EXPLORATORY ADVANCED RESEARCH

Federal Highway Administration

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Behavioral economics and transportation

Identification of published literature between 2012 and 2013, focusing on behavioral economics and transportation safety. Examining the role of behavior in transportation choices, and uncovering those mechanisms, which will "nudge" drivers to making safer choices—cognitive psychology related to transportation, including pay-as-you-drive insurance, finance, mode choice, congestion, and tolling.

TOPIC

CONTENTS

U.S. Department of Transportation
Federal Highway Administration

REFERENCE RESULTS
BEHAVIORAL RESEARCH

A review of game-theoretic models of road user behavior

Author(s): Elvik, Rune[1]
Year: 2014
Source: Accident Analysis and Prevention, vol. 62, pp. 388–396
Publisher: Elsevier
Author affiliation:
[1]Institute of Transport Economics, NO-0349 Oslo, Norway
http://www.scandriaproject.eu/index.php?option=content&id=120

The authors review game-theoretic models that have been developed to explain road user behavior in situations where road users interact with each other. The paper includes the following game-theoretic models: (1) general model of the interaction between road users and their possible reactions to measures improving safety (behavioral adaptation), (2) choice of vehicle size as a prisoners' dilemma game, (3) speed choice as a coordination game, (4) speed compliance as a game between drivers and the police, (5) merging into traffic from an acceleration lane as a mixed-strategy game, (6) choice of level of attention in following situations as an evolutionary game, (7) choice of departure time to avoid congestion as variant of a prisoners' dilemma game, (8) interaction between cyclists crossing the road and car drivers, (9) dipping headlights at night well ahead of the point when glare becomes noticeable, (10) choice of evasive action in a situation when cars are on a collision course. The models reviewed are different in many respects, but a common feature of the models is that they can explain how informal norms of behavior can develop among road users and be sustained even if these informal norms violate the formal regulations of the traffic code. Game-theoretic models are not applicable to every conceivable interaction among road users or to situations in which road users choose behaviors without interacting with other road users. Nevertheless, it is likely that game-theoretic models can be applied more widely than they have been until now.

The Driving Machine: Mobile UX design that combines information design with persuasion design

Author(s): Marcus, Aaron;[1] Abromowitz, Scott[1]
Year: 2013
Source: Design, User Experience, and Usability. User Experience in Novel Technological Environments: Second International Conference, DUXU 2013, Held as Part of HCI International 2013, Las Vegas, NV, USA, July 21–26, 2013, Proceedings, Part III, pp 140–149
Publisher: Springer
Author affiliation:
[1]Aaron Marcus and Associates, Inc., Berkeley, CA 94708, United States, http://www.amanda.com/

Travel and tourism is a booming sector of the 21st century world economy. Vehicles are becoming smarter and are using advanced graphical displays. The Driving Machine seeks to provide an innovative vehicle dashboard that combines information design and persuasion design to change the driver's behavior, promoting safety and fuel efficiency, or sustainability.

Reducing speeding behavior in young drivers using a persuasive mobile application

Author(s): Bergmans, Anne;[1] Shahid, Suleman[2]
Year: 2013
Source: Human-Computer Interaction. Applications and Services: 15th International Conference, HCI International 2013, Las Vegas, NV, USA, July 21–26, 2013, Proceedings, Part II, pp. 541–550
Publisher: Springer
Author affiliation:
[1]Department of Communication and Information Sciences, Tilburg University, 5037 AB Tilburg, Netherlands, http://www.tilburguniversity.edu/about-tilburg-university/schools/humanities/dci/
[2]Tilburg Center for Cognition and Communication, Department of Communication and Information Sciences, Tilburg University, 5037 AB Tilburg, Netherlands, http://www.tilburguniversity.edu/research/institutes-and-research-groups/ticc/

The authors present a solution to the problem of speeding by young male drivers. The authors outline the design of a persuasive mobile application, which aims to reduce speeding behavior by providing various incentives. The application targets both weak- and strong-habit drivers between the ages of 18 and 26 years. Early results show an overall acceptance of the application, mainly due to its unique rewarding mechanism and its ability to demonstrate the actual speeding behavior with major impact on safety, fuel costs, environment, and possible fine costs. Results further indicate a behavior change for weak-habit drivers and attitude change for strong-habit drivers.

Nudging citizens? Prospects and pitfalls confronting a new heuristic

Author(s): Moseley, Alice;[1] Stoker, Gerry[2]
Year: 2013
Source: Resources, Conservation and Recycling, vol. 79, pp. 4–10
Publisher: Elsevier Ltd.
Author affiliation:
[1]Department of Politics, University of Exeter, Devon EX44RJ, United Kingdom http://socialsciences.exeter.ac.uk/politics/contact/
[2]Politics and International Relations, School of Social Sciences, University of Southampton, Southampton SO171BJ, United Kingdom, http://www.southampton.ac.uk/politics

New insights from psychology and behavioral economics have encouraged a paradigm shift in policy debates toward a focus on "nudge" strategies that are influenced by an understanding of the cognitive, social, and even moral factors driving human decision making. In areas such as environmental policy, nudging holds considerable potential as a tool of government to help change citizen and corporate behavior. This article notes the strong evidence base for nudge strategies drawn from the extensive social science literature on how citizens make decisions. It shows, however, that translating behavioral insights into viable policy interventions is far from straightforward and that the powerful insights embedded within nudge heuristics will be lost if advocates of nudge fail to address the complexities and challenges entailed in their respective projects.

Designing large-scale nudge engines

Author(s): Prabhakar, Balaji[1]
Year: 2013
Source: ACM SIGMETRICS Performance Evaluation Review, vol. 41, no. 1, pp. 1–2
Publisher: Association for Computing Machinery
Author affiliation:
[1]Departments of Electrical Engineering and Computer Science, Stanford University, Stanford, CA 94305, United States, http://ee.stanford.edu/

In many of the challenges faced by the modern world, from overcrowded transportation systems to overstretched healthcare systems, significant societal benefits come about from small changes initiated by many individuals. The author surveyed the problems and the costs these challenges impose on society and describes a framework for designing "nudge engines"—algorithms, incentives, and technology for influencing human behavior. The author presents a model for analyzing their effectiveness and the results from transportation pilots conducted in Bangalore, at Stanford University, and in Singapore, as well as a wellness program for the employees of Accenture USA.

Streaming driving behavior data

Author(s): Basalamah, Anas;[1] Ahmad, Muhammad Aurangzeb;[2] Elidrisi, Mohamed;[2] Basalamah, Saleh;[1] Mokbel, Mohamed[1]
Year: 2012
Source: Proceedings of the ACM SIGSPATIAL International Workshop on GeoStreaming, IWGS 2012, pp. 116–119
Publisher: Association for Computing Machinery
Author affiliation:
[1]Department of Computer Engineering, KACST TIC on GeoInformatics, Umm Al-Qura University, Makkah 24382, Saudi Arabia, http://uqu.edu.sa/english#
[2]Department of Computer Science and Engineering, University of Minnesota, Minneapolis, MN 55455, United States, http://www.cs.umn.edu/index.php

People's driving behavior patterns have significant effects on modern transportation systems. Public safety, traffic congestion, and driving convenience are all affected by the driver's behavior on the road. With the recent developments in data communications, streaming and mining technologies, and developing driving behavior monitoring systems that can stream driving behavioral patterns, discovering and predicting traffic violations can be made possible. In this paper, the authors describe their vision towards the realization of such technologies from the viewpoints of data steaming and analysis.

