smartphone or tablet	<---	ICT	0.257	0.013	19.699	***	0.375
walk to town center	<---	Urbanism	1.196	0.052	22.93	***	0.607
enjoy observing people	<---	Urbanism	1				0.616
together could improve	<---	Urbanism	0.171	0.008	20.925	***	0.433
personal safety on bus	<---	Unsafe	1				0.925
concerned about bus schedule	<---	Inconvenience	1				0.466
difficult from destination	<---	Inconvenience	1.507	0.067	22.412	***	0.589
need car at destination	<---	Inconvenience	1.741	0.077	22.549	***	0.596
bus perceived expensive	<---	Expensive	1	113			0.934
bus less stressful	<---	Stress	1				0.926

Technical Appendix: Documentation for the Structural Equation Models

TPB Model	The Full sample						
			Estimate	S.E.	C.R.	P	St. Estimate
From Demographics							
Privacy	<---	Education	-0.354	0.032	-11.107	***	-0.161
ICT	<---	Education	0.102	0.025	4.089	***	0.065
Unsafe	<---	Education	-0.276	0.025	-11.041	***	-0.132
Urbanism	<---	Education	0.096	0.021	4.502	***	0.075
ICT	<---	Employed	0.400	0.034	11.789	***	0.185
Direct TPB Predictors							
RailPropensity	<---	Normative	0.344	0.020	17.463	***	0.301
RailPropensity	<---	PBC	0.346	0.026	13.572	***	0.330
RailPropensity	<---	ATB	0.869	0.043	20.048	***	0.429
Parameters between Latent Factors							
Unsafe	<---	Privacy	0.614	0.020	30.652	***	0.645
ATB	<---	Privacy	-0.144	0.014	-10.296	***	-0.235
Inconvenience	<---	Privacy	0.076	0.014	5.488	***	0.127
ATB	<---	Auto Orientation	-0.154	0.017	-9.189	***	-0.149
Inconvenience	<---	Auto Orientation	0.272	0.018	14.840	***	0.271
Normative	<---	Auto Orientation	-0.243	0.034	-7.096	***	-0.132
Expensive	<---	Auto Orientation	0.245	0.031	7.898	***	0.134
ATB	<---	Urbanism	0.076	0.020	3.789	***	0.072
PBC	<---	Urbanism	0.216	0.037	5.815	***	0.106
Normative	<---	ICT	0.290	0.027	10.908	***	0.191
PBC	<---	ICT	0.247	0.030	8.257	***	0.149
ATB	<---	ICT	0.110	0.015	7.123	***	0.129
Expensive	<---	ICT	0.162	0.026	6.252	***	0.107
Inconvenience	<---	Expensive	0.093	0.008	11.582	***	0.169
ATB	<---	Expensive	0.032	0.007	4.549	***	0.057
Normative	<---	Inconvenience	-1.190	0.064	-18.560	***	-0.651
ATB	<---	Inconvenience	-0.339	0.029	-11.502	***	-0.329
PBC	<---	Inconvenience	-1.595	0.066	-24.091	***	-0.800
Inconvenience	<---	Unsafe	0.309	0.016	19.523	***	0.492
PBC	<---	Unsafe	0.348	0.030	11.456	***	0.278
Normative	<---	Unsafe	0.353	0.030	11.927	***	0.308
ATB	<---	Unsafe	-0.086	0.016	-5.385	***	-0.133
Loadings from Factor to Observed Variable							
how likely	<---	RailPropensity	1.000				0.835
would consider	<---	RailPropensity	0.948	0.012	78.366	***	0.860
with people I do not know	<---	Privacy	-0.619	0.019	-31.954	***	-0.536
uncomfortable with strangers	<---	Privacy	1.000				0.852
freedom and independence	<---	Auto Orientation	1.000				0.569
less dependent than parents	<---	Auto Orientation	-1.228	0.044	-28.203	***	-0.541
prefer to share or borrow car	<---	Auto Orientation	-1.515	0.054	-28.192	***	-0.734
less stressful	<---	ATB	1.000				0.528
how pleasant	<---	ATB	1.583	0.040	40.041	***	0.841
people would take	<---	Normative	1.000				0.781
