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Paper ID: 324

Anders Fjendbo Jensen and Jeppe Rich

Empirical analysis of cycling trends in two of Europe's most bicycle-friendly regions: Identifying the successes and the setbacks

We present a combined longitudinal and socioeconomic study of cycling demand in the Netherlands and Denmark from 2010 to 2021. The countries are comparable in demography and both countries have well-developed cycling cultures. The longitudinal data allow us to study successes and setbacks related to cycling uptake over time. E-bikes are successfully promoting longer cycling trips and increased cycling among elderly people, particularly in the Netherlands. However, in rural areas of Denmark, we see setbacks in the form of significant reductions in cycling among children. By applying an econometric model of the combined selection effect of bicycling and the mileage effect conditional on travelling by bike, we analyse how these effects are related to, e.g. increased distances to school, increased work distance, car ownership, changes in urbanisation and other socio-economic factors. We show that these factors cannot explain all of the decline for childrens cycling in Denmark.

Paper ID: 554

Sander Van Cranenburgh and Francisco Garrido Valenzuela

Using computer vision-enriched discrete choice models to assess the visual impact of transport infrastructure renewal projects: A case study of the Delft railway zone

This study applies a computer vision-enriched discrete choice model to investigate the impact on the visual environment of the redevelopment of the Delft railway zone. Using computer vision-enriched discrete choice models, we evaluate the changes in the utility levels by analysing over 70k street-view images from periods before and after the redevelopment of the railway zone. We find evidence that the railway zone's visual appearance has considerably improved due to the redevelopment. This finding also supports the notion that computer vision-enriched discrete choice models provide a new way to quantitatively evaluate and monitor changes to the visual environment arising from new transport infrastructure projects.

Paper ID: 566

Stephane Hess and Sander Van Cranenburgh

Combine and conquer: model averaging for out-of-distribution forecasting

Travel behaviour modellers are increasingly interested in using models from outside the traditional choice modelling area, first incorporating ideas from behavioural economics, such as in regret modelling, before looking at mathematical psychology and machine learning. A key question arises as to how well these different models perform in prediction, especially when predicting trips of different characteristics from those used in estimation. This paper first compares the elasticities and model fit of different models, bringing together models as diverse as logit, random regret, decision field theory and neural networks. We highlight differences in elasticities and also note that the prediction performance deteriorates at different rates for different models when moving further away from the estimation data. We then develop a model averaging approach that allows us to make the most of the entire collection of models and estimate weights for different models as a function of distance away from the estimation sample.

Paper ID: 618

Sebastian Hörl and Puchinger Jakob

Modeling the ecological and economic footprint of last-mile parcel deliveries using open data: A case study for Lyon

The amount of parcels delivered in the urban space is steadily increasing and is often expected to double by 2030. At the same time rising energy prices and policies towards sustainable development affect the business models and distribution schemes in the sector. The present study uses open data to approximate today's parcel volumes for the specific case of Lyon and estimated how those parcels are delivered in terms of used vehicles, covered distances and ecological impacts. The first part describes our data collection process which hypothesizes market shares and cost structures of the parcel operators. In the second part, we solve Heterogeneous Vehicle Routing Problems to uncover the likely distribution schemes. This way, the study provides rough estimates on the total daily emissions and energy used for parcel deliveries outlined pathways for future modeling efforts and data collection.

Paper ID: 629

Alessio Daniele Marra and Francesco Corman

Evaluating real-time information systems on public transport disturbances

Real-Time Information (RTI) systems are a key component of the management process of public transport disturbances. Smartphone applications, in particular, are becoming a popular means of disseminating information to passengers. Despite the widespread usage of RTI systems, little is known on how accurate those systems are, which information they provide, or which disturbances are not reported. This work proposes a methodological framework and a set of metrics to evaluate a text-based RTI system, comparing the alerts sent to passengers with the actual disturbances in the network, described by Automatic Vehicle Location data (AVL). A case study is conducted on the RTI system of Zurich to evaluate its performance. The results show high precision in providing cor-rect information, despite only a small percentage of disturbances are reported. Finally, this work proposes recommendations on improving the RTI system analyzed.