REFERENCE RESULTS
CONGESTION

Road pricing with complications

Author(s): Fosgerau, Mogens;[1, 2] Van Dender, Kurt[3]
Year: 2013
Source: Transportation, vol. 40, no. 3, pp. 479–503
Publisher: Springer
Author affiliation:
[1]Technical University of Denmark, Department of Transport, 2800 Kongens Lyngby, Denmark http://www.transport.dtu.dk/english
[2]Centre for Transport Studies, SE-100 44 Stockholm, Sweden, http://www.kth.se/en/abe/centra/cts
[3]Joint Transport Research Centre of the OECD and the International Transport Forum, F-75755 Paris Cedex 16, France, http://www.internationaltransportforum.org/Home.html

The rationale for congestion charges is that, by internalizing the marginal external congestion cost, they restore efficiency to the transport market. In the canonical model underlying this view, congestion is a static phenomenon, users are taken to be homogenous, there is no travel time risk, and a highly stylized model of congestion is used. The simple analysis also ignores that real pricing schemes are only rough approximations to ideal systems and that inefficiencies in related markets potentially affect the case for congestion charges. The canonical model tends to understate the marginal external congestion cost, because it ignores user heterogeneity and trip-timing inefficiencies. With respect to the relevance of interactions between congestion and congestion charges and tax distortions and distributional concerns, recent insights point out that there is no general case for modifying charges for such interactions. Therefore, the simple Pigouvian rule remains a good first approximation for the design of road-charging systems.

Role of context in equity effects of congestion pricing

Author(s): Franklin, Joel P.[1]
Year: 2012
Source: Transportation Research Record: Journal of the Transportation Research Board, vol. 2297, pp. 29–37
Publisher: Transportation Research Board
Author affiliation:
[1]Department of Transport Science, KTH Royal Institute of Technology, SE-100 44 Stockholm, Sweden http://www.kth.se/en/studies

The equity effects of congestion pricing have come into focus as a potential hindrance to its acceptability in implementation around the world. Both theoretical arguments and empirical evidence about how the burden of the toll should fall on demographic groups have been mixed, depending on a variety of contextual factors, such as automobile access, work schedule, flexibility, and spatial distribution of activities, yet the evidence obtained so far for implemented congestion pricing systems has not examined explicitly the role of such contextual factors. With the congestion pricing trial in Stockholm, Sweden, as a case study, the authors use structural equation modeling to estimate a model of the role of age, income, and gender as independent variables; contextual factors as endogenous variables; and the change in automobile trips after congestion pricing as dependent variables. The findings indicate that gender is a significant factor in terms of the total

effects and that three of the four contextual variables—access to a car, possession of a long-term transit pass, and having a workplace on the same side of the cordon as home—play significant mediating roles in the indirect effects of the demographic variables on trips by automobile. Moreover, it was found that gender is significant only when the contextual factors were included in the model. This finding suggests that a significant variable could be missed when such factors are omitted.

Effects of impact fees on urban form and congestion in Florida

Author(s): Blanco, Andres G.;[1] Steiner, Ruth L.;[1] Kim, Jeongseob;[1] Chung, Hyungchul[1]
Year: 2012
Source: Transportation Research Record: Journal of the Transportation Research Board, vol. 2297, pp. 38–46
Publisher: Transportation Research Board
Author affiliation:
[1]Department of Urban and Regional Planning, University of Florida, Gainesville, FL 32611, United States
http://www.dcp.ufl.edu/urp

The authors analyze the effects of impact fees on urban form and congestion through econometric analysis. The results show that there is some evidence that impact fees might reduce congestion by creating disincentives to residential development and job creation; however, direct evidence of a negative effect from impact fees in development and job growth was not found. There is no evidence that the difference in impact fees between central cities and outer areas promotes a more compact urban form. Likewise, there is no evidence that more road impact fees decrease congestion through more investment in infrastructure. This finding might be because impact fees usually finance local roads but congestion is concentrated on freeways and arterials, or because there is a spatial, temporal, or financial mismatch between the collection and investment of impact fees. There is a clear, significant, and substantive positive relationship between density and congestion; this relationship indicates a weak increase in transit use in denser environments or a potential increase in automotive travel through higher trip frequency; however, other urban form variables related to the distribution of that density have a negative effect on congestion, indicating that certain urban configurations could decrease congestion. Finally, changes in congestion are negatively correlated with the congestion levels at the beginning of the period. This finding suggests that congestion is increasing faster in those areas that used to be less congested.

REFERENCE RESULTS
CONGESTION AND SAFETY

Impact of distracted driving on safety and traffic flow

Author(s): Stavrinos, Despina;[1] Jones, Jennifer L.;[1] Garner, Annie A.;[1] Griffin, Russell;[1] Franklin, Crystal A.;[1] Ball, David;[1] Welburn, Sharon C.;[1] Ball, Karlene K.;[1] Sisiopiku, Virginia P.;[1] Fine, Philip R.[1]
Year: 2013
Source: Accident Analysis and Prevention, vol. 61, pp. 63–70
Publisher: Elsevier Ltd.
Author affiliation:
[1]Department of Psychology, The University of Alabama at Birmingham, Birmingham, AL 35294, United States, http://www.uab.edu/cas/psychology/

Studies have documented a link between distracted driving and diminished safety; however, an association between distracted driving and traffic congestion has not been investigated in depth. The authors examined the behavior of teens and young adults operating a driving simulator while engaged in various distractions (e.g., cell phone, texting) or while undistracted and in various driving conditions (e.g., free flow, stable flow, and oversaturation). Seventy-five participants, 16 to 25 years of age (split into two groups: novice drivers and young adults), drove a STISIM Drive® simulator three times, each time with one of three randomly presented distractions. Each drive was designed to represent daytime scenery on a four-lane divided roadway and included three equal roadway portions representing Levels of Service (LOS) A, C, and E as defined in the 2000 edition of the *Highway Capacity Manual*. Participants also completed questionnaires documenting demographics and driving history. Both safety- and traffic-flow–related driving outcomes were considered. A Repeated Measures Multivariate Analysis of Variance was used to analyze continuous outcome variables, and a Generalized Estimating Equation Poisson model was used to analyze count variables. Results revealed that, in general, more lane deviations and crashes occurred during texting. Distraction (in most cases, text messaging) had a significantly negative impact on traffic flow, such that participants exhibited greater fluctuation in speed, changed lanes significantly fewer times, and took longer to complete the scenario. In turn, more simulated vehicles passed the participant drivers while they were texting or talking on a cell phone than while undistracted. The results indicate that distracted driving, particularly texting, may lead to reduced safety and traffic flow, thus having a negative impact on traffic operations. No significant differences were detected between age groups, suggesting that all drivers, regardless of age, may drive in a manner that impacts safety and traffic flow negatively when distracted.

REFERENCE RESULTS
CONGESTION AND TOLLING

Speed-based toll design for cordon-based congestion pricing scheme

Author(s): Liu, Zhiyuan;[1] Meng, Qiang;[2] Wang, Shuaian[3]
Year: 2013
Source: Transportation Research Part C: Emerging Technologies, vol. 31, pp. 83–98
Publisher: Elsevier Ltd.
Author affiliation:
[1]Institute of Transport Studies, Department of Civil Engineering, Monash University, Clayton VIC 3800, Australia, http://www.eng.monash.edu.au/civil/research/centres/its/
[2]Department of Civil and Environmental Engineering, National University of Singapore, Singapore 117576, http://www.eng.nus.edu.sg/cee/
[3]School of Mathematics and Applied Statistics, University of Wollongong, Wollongong NSW 2522, Australia, http://eis.uow.edu.au/smas/index.html

The cordon-based Electronic Road Pricing (ERP) system in Singapore adopts the average travel speed as an index for evaluating the traffic congestion within a cordon area, and the maintenance of the average travel speed within a satisfactory range is taken as the objective of the toll adjustment. To formulate this practical speed-based toll design problem, the authors propose a mathematical programming with equilibrium constraint (MPEC) model with the objective of maintaining the traffic condition in the cordon area. In the model, the network users' route choice behavior is assumed to follow probit-based stochastic user equilibrium with elastic demand, asymmetric link travel time functions, and continuous value-of-time. A distributed revised genetic algorithm is designed for solving the MPEC model. Finally, a network example based on the ERP system is adopted to numerically validate the proposed models and algorithms. The example further indicates that the computation speed can be improved greatly by using a distributed computing system.