friends workers would take	<---	Normative	0.755	0.017	44.863	***	0.703
perform tasks, laptop	<---	ICT	1.000				0.694
to receive emails	<---	ICT	0.943	0.037	25.572	***	0.637
own smartphone or tablet	<---	ICT	0.265	0.012	21.359	***	0.383
unsafe by train	<---	Unsafe	0.968	0.015	63.503	***	0.871
crime unruly behavior	<---	Unsafe	1.000				0.824
personal safety	<---	Unsafe	0.856	0.017	49.642	***	0.699
walk to town center	<---	Urbanism	1.123	0.047	23.799	***	0.580
enjoy observing people	<---	Urbanism	1.000				0.633
together could improve	<---	Urbanism	0.168	0.008	21.841	***	0.438
need car at destination	<---	Inconvenience	1.388	0.048	28.755	***	0.552
flexibility of schedules	<---	Inconvenience	1.000				0.534
difficult from destination	<---	Inconvenience	1.534	0.047	32.981	***	0.693
how efficient	<---	PBC	1.000				0.852
how possible	<---	PBC	0.556	0.013	44.834	***	0.551
could easily take	<---	PBC	0.743	0.015	50.742	***	0.653
perceived expensive	<---	Expensive	1.000				0.921

Technical Appendix: Documentation for the Structural Equation Models

TPB Model			The Millennials					The Older Groups				
			Estimate	S.E.	C.R.	P	St. Estimate	Estimate	S.E.	C.R.	P	St. Estimate
From Demographics												
Privacy	<---	Education	-0.392	0.076	-5.140	***	-0.166	-0.338	0.035	-9.757	***	-0.158
ICT	<---	Education	0.034	0.054	0.635	n.s	0.024	0.140	0.028	4.983	***	0.088
Unsafe	<---	Education	-0.359	0.057	-6.258	***	-0.167	-0.255	0.028	-9.165	***	-0.123
Urbanism	<---	Education	0.138	0.049	2.800	0.005	0.101	0.085	0.024	3.620	***	0.067
ICT	<---	Employed	-0.045	0.084	-0.529	n.s	-0.019	0.434	0.037	11.676	***	0.205
Direct TPB Predictors												
RailPropensity	<---	Normative	0.229	0.039	5.941	***	0.219	0.372	0.023	16.363	***	0.319
RailPropensity	<---	PBC	0.354	0.063	5.653	***	0.355	0.341	0.028	12.101	***	0.322
RailPropensity	<---	ATB	0.871	0.102	8.519	***	0.479	0.867	0.049	17.838	***	0.419
Parameters between Latent Factors												
Unsafe	<---	Privacy	0.588	0.045	12.939	***	0.646	0.621	0.022	27.874	***	0.641
ATB	<---	Privacy	-0.102	0.030	-3.455	***	-0.181	-0.153	0.016	-9.643	***	-0.241
Inconvenience	<---	Privacy	0.131	0.030	4.353	***	0.251	0.062	0.016	3.921	***	0.100
ATB	<---	Auto Orientation	-0.211	0.037	-5.721	***	-0.204	-0.145	0.019	-7.691	***	-0.140
Inconvenience	<---	Auto Orientation	0.177	0.035	5.010	***	0.184	0.280	0.021	13.292	***	0.277
Normative	<---	Auto Orientation	-0.255	0.069	-3.696	***	-0.142	-0.230	0.039	-5.927	***	-0.125
Expensive	<---	Auto Orientation	0.150	0.072	2.071	0.038	0.076	0.266	0.034	7.721	***	0.148
ATB	<---	Urbanism	0.084	0.045	1.880	0.060	0.086	0.066	0.023	2.889	0.004	0.061
PBC	<---	Urbanism	0.166	0.078	2.113	0.035	0.093	0.228	0.043	5.327	***	0.108
Normative	<---	ICT	0.237	0.065	3.639	***	0.148	0.292	0.029	9.956	***	0.193
PBC	<---	ICT	0.269	0.079	3.381	***	0.159	0.226	0.033	6.928	***	0.136
ATB	<---	ICT	0.153	0.044	3.478	***	0.166	0.107	0.017	6.415	***	0.126
Expensive	<---	ICT	0.177	0.068	2.627	0.009	0.101	0.164	0.028	5.798	***	0.111