Paper ID: 636

Rowan Hoogervorst, Evelien van der Hurk, Philine Schiewe, Anita Schöbel and Reena Urban

The Bus Rapid Transit Investment Problem

Bus Rapid Transit (BRT) systems can be of great value to attract passengers towards public transport, as they offer an attractive service at relatively low investment costs. Often, BRT lines are created by giving the bus a dedicated right of way along segments of an existing bus line. This paper focuses on quantifying the trade-off between the number of attracted passengers and the available investment budget when upgrading a line. Motivated by the construction of a new BRT line around Copenhagen, we consider multiple municipalities that invest in the line. We additionally allow restrictions on the number of connected components to be upgraded to enforce connectedness. We suggest two passenger responses to determine the number of attracted passengers and propose an epsilon-constraint based algorithm to enumerate all non-dominated points. Moreover, we perform an extensive experimental evaluation on artificial instances and a case study for the BRT line around Copenhagen.

Paper ID: 717

Patrick Stokkink, André de Palma and Nikolas Geroliminis

Carpooling with Transfers and Travel Time Uncertainty

Carpooling is known to have lower CO2 emissions compared to driving individually. One of the limitations of carpooling is that matched drivers and passengers need to have similar itineraries, or their generalized costs will be high. By allowing a single transfer at a designated transfer hub, their itineraries need to be only partially similar. We allow for transfers within the carpooling system and between carpooling and public transport. Thereby, we include travel time uncertainty to evaluate its effect on carpooling with transfers. We model the ride-matching problem with transfers and travel time uncertainty as a two-stage stochastic programming problem. The results indicate that a single transfer hub can already reduce the average generalized cost of passengers by 15%. When travel times are uncertain, commuters tend to find a match that performs relatively well in every traffic situation, rather than one that performs well for only one scenario.

Paper ID: 727

Tom Haering and Michel Bierlaire

A Spatial Branch and Bound Algorithm for Continuous Pricing with Advanced Discrete Choice Demand Modeling

In this paper, we present a spatial branch and bound algorithm to tackle the continuous pricing problem, where demand is captured by an advanced discrete choice model (DCM). Advanced DCMs, like mixed logit or latent class models, are capable of modeling demand on the level of individuals very accurately due to a focus on behavioral realism. The downside of such realistic models is that it is highly nontrivial to include the resulting demand probabilities into an optimization problem, as they usually do not have a convex or even closed-form expression when decision variables are part of the choice model. To this end, a simulation procedure proposed by Paneque et al. (2021) is applied to get a formulation as a mixed integer linear program (MILP). However, due to the large number of variables stemming from the simulation, this MILP is very hard to solve. We first propose to solve the problem as a non-convex quadratically constrained quadratic program (QCQP) instead, where total unimodularity guarantees the integrality of the solution. Isolating all non-convexity into a set of bilinear constraints leads to a formulation as a non-convex quadratically constrained linear program (QCLP) that proves computationally beneficial for general-purpose solvers. Lastly, we present a spatial branch and bound algorithm that employs the McCormick envelope to obtain relaxations and makes use of total unimodularity to generate feasible solutions and thus lower bounds for the maximization fast. We compare the proposed method to the fastest commercially available solver GUROBI, on a parking choice case study from Ibeas et al. (2014). The results show that the custom spatial branch and bound approach outspeeds GUROBI by a factor of at least 35x for the MILP formulation and at least 2.5x for the QCLP in single-price optimization, and a factor of at least 4.5x for the QCQP and 1.3x for the QCLP when optimizing multiple prices simultaneously. The ratio of the speedup further increases with the size of the instance.

Paper ID: 840

Ruben A. Kuipers and Michelle Ochsner

The Impact of Weather Phenomena on Passenger Volumes for Commuter Trains

Weather impacts several aspects of our daily life, of which the way we travel is one. The relationship between weather phenomena and ridership of trains has not received much attention previously. The study we present here aims to understand the impact of tempera-ture, wind, and precipitation on passenger volumes for commuter trains. To do so we make use of automatic passenger count and weather data from over a million unique sta-tion stops, spanning two years, in the Southern region of Scania in Sweden. Our findings show that changes in the level of precipitation do not affect the volume of boarding pas-sengers. Statistically significant effects are found for changes in temperature and wind speeds. These effects are most prominent for departures outside of peak hours. The results are useful for planning more accurate dwell times and rolling stock circulations and can serve as inputs during real-time rescheduling problems and demand modelling.