Managing congestion and emissions in road networks with tolls and rebates

Author(s): Chen, Linxi[1]; Yang, Hai1[1]
Year: 2012
Source: Transportation Research Part B: Methodological, vol. 46, no. 8, pp. 933–948
Publisher: Elsevier Ltd.
Author affiliation:
[1]Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology, Kowloon, Hong Kong, China, http://www.ce.ust.hk/

Traffic congestion and emissions are two main types of social cost, and their minimization sometimes conflicts with each other. In this paper, the authors seek nonnegative link toll schemes and/or link toll cum rebate schemes for Pareto-efficient control and management of both vehicular congestion and emissions on road networks using a bi-objective optimization approach. The authors provide necessary and sufficient conditions for the existence of such schemes to decentralize a given target link flow pattern. Then, they investigate the possibility of introducing such schemes to obtain specific Pareto system optimum target link flow patterns with two types of link emission function: increasing functions and nonmonotonic functions, respectively.

REFERENCE RESULTS
FEAR AND ANXIETY-MOTIVATING BEHAVIOR

Fear and anxiety while driving: Differential impact of task demands, speed, and motivation

Author(s): Schmidt-Daffy, Martin[1]
Year: 2013
Source: Transportation Research Part F: Traffic Psychology and Behaviour, vol. 16, pp. 14–28
Publisher: Elsevier Ltd.
Author affiliation:
[1]Department of Biological Psychology and Neuroergonomics, Technische Universität Berlin, D-10587 Berlin, Germany, https://www.bpn.tu-berlin.de/menue/biological_psychology_and_neuroergonomics/parameter/en/

In many motivational models of driving behavior, threat-related feelings and arousal play a key role in inducing drivers to opt for lower driving speeds. The author proposes that these emotional symptoms can be ascribed to different underlying processes, namely fear and anxiety. Fear arises if the current task demands exceed the driver's perceived capabilities, whereas anxiety increases with the strength of the driver's goal conflict between safety and velocity. Therefore, the author predicted that choosing a lower driving speed would compensate for an increase in fear but would not decrease anxiety. A driving simulator study confirmed this prediction. Both an increase in task demands due to lower visibility of the road and an increase in goal conflict due to higher motivational incentives for fast and safe driving led participants to choose a lower speed during self-paced driving. Higher task demands increased self-reported anxiety and physiological arousal in runs with prescribed velocities; however, during self-paced runs in which participants adapted their speed to the viewing condition, symptoms of a threat-related emotion only occurred if the goal conflict increased. Effects of prescribed velocities suggest that lower driving speeds annihilated the emotional effects of task demands but not the effects of goal conflict. The amplitude of electro-dermal responses to a deer on the road indicated that this difference also applies to drivers' immediate responses to an acute danger. The author concluded that cautious driving behavior can be guided by either fear or anxiety. Understanding the difference between these emotional processes might help to develop road safety measures that are particularly adapted to specific requirements.

REFERENCE RESULTS
FINANCE AND INVESTING

Risk-neutral pricing approach for evaluating BOT highway projects with government minimum revenue guarantee options

Author(s): Ashuri, B.;[1] Kashani, H.;[1] Molenaar, K.R.;[2] Lee, S.;[3] Lu, J.[1]
Year: 2012
Source: Journal of Construction Engineering and Management, vol. 138, no. 4, pp. 545–557
Publisher: American Society of Civil Engineers
Author affiliation:
[1]Georgia Institute of Technology, Economics of the Sustainable Built Environment Lab, School of Building Construction, Atlanta, GA 30332, United States, http://www.esbe.gatech.edu/
[2]Department of Civil, Environmental, and Architectural Engineering, University of Colorado at Boulder, Boulder, CO 80309, United States, http://ceae.colorado.edu/
[3]Road Planning and Construction Division; Ministry of Land, Transport, and Maritime Affairs, Gwacheon-si, Gyeonggi-do 427-712, Republic of Korea, http://english.molit.go.kr/intro.do

Build–operate–transfer (BOT) is a public–private partnership project delivery system for the financing, development, and operations of highway projects around the world. Uncertainty about future traffic demands is one of the most important risk factors in the operations phase of a BOT project. There is a considerable amount of evidence indicating that the improper consideration of this uncertainty contributes to the financial failure of BOT projects. The inherent limitation of conventional economic analysis methods contributes to this uncertainty; most notably the net present value (NPV) approach that is typically used in the economic valuation of BOT projects. In addition, the NPV approach is insufficient to determine the correct market value of minimum revenue guarantee (MRG) options. The government offers MRG options to the concessionaire as a revenue-risk–sharing strategy in BOT projects. The authors apply the real options theory from finance–decision science to explicitly price MRG options in BOT projects. This real options model has several prominent attributes that make it different from NPV models. It uses a market-based option pricing approach called *risk-neutral valuation method* to determine the correct value of MRG options. Unlike the other models, this approach treats the risk of underestimating future traffic demands internally and adjusts for the traffic market risk in the valuation of MRG options. The authors also describe a procedure for characterizing the concessionaire's economic risk profile under uncertainty about future traffic demands. In addition, it uses real options analysis to price MRG and traffic revenue cap (TRC) options as compound options and determines their effects on the concessionaire's economic risk profile. The authors also present the probability distributions of when the concessionaire may request MRG and when the public sector may receive additional revenues as TRC options. Further, the authors characterize the distributions of the number of times that the concessionaire may request the MRG option and the number of times that the public sector may receive additional revenue. Finally, this model identifies the probability distributions of the present value of MRG options and the present value of total additional revenues recalled by the public sector. The proposed model can help the public and private sectors better analyze and understand the economic risk of BOT projects under uncertainty about future traffic demands. The private sector can use this proposed model to make better entry decisions about BOT highway projects by considering the level of support provided by the government. The

government can also use this proposed model to identify the appropriate MRG levels to encourage private investments without compromising future budgetary strength.

REFERENCE RESULTS
MODE CHOICE

Research on the interdependencies between commute mode choice and trip chaining behavior

Author(s): Jianchuan, Xianyu[1, 2]
Year: 2013
Source: International Conference on Management Science and Engineering—Annual Conference Proceedings, pp. 2042–2046
Publisher: IEEE Computer Society
Author affiliation:
[1]Antai College of Economics and Management, Shanghai Jiaotong University, 200052 Shanghai, China http://www.acem.sjtu.edu.cn/en/
[2]Business School, Shanghai Dian Ji University, 201306 Shanghai, China, http://english.sdju.edu.cn/

Based on the analysis of travel survey data, the authors developed and applied the mixed binary–multinomial choice modeling method to the exploration of the relationship between travel mode choice and trip-chaining behavior of home-based commutes. The analysis was conducted from two directions, namely, trip chaining to travel mode and travel mode to trip chaining. The developed model considers the effects of the interdependencies between trip chaining and travel-mode choice on each choosing behavior, which emphasizes the guidance of the decision mechanism on travel-behavior forecasting. The results show the dominating trend to be that trip chaining drives mode choice. This means that travelers first decide how to organize different activities and travel in trip chains based on individual and family needs and then make travel mode choices conditioned under the limit of trip chaining. These findings have important implications for travel demand forecasting and for the design and carrying out of demand-management measures.

Explaining stability in travel mode choice: An empirical comparison of two concepts of habit

Author(s): Friedrichsmeier, Thomas;[1] Matthies, Ellen;[2] Klöckner, Christian A.[3]
Year: 2013
Source: Transportation Research Part F: Traffic Psychology and Behaviour, vol. 16, pp. 1–13
Publisher: Elsevier Ltd.
Author affiliation:
[1]Workgroup for Environmental and Cognitive Psychology, Department of Psychology, Ruhr-University Bochum, D-44780 Bochum, Germany, http://eco.psy.ruhr-uni-bochum.de/ecopsy/?language=en
[2]Institute for Psychology, Otto-von-Guericke University, D-39106 Magdeburg, Germany http://www.ipsy.ovgu.de/ipsy/en/Institute+of+Psychology.html
[3]Section for Risk Psychology, Environment and Safety (RIPENSA), Psychological Institute, Norwegian University of Science and Technology, NO-7491 Trondheim, Norway http://www.ntnu.edu/psychology

At least two distinct views on habit have been proposed in the literature: the view of habits as an association between situational cues and a specific behavior, and the view

of habits as schemas or generalized scripts applying to a wider range of situations. The authors compared these concepts on their ability to account (1) for a moderation of the intention–behavior link and (2) for a stabilization of behavior in the domain of travel mode choice. In a survey study with 1,048 university students, participants recorded their travel mode choice on four standard trips during two 1-week periods 6 months apart. Intention to use public transportation and several measures of habit were recorded for each period. Only the measure related to the associationist view showed the expected moderating effect. Stabilizing effects were found for all measures, but except for the measure related to the associationist view, these cannot be reliably differentiated from ceiling effects. The pattern of results supports the associationist point of view on habits.