Inconvenience	<---	Expensive	0.072	0.015	4.718	***	0.146	0.098	0.009	10.545	***	0.174
ATB	<---	Expensive	0.042	0.015	2.896	0.004	0.080	0.029	0.008	3.538	***	0.050
Normative	<---	Inconvenience	-0.969	0.162	-6.001	***	-0.519	-1.241	0.070	-17.677	***	-0.682
ATB	<---	Inconvenience	-0.325	0.083	-3.907	***	-0.302	-0.357	0.032	-11.223	***	-0.349
PBC	<---	Inconvenience	-1.487	0.176	-8.450	***	-0.758	-1.613	0.072	-22.398	***	-0.807
Inconvenience	<---	Unsafe	0.299	0.034	8.685	***	0.519	0.311	0.018	17.490	***	0.485
PBC	<---	Unsafe	0.424	0.081	5.201	***	0.375	0.315	0.033	9.499	***	0.246
Normative	<---	Unsafe	0.448	0.077	5.826	***	0.417	0.313	0.032	9.706	***	0.268
ATB	<---	Unsafe	-0.023	0.039	-0.592	n.s	-0.037	-0.100	0.018	-5.619	***	-0.152
Loadings from Factor to Observed Variable												
how likely	<---	RailPropensity	1.000				0.787	1.000				0.845
would consider	<---	RailPropensity	0.964	0.031	30.718	***	0.835	0.947	0.013	72.428	***	0.865
with people I do not know	<---	Privacy	-0.534	0.041	-12.985	***	-0.483	-0.658	0.022	-29.623	***	-0.557
uncomfortable with strangers	<---	Privacy	1.000				0.858	1.000				0.847
freedom and independence	<---	Auto Orientation	1.000				0.534	1.000				0.582
less dependent than parents	<---	Auto Orientation	-1.230	0.101	-12.190	***	-0.523	-1.172	0.047	-24.760	***	-0.531
prefer to share or borrow car	<---	Auto Orientation	-1.728	0.147	-11.733	***	-0.758	-1.418	0.056	-25.143	***	-0.716
less stressful	<---	ATB	1.000				0.517	1.000				0.531
how pleasant	<---	ATB	1.632	0.093	17.614	***	0.861	1.571	0.044	36.094	***	0.837
people would take	<---	Normative	1.000				0.774	1.000				0.782
friends workers would take	<---	Normative	0.867	0.042	20.826	***	0.769	0.726	0.018	39.526	***	0.685
perform tasks, laptop	<---	ICT	1.000				0.704	1.000				0.688
to receive emails	<---	ICT	0.939	0.095	9.854	***	0.617	0.948	0.040	23.422	***	0.636
own smartphone or tablet	<---	ICT	0.106	0.022	4.817	***	0.178	0.294	0.015	20.266	***	0.412
unsafe by train	<---	Unsafe	1.014	0.036	28.336	***	0.873	0.949	0.017	56.404	***	0.868
crime unruly behavior	<---	Unsafe	1.000				0.809	1.000				0.828
personal safety	<---	Unsafe	0.871	0.040	21.882	***	0.692	0.845	0.019	44.262	***	0.697
walk to town center	<---	Urbanism	0.965	0.080	12.022	***	0.561	1.176	0.057	20.673	***	0.587
enjoy observing people	<---	Urbanism	1.000				0.667	1.000				0.621
together could improve	<---	Urbanism	0.181	0.016	11.603	***	0.514	0.166	0.009	18.746	***	0.420
need car at destination	<---	Inconvenience	1.401	0.114	12.250	***	0.540	1.391	0.053	26.238	***	0.557
flexibility of schedules	<---	Inconvenience	1.000				0.506	1.000				0.540
difficult from destination	<---	Inconvenience	1.591	0.113	14.131	***	0.697	1.527	0.051	30.010	***	0.693
how efficient	<---	PBC	1.000				0.864	1.000				0.848
how possible	<---	PBC	0.572	0.027	20.876	***	0.601	0.556	0.015	36.664	***	0.542
could easily take	<---	PBC	0.720	0.032	22.481	***	0.641	0.752	0.017	45.500	***	0.657
perceived expensive	<---	Expensive	1.000				0.932	1.000				0.918