Paper ID: 856

Takara Sakai, Takashi Akamatsu and Koki Satsukawa

Welfare impacts of remote and flexible working policies in the bottleneck model

This study investigates the effects of remote and flexible working styles on traffic congestion. We first formulate an integrated equilibrium model simultaneously considering the working style, official work start time, and departure time choice of workers via an extension of the bottleneck model. Subsequently, we derive the equivalent optimization problem of the equilibrium problem as linear programming (LP) and demonstrate that we can obtain an analytical solution to the LP. This analytical solution enables us to assess the effects of remote and flexible working on social surplus and queueing loss. By comparing various situations, we show that implementing remote and flexible work causes higher queueing loss with an equal social surplus than implementing only remote work. Finally, we propose an integrated road management scheme that includes dynamic pricing to prevent this paradoxical phenomenon and efficiently implements remote and flexible working.

Paper ID: 1055

Arkadiusz Drabicki, Oded Cats and Rafał Kucharski

Willingness to wait with real-time crowding information in urban public transport – before vs. after COVID-19 pandemic

Passenger overcrowding is a major problem influencing travel behaviour in urban public transport (PT). Its relevance has been presumably shaped by the covid-19 pandemic impacts, which have to be yet fully understood. Real-time crowding information (RTCI) is therefore potentially instrumental in the post-covid recovery of PT ridership. This study investigates the willingness to wait (WTW) to reduce overcrowding in urban PT, analysing pre- vs. post-covid travel behaviour attitudes. Ex-post stated-preference data and (subsequently estimated) choice models indicate, compared to pre-covid findings, a higher propensity to skip overcrowded services with RTCI on seats available in later departures, and lower utility of RTCI on moderately crowded services. The WTW with RTCI seems to have become less dependent on individual characteristics and more prominent for time-critical (obligatory) trips as well. Implications of these findings are discussed in final study sections.

Paper ID: 1203

Thomas Hancock, Charisma Choudhury, Joan Walker and Stephane Hess

Quantum choice models leap out of the laboratory: capturing real-world behavioural change.

Quantum choice models have been recently introduced to travel behaviour modelling, showing significant promise in explaining preferential change as a result of a change in choice context. However, thus far, quantum choice models have only been applied to stated preference (SP) data. This paper focusses on the application of these models to revealed preference (RP) data and the methodological adaptations required to deal with the increased complexities that come with RP data. Using 2-week travel diaries from 273 individuals in/near Leeds, UK, we demonstrate that quantum choice models can effectively capture the impact of behavioural nudges used to shift travellers towards greener travel modes. The results demonstrate that the provision of feedback on behaviour relative to those of a similar demographic reinforces current behaviour: travellers who make more green choices become greener, whilst the converse is true for travellers who use make less green choices than average.

Paper ID: 1241

Konstantin Krauss

Shifting to sharing: Are external costs reduced or merely redistributed?

Shared mobility is discussed as one potential solution making transportation more sustainable since it can enable a more multi-modal behaviour and provides joint access to vehicle fleets. Research has focused on respective potentials for greenhouse gas (GHG) emission reductions. However, there are more external effects such as land use, accidents or noise that need to be incorporated in analyses. Thus, this work takes a systemic perspective on external cost effects regarding shifting transport demand to shared mobility services, i.e. carsharing, ridepooling, (e-)bikesharing, and shared e-scooters. To do so, survey and external cost data is combined to compute the effects of shifts to shared services concerning seven external cost dimensions. Results show that overall external costs are decreased by 2.3 % due to indicated shifts to shared services, mainly resulting from land use and GHG emission cost reductions. Yet, particularly regarding accidents, these shifts also cause external cost increases.

Paper ID: 1250

Bastián Henríquez-Jara, C. Angelo Guevara and Angel Jimenez-Molina

Identifying instant utility (latent emotion) triggers using psychophysiological indicators with an Experience-Based Choice Model in a travel experiment

We propose the Experience-Based Choice Model (EBCM), a novel approach capable of: (1) revealing the triggers of instant utility (emotions) in a transportation context, (2) measuring instant utility using psychophysiological indicators, and (3) estimating choices based on experiences. This framework combines the canonical discrete choice modelling, with the cyclical idea of decisions influenced by hedonic measures of experiences. In this article, we apply the components (1) and (2) of EBCM with data from a real-life travel experiment, in which skin temperature (SKT), heart rate (HR), heart rate variation (HRV), and electrodermal activity (EDA) were measured with a specially designed wristband. Using a latent variable approach, the main results show that instant utilities are sensible, to the travel mode; speed; crowding; brightness; and noise. In addition, it is shown that the participants kept a biased memory of the emotions and that EDA and SKT are meaningful indicators of instant utilities.