Multiple purposes at single destination: A key to a better understanding of the relationship between tour complexity and mode choice

Author(s): Ho, Chinh Q.;[1] Mulley, Corinne[1]
Year: 2013
Source: Transportation Research Part A: Policy and Practice, vol. 49, pp. 206–219
Publisher: Elsevier Ltd.
Author affiliation:
[1]Institute of Transport and Logistics Studies, University of Sydney Business School, Sydney NSW 2006, Australia, http://sydney.edu.au/business/itls

The authors investigate the nature of tours undertaken by public transport and car. By using a new approach to the typology of tours, which takes into account not only the number but also the spatial distribution of activities chained into a tour, the authors shed light on the reasons why findings in the existing research literature conflict. Descriptive and modeling analyses on a home-based tour dataset created from the Sydney Household Travel Survey are presented to show that tours that use car or public transport are different in nature. For public transport, activities chained into a tour have destinations that are typically in close proximity and reachable by walking whereas the car was found to be utilized for travel involving multiple purposes at multiple destinations. The new approach in this paper to the typology of tours takes the destination into account to give clearer and more significant relationships between tour complexity and mode choice, allowing potential policy and planning implications for promoting public transport ridership to be drawn. The results indicate that if there is a spatial dispersion to the activities chained into a tour, then this significantly reduces public transport use. In contrast, public transport use increases as the number of activities that share a destination with others chained into a tour increases. These findings suggest that planning strategies to increase public transport use need to focus on providing multiple purposes at a single destination.

Integrating congestion pricing, transit subsidies, and mode choice

Author(s): Basso, Leonardo J.;[1] Jara-Díaz, Sergio R.[1]
Year: 2012
Source: Transportation Research Part A: Policy and Practice, vol. 46, no. 6, pp. 890–900
Publisher: Elsevier Ltd.
Author affiliation:
[1]Civil Engineering Department, Universidad de Chile, Santiago, Chile, http://www.uchile.cl/english

The authors model and analyze optimal (welfare maximizing) prices and design of transport services in a bimodal context. Car congestion and transit design are

simultaneously introduced, and consumers choose based on the full price they perceive. The optimization variables are the congestion toll, the transit fare (and hence the level of subsidies), and transit frequency. The authors obtain six main results: (1) the optimal car–transit split is generally different from the total cost minimizing one; (2) optimal congestion and transit price are interdependent and have an optimal frequency attached; (3) the optimal money price difference, together with the optimal frequency, yield the optimal modal split; (4) if this modal split is used in traditional stand-alone formulations—in which each mode is priced independently—resulting congestion tolls and transit subsidies and fares are consistent with the optimal money price difference; (5) self-financing of the transport sector is feasible; and (6) investment in car infrastructure induces an increase in generalized cost for all public transport users.

Travel mode choice and transit route choice behavior in Montréal: Insights from McGill University members' commute patterns

Author(s): Eluru, Naveen;[1] Chakour, Vincent;[1] El-Geneidy, Ahmed M.[2]
Year: 2012
Source: Public Transport, vol. 4, no. 2, pp. 129–149
Publisher: Springer
Author affiliations:
[1]Department of Civil Engineering and Applied Mechanics, McGill University, Montréal, QC H3A 2K6, Canada, http://www.mcgill.ca/civil/
[2]School of Urban Planning, McGill University, Montréal, QC H3A 2K6, Canada http://www.mcgill.ca/urbanplanning/

In developed countries such as Canada and the United States, a significant number of individuals depend on the automobile as their main mode of transport. There has been a stronger push towards analyzing travel behavior at the individual level so that transportation agencies can formulate appropriate strategies to reduce the auto dependency. Towards this pursuit of enhancing the authors' understanding of travel behavior, the authors examine individual home-to-work/school commute patterns in Montréal, Canada, with an emphasis on the transit mode of travel. The overarching theme of this paper is to examine the effect of the performance of the public transportation system on commuter travel mode and transit route choice (for transit riders) in Montréal. The authors investigate two specific aspects of commute mode choice: (1) the factors that dissuade individuals from commuting by public transit and (2) the attributes that influence transit route choice decisions (for those individuals who commute by public transit). This study uses a unique survey conducted by researchers as part of the McGill University Sustainability Project. The survey collected information on the commute patterns of students, faculty, and staff from McGill University. In addition, the authors also collected detailed socio-demographic and residential location information. The analysis was undertaken by using a multinomial logit model for the travel mode choice component and a mixed multinomial logit model for the transit route choice component. The model estimation results were used to conduct policy sensitivity analysis that allows the authors to provide recommendations to public transportation and metropolitan agencies.

Simulation of users' decision in transport mode choice using a Neuro-fuzzy approach

Author(s): Dell'Orco, Mauro;[1] Ottomanelli, Michele[1]
Year: 2012
Source: Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol. 7334 LNCS, no. PART 2, pp. 44–53
Publisher: Springer
Author affiliation:
[1]Technical University of Bari, Bari, Italy, http://www.uniba.it/english-version

In this paper, soft computing and artificial intelligence techniques have been used to define a model for simulating users' decisional processes in a transportation system. Through this framework, the variables involved are expressed by approximate or linguistic values, similar to human reasoning, in order to forecast users' mode choice behavior. The model has been specified and calibrated using a set of real-life data. Results appear good in comparison with those obtained by a classical random-utility–based model calibrated with the same data; also, the methodology seems promising in the case of different applications used in the field of choice behavior simulation.

Investigating telecommuting considerations in the context of commuting mode choice

Author(s): Nurul Habib, Khandker M.;[1] Sasic, Ana;[1] Zaman, Hamid[2]
Year: 2011
Source: International Journal of Sustainable Transportation, vol. 6, no. 6, pp. 362–383
Publisher: Taylor and Francis Ltd.
Author affiliation:
[1]Department of Civil Engineering, University of Toronto, Toronto, ON M5S 1A4, Canada http://www.civil.engineering.utoronto.ca/Page13.aspx
[2]Department of Civil and Environmental Engineering, University of Alberta, Edmonton, AB T6G 2W2, Canada, http://www.civil.engineering.ualberta.ca/

The authors apply an econometric model to investigate the determinants of telecommuting choices in the context of commute mode choices, based on a survey dataset from the City of Edmonton, Canada. The authors' results indicate that attributes of different commuting modes have different cross-elastic effects on the attitude toward telecommuting; however, the magnitudes of cross elasticity are very low. Time of start of work plays a major role in considering telecommuting as a feasible choice. Moreover, it is clear that complementary Travel Demand Management policies are necessary to encourage a positive attitude toward telecommuting.

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Public transportation travel mode choice behavior research

Author(s): Yin, Huanhuan;[1] Li, Juan;[2] Zhao, Hongzheng[3]
Year: 2012
Source: CICTP 2012: Multimodal Transportation Systems—Convenient, Safe, Cost-Effective, Efficient—Proceedings of the 12th COTA International Conference of Transportation Professionals, pp. 1337–1344
Publisher: American Society of Civil Engineers
Author affiliation:
[1]Research Institute of Highway Ministry of Transport, Beijing 100088, China
[2]Tianjin Bohai Urban Planning and Design Institute, Tianjin 300451, China
[3]China Highway Engineering Consulting Group Company Ltd., Beijing 100098, China

Based on 2009 resident travel survey data from the city of Jinan, China, the authors analyze public transit travel time and spatial characteristics from the perspective of travel behavior; establish a public transit choice behavior model that draws on existing models, theories, and methods; study factors of public transit travel behavior; and discuss how to encourage people to stop driving cars and start riding buses. The results can provide the basis for urban transport planning and public transit management decision making, for improving the urban public transport split rate, and for easing the pressure on urban traffic.

REFERENCE RESULTS
MONETARY INDUCEMENTS FOR SAFETY

Automobile drivers' willingness to pay for moving violation behavior—Compared to motorcyclists

Author(s): Jou, Rong-Chang;[1] Pai, Chih-Wei;[2] Wang, Pei-Lung[1]
Year: 2013
Source: Accident Analysis and Prevention, vol. 59, pp. 55–63
Publisher: Elsevier Ltd.
Author affiliation:
[1]Department of Civil Engineering, National Chi Nan University, Puli, Nantou Hsien 545, Taiwan http://www.ncnu.edu.tw/web/english/index.htm
[2]Graduate Institute of Injury Prevention and Control, College of Public Health and Nutrition, Taipei Medical University, Taipei City 110 , Taiwan, http://www.tmu.edu.tw/english/about/super_pages.php?ID=about1

The authors applied a triple-bounded dichotomous choice structure and spike models to investigate the amount of money Taiwan automobile drivers are willing to pay for five types of moving violations, including local street speeding, expressway and freeway speeding, red-light running, right turn on red, and drunk driving. The authors conducted a face-to-face survey at freeway rest areas by targeting passenger car drivers. The spike model, superior to other traditional models by capturing excessive zero responses, was applied, and the estimated results showed that speeders would accept willingness to pay (WTP) of $37 and $48, respectively, for local roads and expressways and highways, whereas red-light runners would accept a WTP of $44, drivers who turn right on red would accept a lower WTP of $9, and drunk drivers would accept a WTP as high as $597. It is interesting to note that the difference in WTP for drunk driving between drivers and motorcyclists is significant, whereas others are not.

The effects of external motivation and real-time automated feedback on speeding behavior in a naturalistic setting

Author(s): Reagan, Ian J.;[1] Bliss, James P.;[2] Van Houten, Ron;[3] Hilton, Bryan W.[3]
Year: 2013
Source: Human Factors, vol. 55, no. 1, pp. 218–230
Publisher: SAGE Publications Inc.
Author affiliation:
[1]Office of Behavioral Safety Research, National Highway Traffic Safety Administration, Washington, DC 20590, United States, http://www.nhtsa.gov/Driving+Safety/Research+&+Evaluation
[2]Department of Psychology, Old Dominion University, Norfolk, VA 23529, United States http://sci.odu.edu/psychology/
[3]Department of Psychology, Western Michigan University, Kalamazoo, MI 49008, United States http://wmich.edu/psychology/index.html

In this field experiment, the authors tested an alerting system and a monetary incentive system with the objective of reducing speeding more than 5 mi/h faster than the posted speed limit. Speeding is a factor in a significant number of traffic fatalities. The systems tested in this project have been evaluated outside but not within the United States. These studies indicated that similar systems led to reductions in speeding. For this study, eight vehicles were instrumented such that vehicle speed and speed limits were linked in real time. A total of 50 participants drove assigned vehicles for 4 weeks. Week 1 was a baseline period; during Week 2 or Week 3, 40 participants experienced the alerting system that issued auditory and visual advisory signals when drivers exceeded the limit by 5 mi/h or more. Of these 40 individuals, 20 experienced the monetary incentive system during Weeks 2 and 3; Week 4 was a return-to-baseline period. A control group of 10 drivers experienced neither system during the study. Results indicated that the incentive system resulted in significant reductions in driving faster than the posted limit, and the feedback system led to modest changes in speeding. In the condition in which drivers experienced the feedback and incentive, reductions in speeding were similar to those found during the incentive-only condition. The technology tested in this study has the potential to benefit traffic safety by reducing the incidence of driving faster than the posted limit, which should lead to a reduction in speed-related crashes. Insurers provide incentive-based discounts on premiums. Combining this technology with such a discount program may improve traffic safety significantly.

An empirical assessment of driver motivation and emotional states in perceived safety margins under varied driving conditions

Author(s): Zhang, Y.;[1] Kaber, David B.[1]
Year: 2013
Source: Ergonomics, vol. 56, no. 2, pp. 256–267
Publisher: Taylor and Francis Ltd.
Author affiliation:
[1]Edward P. Fitts Department of Industrial and Systems Engineering, North Carolina State University, Raleigh, NC 27695, United States, http://www.ise.ncsu.edu/

Motivation models in driving behavior postulate that driver motives and emotional states dictate risk tolerance under various traffic conditions. The authors of the present study used time and driver performance-based payment systems to manipulate motivation and risk-taking behavior. Ten participants drove to a predefined location in a simulated

driving environment. Traffic patterns (density and velocity) were manipulated to cause driver behavior adjustments due to the need to conform to the social norms of the roadway. The authors investigated the driving environment complexity as a mediating factor in risk tolerance. Results revealed the performance-based payment system to closely relate to risk-taking behavior as compared with the time-based payment system. Drivers conformed to social norms associated with specific traffic patterns. Higher roadway complexity led to more conservative safety margins and speeds. This research contributes to the further development of motivational models of driver behavior. This study provides empirical justification for two motivation factors in driver risk-taking decisions, including compliance with social norms and emotions triggered by incentives. The authors identified environment complexity as a mediating factor in the motivational behavior model and they also recommended safety margin measures sensitive to changes in driver risk tolerance.

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Velocity, safety, or both? How do balance and strength of goal conflicts affect drivers' behavior, feelings, and physiological responses?

Author(s): Schmidt-Daffy, Martin;[1] Brandenburg, Stefan;[1] Beliavski, Alina1,[2]
Year: 2013
Source: Accident Analysis and Prevention, vol. 55, pp. 90–100
Publisher: Elsevier Ltd.
Author affiliation:
[1]Department of Psychology and Neuroergonomics, Technische Universität Berlin, D-10587 Berlin, Germany, http://www.tu-berlin.de/menue/home/parameter/en
[2]Faculty of Medicine, University of Ottawa, Ottawa, ON K1H 8M5, Canada http://www.medecine.uottawa.ca/eng/

Motivational models of driving behavior agree that choice of speed is modulated by drivers' goals. Although it is accepted that some goals favor fast driving and others favor safe driving, little is known about the interplay of these conflicting goals. In the present study, the authors investigate two aspects of this interplay: the balance of conflict and the strength of conflict. Thirty-two participants completed several simulated driving runs in which fast driving was rewarded with a monetary gain if the end of the track was reached; however, some runs ended with the unpredicted appearance of a deer. In these runs, fast driving was punished with a monetary loss. The ratio between the magnitudes of gains and losses varied in order to manipulate the balance of conflict. The absolute magnitudes of both gains and losses altered the strength of conflict. Participants drove slower, reported an increase in anxiety-related feelings, and showed indications of physiological arousal if there was more money at stake. In contrast, only marginal effects of varying the ratio between gains and losses were observed. Results confirm that the strength of a safety–velocity conflict is an important determinant of drivers' behavior, feelings, and physiological responses. The lack of evidence for the balance of conflict playing a role suggests that in each condition, participants subjectively weighted the loss higher than the gain (loss aversion). The authors concluded that the interplay of the subjective values that drivers attribute to objective incentives for fast and safe driving is a promising field for future research. Incorporating this knowledge into motivational theories of driving behavior might improve their contribution to the design of adequate road safety measures.

Participant characteristics and speeding behavior during an advisory warning and cash incentive intervention

Author(s): Berlin, Sharon;[1] Reagan, Ian J.;[2] Bliss, James P.[3]
Year: 2012
Source: Proceedings of the Human Factors and Ergonomics Society, pp. 1044–1048
Publisher: SAGE Publications Inc.
Author affiliation:
[1]AAA Foundation for Traffic Safety, Washington, DC 20005, United States
https://www.aaafoundation.org/
[2]National Highway Traffic Safety Administration, Washington, DC 20590, United States
http://www.nhtsa.gov/
[3]Department of Psychology, Old Dominion University, Norfolk, VA 23529, United States
http://sci.odu.edu/psychology

Speeding-related crashes are responsible for a significant economic and human toll to society. The authors present data from a field study evaluating the effectiveness of in-vehicle automated feedback and monetary incentive systems to reduce speeding behavior. The current effort was a unique opportunity to compare self-reported speeding beliefs and behaviors to observed driving behaviors and quantify associations between participant characteristics and driving behaviors. Fifty participants completed the 4-week study within three experimental groups: automated feedback with monetary incentive (n=20), automated feedback without incentive (n=20), and control (n=10). Results indicated little connection between self-reported and observed speeding behaviors, despite high correlation between self-reported and observed driving patterns overall. Associations were found between sensation-seeking personalities and speeding behavior. Few differences were found between sexes. Results highlight the relationship between personality and driving behavior and suggest a closing gap between male and female driving behaviors.