Paper ID: 1397

Joris Wagenaar, Evelien van der Hurk, Marie Schmidt and Evelien van der Hurk

A model for Robust Rolling Stock Scheduling

Major disruptions render the schedules of public transport operators infeasible. The majority of the recently developed algorithms for updating these schedules assume the duration of the disruption is known when they occur. However, in practice, this is generally untrue. This paper compares three different models for Rolling Stock Rescheduling under uncertainty: an optimistic approach, a strict-robust model inspired by the definition of disruption of Ben Tal et al, and a Light-Robustness approach that aims to provide a middle way between the two. The models are evaluated on a realistic case study of the Netherlands Railways. Initial results indicate that building robustness against different disruption durations is worthwhile when alternative scenarios are associated with a sizable probability mass. The best approach depends on the probability distribution over the different scenarios.

Paper ID: 1540

Rui Yao and Renming Liu

Can Bayesian Optimization be the Last Puzzle for Automatic Estimation of Neural Network Discrete Choice Models? An experiment

This study investigates the performances of Bayesian optimization (BO) and random grid search methods for tuning neural network hyper-parameters in the context of discrete choice modeling. Specifically, the fully-connected feed-forward (FNN) and alternative-specific-utility neural networks (ASU) are tuned. Results show that BO outperforms random grid search for both FNN and ASU models in terms of out-of-sample log-likelihood. Furthermore, it is illustrated that BO has higher sample efficiency and is relatively more robust to different random initialization. Our experiments show that the Bayesian hyper-parameter tuning framework could accommodate and complement existing neural network models that are cast for automatic utility function specifications, and create a fully automatic estimation workflow.

Paper ID: 1567

Gabriel Nova and C. Angelo Guevara

In-depth, Breath-first or Both? Toward the Development of a RUM-DFT Discrete Choice Model

Development in discrete choice modelling has been dominated by Random Utility Maximization approaches due to their ease of application and high economic interpretability. However, this model assumes that decision-makers perform an in-depth information search process (ISP) implicitly and instantaneously. It has not been investigated in detail whether the ISP of transport users is in depth or breadth-first in a public transport choice context, a gap that this research aims to fill. To this end, the ISP of public transport users has been characterized in three SP surveys with click-tracking, which were pivoted concerning commute and varied in the number of dimensions. The results allow us to conclude that the ISP is part of a heuristic, heterogeneous, complex, and mixed deliberation process, which depends on the dimensions of the choice tasks. However, breadth-first searches predominate, i.e., the evaluation of the information is done by comparing alternatives under one attribute in each search.

Paper ID: 1777

Carlos Gaete-Morales, Julius Jöhrens, Florian Heining and Wolf-Peter Schill

Power sector effects of alternative options for electrifying heavy-duty vehicles

In the passenger car segment, battery-electric vehicles have emerged as the most promising option to decarbonize transportation. For heavy-duty vehicles, the technology space still appears to be more open. Aside from stationary-charged battery-electric trucks, electric road systems (ERS) for dynamic power transfer to electric vehicles are also discussed, as well as trucks that use hydrogen fuel cells or e-fuels. Here we investigate the power sector implications of these different options. We apply an open-source power sector capacity expansion model to future scenarios of Germany with high renewable energy shares, drawing on detailed route-based truck mobility data. Results show that power sector costs are highest in the case of e-fuels, and lowest for battery-electric and ERS trucks. The latter technologies can generally provide more temporal flexibility to the power sector than battery-electric and ERS trucks. Yet, these flexibility benefits do not outweigh their disadvantages in terms of energy efficiency. In equilibrium, the different flexibility characteristics lead to higher capacity expansion and use of solar PV for battery-electric and ERS trucks, and to a higher use of wind power for hydrogen and e-fuel trucks. If battery-electric and ERS trucks are charged non-optimised, power sector costs increase but still remain below those of hydrogen and e-fuel trucks.

Paper ID: 1943

Leon Weinsziehr, Frederik Bachmann, Antonios Tsakarestos and Klaus Bogenberger

Detection of Bus Bunching through the Analysis of Prevalent Public Transport Control Data

Bus bunching describes a phenomenon that is familiar to many public transport users. Two buses, running according to a scheduled frequency, arrive at a stop in immediate succession. In most cases, the leading vehicle is delayed. The delay causes an increasing number of waiting passengers at the stops. Through this higher number of boarding and alighting passengers, the dwell time of the leading bus lengthens and by that also its delay. This problem is made visible using freely available public transport control data of two routes from Sydney, Australia. To validate the bunching events captured from the bus control data, General Transit Feed Specification (GTFS) data is used. The buses' positioning logs are traced to determine the distance between bunched vehicles. Additionally, a direct association between late departures of buses induced by delay propagation from one direction and increased bunching occurrence in the opposite direction is observed.