REFERENCE RESULTS
PAY-AS-YOU DRIVE (PAYD) INSURANCE OR PAY-AS-YOU-SPEED (PAYS) INSURANCE

Profiting from business model innovation: Evidence from Pay-as-You-Drive auto insurance

Author(s): Desyllas, Panos;[1] Sako, Mari[2]
Year: 2013
Source: Research Policy, vol. 42, no. 1, pp. 101–116
Publisher: Elsevier Ltd.
Author affiliation:
[1]Manchester Business School, University of Manchester, Manchester M15 6PB, United Kingdom
http://www.mbs.ac.uk/
[2]Said Business School, University of Oxford, Oxford OX1 1HP, United Kingdom
http://www.sbs.ox.ac.uk/Pages/default.aspx

The emergent business model literature, revolving mainly around the mechanisms through which new business models create and deliver value, has left the value capture

challenge underexplored. The authors examine how an incumbent firm profits from business model innovation through the study of Pay-as-You-Drive auto insurance. Although business models do not warrant formal intellectual property (IP) protection, their constituent components (e.g., business methods and brands) often do. Drawing on the profiting-from-innovation framework, the authors found that formal and strategic IP protection methods play complementary roles. Initially, formal IP rights are primarily used as a defensive strategy, as a vehicle for packaging and trading know-how, and, most importantly, as a means of "buying time" to build specialized complementary assets. Long-term competitiveness, however, depends on whether the innovator builds a strong position in specialized complementary assets and is capable of reconfiguring them over time in line with changes in the market environment; thus, the authors explicate the complex mechanism and dynamic capability for capturing value from business model innovation.

Evaluation and aggregation of Pay-as-You-Drive insurance rate factors: A classification analysis approach

Author(s): Paefgen, Johannes;[1] Staake, Thorsten;[2, 3] Thiesse, Frédéric[4]
Year: 2013
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Publisher: Elsevier Ltd.
Author affiliation:
[1]ITEM-HSG, University of St. Gallen, 9000 St. Gallen, Switzerland, http://www.item.unisg.ch/en/Institute
[2]MIS and Energy-Efficient Systems, University of Bamberg, 96047 Bamberg, Germany http://www.uni-bamberg.de/
[3]Information Management, WEV G 217, 8092 Zurich, Switzerland, http://www.ethz.ch/index_EN
[4]IS Engineering, University of Würzburg, 97070 Würzburg, Germany http://www.uni-wuerzburg.de/en/new/

Vehicle sensor data enable novel, usage-based insurance premium models known as Pay-as-You-Drive (PAYD) insurance but pose substantial challenges for actuarial decision making because of their inherent complexity and volume. Based on a large real-world sample of location data from 1,572 vehicles, the authors propose a classification analysis approach that addresses (1) the selection of predictor variables, (2) the presence of class skew and time-variant prior distributions, and (3) the suitability of classifier scores as an aggregated actuarial rate factor. By using raw location data, the authors derived a set of 15 predictor variables that they used to train and compare logistic regression, neural network, and decision tree classifiers. The authors found that although neural networks exhibit superior classification performance, logistic regression is better suited from an actuarial viewpoint in several ways. In sum, the results clearly demonstrate the potential of high-resolution exposure data for reducing the complexity of PAYD insurance pricing in practice.

Voluntary internalization of speeding externalities with vehicle insurance

Author(s): Hultkrantz, Lars;[1] Nilsson, Jan-Eric;[2] Arvidsson, Sara[2]
Year: 2012
Source: Transportation Research Part A: Policy and Practice, vol. 46, no. 6, pp. 926–937
Publisher: Elsevier Ltd.
Author affiliation:
[1]Swedish Business School, Örebro University, 701 82 Örebro, Sweden, http://www.oru.se/English/
[2]Swedish National Road and Transport Research Institute (VTI), Box 55685, 102 15 Stockholm, Sweden http://www.vti.se/en/

High speed is an important determinant of accidents for speeders as well as for other motorists. The authors develop a framework for analyzing instruments that encourage drivers to internalize the full consequences of their behavior with respect to choice of speed using Pay-as-You-Speed (PAYS) insurance, possibly as an extension of Pay-as-You-Drive (PAYD) insurance. The authors demonstrate how the combination of a Pigovian taxation scheme and PAYS can be designed in a setting involving two principals (the state and an insurance company) that affect the incentives of commuters to choose between driving and other modes of transport and for those who use the car mode to drive carefully. Although the government is assumed to maximize overall social efficiency and therefore wants to implement marginal cost pricing, insurance companies do actuarial pricing, that is, average cost pricing within risk classes that are homogeneous to the degree that the insurers have information about actual behavior. PAYS insurance improves the insurance industry's ability to differentiate premiums according to behavior and therefore to target risk classes in a better way than it does today. Moreover, because the authors' framework is designed to accomplish differentiation by self-selection, compulsory regulation is not necessary, although there may be reason for the government to facilitate the implementation of the new technology.

Preferences for Pay-as-You-Drive insurance offers among residential customers in Germany—A conjoint analytical investigation

Author(s): Gerpott, Torsten J.;[1] Berg, Sabrina[1]
Year: 2012
Source: International Journal of Services, Technology and Management, vol. 17, no. 1, pp. 22–53
Publisher: Inderscience Enterprises Ltd.
Author affiliation:
[1]Department of Strategic and Telecommunications Management, Mercator School of Management, University of Duisburg-Essen, D-47057 Duisburg, Germany, http://www.msm.uni-due.de/index.php?id=409&L=1

Advanced pay-as-you-drive (PAYD) insurances entail the collection, the analysis, and frequently the mobile radio-network–based transmission of trip and car data to take vehicle-specific accident risks into account when deriving liability insurance rates. An online-survey of 517 German-speaking car drivers was conducted to estimate via limit conjoint analysis utilities which individuals ascribe to four selected PAYD design features. At the aggregate sample level, participants favored most (least) PAYD offerings with 50% (10%) potential savings, automatic emergency call in case of an accident (without supplementary services), car data transfer at the end of an accounting period (real-time data transmission while driving) and with two (three) driving characteristics used to

calculate individual rates. The results suggest that insurers should initially tailor PAYD offers to a segment of insured persons who are mainly interested in an automatic car emergency call system, but who are inclined also to subscribe to a PAYD offer as an 'add-on' even if it entails limited saving prospects.

Moving Toward Pay as You Drive

Author(s): Walker, John;[1] Blythe, Phil;[2] Pickford, Andrew[3]
Year: 2012
Source: IET and ITS Road Transport Information and Control Conference (RTIC 2012)
Publisher: The Institution of Engineering and Technology
Author affiliation:
[1]Transportation Research Group, School of Engineering and the Environment, University of Southampton, Southampton SO16 7QF, United Kingdom, http://www.trg.soton.ac.uk/dept.htm
[2]Transport Operations Research Group (TORG), Newcastle University, Newcastle upon Tyne NE1 7RU, United Kingdom, http://www.ncl.ac.uk/ceg/research/transport/
[3]Transport Technology Consultants Ltd., Wan Chai, Hong Kong, China, http://www.ttc-global.com/

It was not until the 1990s that successful road user charging schemes emerged in Singapore, London, and Stockholm. The excuse was that "the technology has not yet been proven," in addition to the difficulty of making a lucid case to politicians, businesses, and individual travelers, who would all benefit from the introduction of road pricing in congested cities and arterial routes. The authors show that technology can now provide solutions to deliver innovative charging policies. The authors review key schemes and trials and show what can be learned from them; and how the technical innovations and the evolution in policy-thinking permit schemes make road pricing acceptable and relevant to today's congestion, energy, climate change, and fiscal challenges. Moreover, these innovations enable policymakers and road operators to offer a "new deal" for road users, in which ownership and fuel taxes can be replaced by more effective Pay-as-You-Drive (PAYD) schemes based on time, distance, and place charging.

Pay as You Speed, ISA with incentives for not speeding: A case of test driver recruitment

Author(s): Lahrmann, Harry;[1] Agerholm, Niels;[1] Tradisauskas, Nerius;[1] Næss, Teresa;[1] Juhl, Jens;[1] Harms, Lisbeth[2]
Year: 2012
Source: Accident Analysis and Prevention, vol. 48, pp. 10–16
Publisher: Elsevier Ltd.
Author affiliation:
[1]Aalborg University, Department of Development and Planning, DK-9220 Aalborg, Denmark http://www.en.plan.aau.dk/
[2]University of Copenhagen, Department of Psychology, DK-1353 Copenhagen K, Denmark http://psychology.ku.dk/

The Intelligent Speed Adaptation (ISA) project that the authors describe in this paper is based on Pay-as-You-Drive principles. These principles assume that the ISA equipment informs a driver of the speed limit, warns the driver when he or she is speeding, and calculates penalty points. Each penalty point entails the reduction of a 30 percent discount on the driver's car insurance premium, which therefore produced the name Pay

as You Speed. The ISA equipment consists of a Global Positioning System-based onboard unit with a mobile phone connection to a Web server. The project was planned for a 3-year test period with 300 young car drivers, but it never succeeded in recruiting that number of drivers. After several design changes, the project eventually went forward with 153 test drivers of all ages. This number represents approximately one thousandth of all car owners in the proving ground of North Jutland in Denmark. Furthermore, the project was terminated before its scheduled closing date. The authors describe the project with an emphasis on recruitment efforts and the project's progress. The authors include a discussion of possible explanations for the failure to recruit volunteers for the project and reflect on the general barriers to using ISA with ordinary drivers.

Pay as You Speed, ISA with incentive for not speeding: Results and interpretation of speed data

Author(s): Lahrmann, Harry;[1] Agerholm, Niels;[1] Tradisauskas, Nerius;[1] Berthelsen, Kasper K.;[2] Harms, Lisbeth[3]
Year: 2012
Source: Accident Analysis and Prevention, vol. 48, pp. 17–28
Publisher: Elsevier Ltd.
Author affiliation:
[1]Aalborg University, Department of Development and Planning, DK-9220 Aalborg, Denmark
http://www.en.plan.aau.dk/
[2]Aalborg University, Department of Mathematical Sciences, DK-9220 Aalborg, Denmark
http://www.math.aau.dk/index.php?id=157
[3]University of Copenhagen, Department of Psychology, DK-1353 Copenhagen K, Denmark
http://psychology.ku.dk/

To simulate a market introduction of Intelligent Speed Adaptation (ISA) and to study the effect of a Pay-as-You-Speed (PAYS) concept, the authors conducted a field trial with 153 drivers during 2007–2009. The participants drove under PAYS conditions for a short or long period. The PAYS concept consisted of informative ISA linked with an economic incentive for not speeding, measured through an automatic count of penalty points whenever the speed limit was exceeded. The full incentive was set to 30 percent of a participant's insurance premium. The participants were exposed to different treatments, with and without incentive crossed with informative ISA present or absent. The results showed that ISA is an efficient tool for reducing speeding, particularly on rural roads. The analysis of speed data demonstrated that the proportion of distance driven above the speed where the ISA equipment responded (PDA) was a sensitive measure for reflecting the effect of ISA, whereas mean free flow speed and the 85th percentile speed were less sensitive to ISA effects. The PDA increased a little over time but still remained at a low level; however, when ISA was turned off, the participants' speeding relapsed to the baseline level. Both informative ISA and incentive ISA reduced the PDA, but there was no statistically significant interaction. Informative ISA reduced it more than the incentive ISA.

REFERENCE RESULTS
PENALTIES INCENTIVIZING SAFE BEHAVIOR

Stated response to increased enforcement density and penalty size for speeding and driving unbelted

Author(s): Hössinger, Reinhard;[1] Berger, Wolfgang J.[1]
Year: 2012
Source: Accident Analysis and Prevention, vol. 49, pp. 501–511
Publisher: Elsevier Ltd.
Author affiliation:
[1]Institute for Transport Studies, University of Natural Resources and Life Sciences, Vienna (BOKU), A-1190 Vienna, Austria, https://forschung.boku.ac.at/fis/suchen.orgeinheit_projekte?sprache_in=en&menue_id_in=204&id_in=H856

To what extent can traffic offenses be reduced through stronger enforcement, higher penalties, and the provision of information to road users? The authors addressed this question with respect to the offenses of "speeding" and "driving unbelted." Data were collected by a telephone survey of admitted speeders, followed by 438 face-to-face stated response interviews. On the basis of the data collected, separate statistical models were developed for the two offenses. The models predict the behavioral effect of increasing enforcement density and/or penalty size as well as the additional effect of providing information to car drivers. All three factors are predicted to be effective in reducing speeding. According to the model, one additional enforcement event per year will cause a driver to reduce his current frequency of speeding by 5 percent. A penalty increase of €10 is predicted to have the same effect. An announcement of stronger enforcement or higher fines is predicted to have an additional effect on behavior, independent of the actual magnitudes of increase in enforcement or fines. With respect to the use of a seat belt, however, neither an increase in enforcement density nor its announcement is predicted to have a significant effect on driver behavior. An increase in the penalty size is predicted to raise the stated wearing rate, which is already 90 percent in Austria. It seems that both the fear of punishment and the motivation for driving unbelted are limited, so that there is only a weak tradeoff between the two. This may apply to most traffic offenses, with the exception of speeding, which accounts for over 80 percent of tickets alone, whereas all other offenses account for less than 3 percent each.

REFERENCE RESULTS
PROTECTION MOTIVATION

Can antispeeding messages based on protection motivation theory influence report speeding intentions?

Author(s): Glendon, A. Ian;[1] Walker, Britta L.[1]
Year: 2013
Source: Accident Analysis and Prevention, vol. 57, pp. 67–79
Publisher: Elsevier Ltd.
Author affiliation:
[1]School of Applied Psychology and Behavioral Basis of Health Research Centre,
Griffith University, Gold Coast Campus, Southport QLD 4222, Australia
http://www.griffith.edu.au/health/behavioural-basis-health

The authors investigated the effects of antispeeding messages based on protection motivation theory (PMT) components: severity, vulnerability, rewards, self-efficacy, response efficacy, and response cost on reported speeding intentions. Eighty-three participants aged 18–25 years with a current Australian driver's license completed a questionnaire that measured their reported typical and recent speeding behaviors. Comparisons were made between 18 antispeeding messages used on Australian roads and 18 new antispeeding messages developed from the PMT model. Participants reported their reactions to the 36 messages on the perceived effectiveness of the messages for themselves and for the general population of drivers and also the likelihood of themselves and other drivers to drive within the speed limit after viewing each message. The PMT model-derived antispeeding messages overall were better than jurisdiction-use antispeeding messages in influencing participants' reported intention to drive within the speed limit. Severity and vulnerability were the most effective PMT components for developing antispeeding messages. Male participants reported significantly lower intention to drive within the speed limit than did female participants; however, males reported significantly higher intention to drive within the speed limit for PMT-derived messages compared with jurisdiction-based messages. Third-person effects were that males reported antispeeding messages to be more effective for the general driving population than for themselves. Females reported the opposite effect that is, that all messages would be more effective for themselves than for the general driving population. Findings provided support for using a sound conceptual basis as an effective foundation for antispeeding message development as well as for evaluating proposed antispeeding messages on the target driver population.