Paper ID: 2045

Rasha Bowirrat, Karel Martens and Yoram Shiftan

Explaining Walking in Cities – a Machine Learning Approach

A large body of research has developed on walking and walkability, in part in response to increasing concerns over people's health, climate change, livability, and social cohesion. Literature shows that some built environment and socio-demographic characteristics influ-ence walking rates more than others. Different approaches and methods have been used to study the relationship between the built environment characteristics, socio-demographic variables and walking patterns. Yet, so far very few studies have applied machine learning tools to study and explore these re-lationships. This research aims to start filling this void. The study draws on a dataset contains details about trips made by over 37,000 respond-ents in the Tel-Aviv metropolitan area. The detailed data allow us to differentiate between walk-only trips and walk trips that are combined with other modes of transport. Our re-sults show that the built environment shapes walk-only trips more than walking as an ac-cess or egress mode.

Paper ID: 2155

Mads Paulsen and Jeppe Rich

Optimal bicycle network expansions with endogenous demand

The challenge of identifying the ideal spatial and temporal prioritization for long-term expansions of bicycle networks is a complex undertaking. Our objective in this research is to determine the most beneficial expansions of bicycle networks for society, while considering the impact of level-of-service effects and induced demand throughout the evaluation period. While the effects of constant demand can be approximated through a sequence of linear binary mathematical programs (Paulsen & Rich, 2023), accommodating induced demand necessitates a different optimization approach that accounts for the likelihood of various segments being integrated in the infrastructure in future years during the optimization process. We put this approach to the test by applying it to the Greater Copenhagen Cycle Superhighway network. It is demonstrated that the optimized infrastructure render benefit-cost ratios exceeding 10, and that accounting for demand effects, significantly increases the societal return and changes the geographical structure of optimal investments.

Paper ID: 2329

Felix Hofinger and Martin Fellendorf

Lane change behavior on motorways based on naturalistic trajectory data

Lane change behavior is a major aspect in traffic flow modeling. Since only a few empirical analyzes are available, validation of lane change models is frequently limited to macroscopic characteristics (e.g. number of lane changes). In addition, many existing lane change models do not reflect lane change behavior in complex situations realistic enough. Therefore, we investigate naturalistic trajectory data from German motorways and analyze gap acceptance behavior focusing on varying discretionary lane change objectives, especially on cooperative lane changes. We propose a methodology to classify different lane change objectives and analyze the critical time gap using the Raff´s method. The results show differences in gap acceptance between varying discretionary lane changes classes. Moreover, we found that drivers who perform a cooperative lane change accept rather low time gaps. The analyzes should provide a basis for validating existing and developing new lane change models.

Paper ID: 2357

Hannes Wallimann, Kevin Blättler and Widar von Arx

Do price reductions attract customers in urban public transport? A synthetic control approach

In this paper, we assess the demand effects of lower public transport fares in Geneva, an urban area in Switzerland. Considering a unique sample based on transport companies' annual reports, we find that, when reducing the costs of annual season tickets, day tickets, and hourly tickets (by up to 29%, 6%, and 20%, respectively), demand increases over five years by about 10.6%. To the best of our knowledge, we are the first to show how the synthetic control method can be used to assess such (for policy-makers) important price reduction effects in urban public transport. Furthermore, we propose an aggregate metric that inherits changes in public transport supply (e.g., frequency increases) to assess these demand effects, namely passenger trips per vehicle kilometre. This metric helps us to isolate the impact of price reductions by ensuring that companies' supply changes do not affect estimators of interest.