REFERENCE RESULTS
TOLLING

The influence of economic incentives linked to road safety indicators on accidents: The case of toll concessions in Spain

Author(s): Rangel, Thais;[1] Vassallo, José Manuel;[1] Herraiz, Israel[2]
Year: 2013
Source: Accident Analysis and Prevention, vol. 59, pp. 529–536
Publisher: Elsevier Ltd.
Author affiliation:
[1]Transport Research Center (TRANSyT), Universidad Politécnica de Madrid, 28040 Madrid, Spain http://www.transyt.upm.es/index.php/en/acerca-de-transyt-eng/mnurecursos-eng.html
[2]Departamento de Matemática e Informática Aplicadas a la Ingeniería Civil, Universidad Politécnica de Madrid, 28040 Madrid, Spain, http://www2.caminos.upm.es/Departamentos/matematicas/PORTADA.htm

The authors evaluated whether the incentives incorporated in toll highway concession contracts to encourage private operators to adopt measures to reduce accidents are actually effective at improving safety. To this end, the authors implemented negative binomial regression models by using information about highway characteristics and accident data from toll highway concessions in Spain from 2007 to 2009. The authors' results show that although road safety is highly influenced by variables that are not managed by the contractor—such as the annual average daily traffic, the percentage of heavy vehicles on the highway, number of lanes, number of intersections, and average speed—the implementation of these incentives has a positive influence on the reduction of accidents and injuries. As a consequence, this measure seems to be an effective way of improving safety performance in road networks.

Willingness to pay for high-occupancy toll lanes: Empirical analysis from I-15 and I-394

Author(s): Burris, Mark;[1] Nelson, Scott;[1] Kelly, Pete;[2] Gupta, Partha;[1] Cho, Youngjae[1]
Year: 2012
Source: Transportation Research Record: Journal of the Transportation Research Board, vol. 2297, pp. 44–55
Author affiliation:
[1]Zachry Department of Civil Engineering, Texas A&M University, 3136 TAMU, College Station, TX 77843-3136, United States, http://engineering.tamu.edu/civil/
[2]615 North 600 West #8, Provo, UT 84601

The authors examined the willingness of travelers to pay for travel time savings (TTS) on the Interstate 394 (I-394) MnPASS express lanes in Minneapolis, MN, and the I-15 express lanes in San Diego, CA. The findings from both facilities indicate that many travelers are willing to pay a toll for a small TTS. The revealed preference values of time for the I-394 paying customers averaged $73/h in the morning and $116/h in the afternoon. Travelers on the I-15 express lanes received slightly higher TTS than on the I-394 and typically had a lower willingness to pay. Their revealed preference values of time averaged $49/h in the morning and $54/h in the afternoon. On the basis of the magnitude of these values, it is likely that travelers are paying for more than just TTS, possibly also travel time reliability. This finding means that these lanes likely have added value to travelers beyond time

savings. The variability of the dynamic toll prices on the I-394 MnPASS express lanes in Minneapolis and the I-15 express lanes in San Diego was also examined. Toll rates during the morning and afternoon peak hours varied considerably, with tolls ranging from $0.50 to $8.00. Conversely, off-peak times showed little to no variation. These trends were similar for different days of the week, and even from year to year. These trends were common across both the I-394 and I-15 express lanes, although more variation was found on I-15. Tolls varied little during off-peak periods.

Impact of peak and off-peak tolls on traffic in San Francisco–Oakland Bay bridge corridor in California

Author(s): Barnes, Ian C.;[1] Frick, Karen Trapenberg;[2] Deakin, Elizabeth;[3] Skabardonis, Alexander[4]
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Source: Transportation Research Record: Journal of the Transportation Research Board, vol. 2297, pp. 73–79
Author affiliation:
[1]Fehr & Peers Transportation Consultants, San Jose, CA 95113, United States http://www.fehrandpeers.com/
[2]University of California Transportation Center, Berkeley, CA 94720, United States, http://www.uctc.net/
[3]Department of City and Regional Planning, University of California, Berkeley, Berkeley, CA 94720, United States, http://ced.berkeley.edu/academics/city-regional-planning/
[4]Department of Civil and Environmental Engineering, University of California, Berkeley, Berkeley, CA 94720, United States, http://www.ce.berkeley.edu/

The San Francisco–Oakland Bay Bridge is located in the heart of the San Francisco Bay Area in California and connects two of the largest cities in northern California over San Francisco Bay. In July 2010, the Bay Area Toll Authority (BATA) increased tolls on the San Francisco–Oakland Bay Bridge from a flat toll collected westbound only to weekday peak and off-peak tolls. BATA also instituted a carpool toll of $2.50 (previously carpools crossed for free) payable by FasTrak® electronic toll collection tag only. With floating-car data provided by BATA, the change in travel time for the Interstate 80 (I-80), I-580, and I-880 approaches was computed by payment type (e.g., cash, FasTrak, and high-occupancy vehicle access lanes) and hour. Travel times were reduced by 0 min to 16 min for cash customers (varying by time of day and approach), with varying results for FasTrak customers and little change for high-occupancy vehicle customers. Data collected by BATA at the toll plaza were analyzed by hour and payment type. The authors found that the number of vehicles in the carpool lanes was reduced by more than 20 percent at times, whereas FasTrak volumes remained steady or increased and cash volumes were slightly lower than before the toll switch.

Risk allocation in toll highway concessions in Spain: Lessons from economic recession

Author(s): Vassallo, José Manuel;[1] Ortega, Alejandro;[1] Baeza, María de los Ángeles[2]
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Author affiliation:
[1]ETSI de Caminos, Canales y Puertos, Universidad Politécnica de Madrid, 28040 Madrid, Spain http://www.caminos.upm.es/default.asp
[2]Facultad de Ciencias Económicas y Empresariales, Departamento de Economía Financiera y Contabilidad, Universidad de Granada, 18071 Granada, Spain, http://fccee.ugr.es/?lang=en

Spain has a long tradition of encouraging toll highways by granting concessions to private companies. Concessions in Spain have been characterized by a willingness to transfer considerable risk to the private sector. Traffic demand, acquisition of the right-of-way, and financial risk often have been allocated to the private sector. From 1996 to 2011, 16 toll highway concessions, covering a total distance of 835 km, were awarded by the central government of Spain with this approach. Some of those highways started their operations just before the economic recession began. The recession had negative consequences for Spain's economy. The gross domestic product per capita plummeted, and the unemployment rate increased from 9 percent to 20 percent of the working population in just 2 years. The recession also had severe consequences for the economic performance of toll highway concessions. Traffic levels declined at a much greater rate than did the gross domestic product. In addition, the conditions imposed by the financial markets on borrowers became much stricter because of the liquidity crisis. The authors analyze the impact that the economic recession ultimately had on the performance of toll highway concessions in Spain and the actions that the government adopted to avoid the bankruptcy of the concessionaires. The authors found that the economic recession helped identify some deficiencies in how risk had been allocated in Spain. The authors discuss the measures that both Spain and the European Union are adopting so as to improve risk allocation.

Step tolling with price-sensitive demand: Why more steps in the toll make the consumer better off

Author(s): van den Berg, Vincent A.C.[1]
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Publisher: Elsevier Ltd.
Author affiliation:
[1]Department of Spatial Economics, VU University Amsterdam, 1081 HV Amsterdam, Netherlands http://www.feweb.vu.nl/nl/afdelingen-en-instituten/spatial-economics/index.asp

Most dynamic models of congestion pricing use fully time-variant tolls; however, in practice, tolls are uniform over the day or at most have just a few steps. Such uniform and step tolls have received surprisingly little attention in the literature; moreover, most models that do study them assume that demand is insensitive to the price. This seems an empirically questionable assumption that, as the author finds, strongly affects the

implications of step tolling for the consumer. In the bottleneck model, first–best tolling has no effect on the generalized price, and thus consumer surplus remains the same as without tolling. Conversely, under price-sensitive demand, step tolling increases the price, making the consumer worse off. The more steps the toll has, the closer it approximates the first–best toll, thereby increasing the welfare gain and making consumers better off. This indicates the importance for real-world tolls to have as many steps as possible. This not only raises welfare, but may also increase the political acceptability of the scheme by making consumers better off.

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