Paper ID: 2359

Muhamad Rizki, Tri Basuki Joewono and Yusak Susilo

Exploring the Effect of Apps Evolution and Users' Personality on Mobile Apps Adoption and Post-Adoption Pattern Over Time: Evidence from Super-Apps Users in Indonesian Cities

This study aims to investigate the effect of users' personalities as well as apps' transformation to the adoption and post-adoption patterns of multi-functional apps/Super-Apps over time. A questionnaire was distributed to Super-Apps users in four Indonesian cities. Latent Markov model (LMM) was used to investigate the users' Super-Apps usage from 2015 to 2022. Four distinctive states were recognized: the Super User (SU) state; the Transport, Consumption, and Finance (TCF) state; the Food and Beverage (F&B) and Transport (FT) state; and the Less Explored (LE) state. The analysis found that LE users have a higher probability of changing into another state of users, while TCF users tend to be more stable than other groups. A higher number of functions available does not necessarily lead to highest exploration, but it contributes to making the users evolve from LE to other states. Users who are more sociable tend to explore the apps more.

Paper ID: 2398

Florian Fuchs, Viera Klasovitá and Francesco Corman

Routing Passengers while Timetabling Based on Promises from Line Planning: A Logic-Based Benders Approach

Effective line planning and timetabling are critical for enhancing public transport efficiency and passenger satisfaction. We propose a Logic-Based Benders decomposition approach to optimise a timetable for a passenger railway system based on the promises made in earlier planning stages. Our approach ensures that the promised travel times and transfers are available and passenger routes are chosen according to the shortest available path. We test this approach on real-world data from the Rhätische Bahn railway system, demonstrating promising results. The proposed approach has shown to be valuable for optimising transfers, improving efficiency and passenger satisfaction, and reducing travel times. The method has limitations, including the inability to consider multiple connections per origin-destination pair, adaptation time at the origin station, and crowding. Further research can focus on improving and extending the model's performance to include these factors.

Paper ID: 2447

Anupriya Anupriya, Daniel Graham and Prateek Bansal

Quantification of non-linear effects in agglomeration economies for transport appraisals

Agglomeration economies arising from the spatial concentration of economic activity have been known to exist and induce higher productivity for firms. The existing empirical evidence, however, has two key caveats. First, it mostly assumes a pre-specified (mostly log-log) functional form for the relationship between firm productivity and agglomeration. Second, it may lack valid instruments to adjust for potential confounding biases (for instance, from the omission of characteristics of local input and output markets) in the estimation of this relationship. This study adopts a flexible Bayesian Non-Parametric Instrumental Variables based approach to quantify non-linear effects in agglomeration economies. The approach uses innovative external instruments derived from traffic casualty data. We adopt a two-step framework: we first isolate the firm's total factor productivity from a Cobb-Douglas production function and thereafter estimate the non-linear effects of agglomeration on this productivity. Using data from a sample of firms classed into six key industry sectors in England, we present novel evidence that indicates the presence of significant non-linearities in agglomeration elasticities for most industry sectors. Our results provide critical inputs for the appraisal of transport investments.

Paper ID: 2590

Georgios Kapousizis, Rumana Sarker, Baran Ulak and Karst Geurs

Acceptance of new technologies affecting safety on electric bicycles: evidence from five European countries

Electric bicycles (e-bikes) are one of the main solutions towards mitigating transport externalities, such as traffic congestion and emission, and have thus been promoted in many countries. Despite the advantages of e-bikes, users are prone to be involved in crashes, usually due to the high speed. Leveraging new technologies could help reduce such crashes; however, e-bike users' willingness to accept new technologies still needs to be investigated. Hence, this study explores e-bike users' motivation to use smart e-bikes by adopting the extended Unified Theory of Acceptance and Use of Technology (UTAUT2). A cross-national survey was administered in five European cities-Austria, Belgium, Germany, Greece and the Netherlands, differing in sizes and cycling culture. The survey yielded 1116 responses, and the structural equation model (SEM) results indicate that 'performance expectancy', 'hedonic motivation' and 'perceived safety' are the strongest predictors of users' acceptance of new technologies on e-bikes to increase safety and comfort.

Paper ID: 2643

Gunnar Flötteröd

Improved precision in a heuristic for particle-based and stochastic dynamic traffic assignment

This work continues Flötteröd (2022) and refines an operational and efficient heuristic for the stochastic and particle-based dynamic traffic assignment problem. Experimental results indicate that the method performs advantageous when compared to alternative techniques that are applicable in the considered "agent-based" setting (variations of the method of successive averages (MSA) and the sorting technique of Sbayti et al. (2007)). Conveniently, the method requires no tuning parameters, not even an MSA-like step size rule.

Paper ID: 2677

Magdalena Schilling, Marvin V. Baumann, Jörg Sonnleitner, Markus Friedrich and Peter Vortisch

Design hourly volume estimation at freeway nodes using floating car data

The estimation of the Design Hourly Volume (DHV) is an essential step for a traffic assessment. At freeway nodes, not all ramps are detected by permanent traffic count (PTC) stations. Therefore the German HCM recommends additional short-term counts (STC) to determine the DHV. Since conducting STC is usually associated with high effort, the question arises whether the information obtained by STC can also be derived from Floating Car Data (FCD). We propose an approach for processing the FCD in order to apply it instead of the STC for the determination of the DHV at ramp junctions. The performance of the method is evaluated on five nodes, for which FCD from 2017 and a reference database covering all 8,760 hourly volumes of all ramps and main lanes of the road section are available. The result show, the usage of representative FCD days is possible.

Paper ID: 2680

Claudia Bandiera, Richard Connors and Francesco Viti

Mobility Service Providers' Equilibrium Strategies in Multi-modal Networks

Due to the increasing introduction of new mobility solutions in the transport offers, the market equilibrium among Mobility Service Providers (MSPs) has become more complex. The focus of this paper is to develop a novel analytical approach to study competition and/or cooperation between multiple MSPs within a multi-modal network system. We formulate a novel Equilibrium Problem with Equilibrium Constraints (EPEC), where each MSP seeks to maximize their own profits at the upper level. At the lower level, users are divided into classes that capture their heterogeneity in terms of socioeconomic characteristics and activity-travel behaviour. We consider the multi-modal network link costs to be non-separable, therefore the lower-level equilibrium is formulated as a Variational Inequality (VI) problem. A solution approach is proposed and illustrated, based on a relaxation of the Diagonalization method. Finally, we apply the described methodology to a small example to illustrate some key properties of the proposed approach.

Paper ID: 2727

Thomas Schatzmann, Felix Zwick and Kay Axhausen

Investigating the preferences for the use of urban ridepooling

This study investigates the preferences for the use of the urban ridepooling service MOIA in Hamburg, Germany. A survey with over 4,000 (non-)users was conducted and a discrete choice model was estimated to understand users' preferences to use the service. The study provides insights into the sociodemographic characteristics of ridepooling users, their preferences towards the service and first findings on the preferences towards an intermodal combination with public transportation. The results show that factors such as travel cost, time, trip distance and purpose are significant in influencing the use of ridepooling services. According to the choice experiment, intermodal travel is a viable choice for trip distances above 10~km, primarily for public transport subscription holders. The findings of this study can inform the design and marketing of future ridepooling services, and contribute to the broader debate on the potential benefits and challenges of shared mobility services in improving urban mobility and reducing the negative impacts of transportation on the environment.

Paper ID: 2854

Ilka Dubernet and Dennis Seibert

Investigating preferences for powertrains when buying a car in Germany

Germany's Federal Climate Change Act requires the transport sector to reduce its greenhouse gas emissions by almost half until 2030. The government has set an ambitious goal of increasing the number of fully electric vehicles to 15 million within the same period. Data on the factors influencing the purchase of low- or zero-emission vehicles is still scarce. Based on stated preference data collected in spring 2022, we found that battery electric vehicles are the preferred choice of respondents in the hypothetical situation of buying a new car, but not in the used car market. Our results support the high demand for battery electric vehicles, suggesting that stagnating shares in new registrations could be due to supply shortages. Purchase price and energy costs are the most important factors leading to the choice of an electric powertrain, indicating that purchase premiums currently put into place in Germany are highly effective.

Paper ID: 3039

Dimitrios Pappelis, Emmanouil Chaniotakis, Tim Hillel and Maria Kamargianni

Modelling Travel Time Anticipation Under Rational Inattention and Endogenous Information Constraints

Transportation research has been traditionally grounded on the economic theory of Rational Expectations, assuming that individuals are fully informed, optimizing, and self-interested decision makers. However, this assumption fails to sufficiently explain the inertia that characterizes travellers' behaviour in face of uncertainty. In recent years, there has been a rising interest in the theory of Rational Inattention, arguing that individuals choose to make seemingly suboptimal choices due to the cost of acquiring and processing available information. In this paper, we present a continuous quadratic Rational Inattention model of travel time anticipation. We showcase that its properties satisfy behavioural hypotheses derived from data collected through a case study in the city of Turin on within-day travel re-evaluation. We conduct simulation experiments and propose an alternative 2-stage framework for enhancing existing neoclassical travel behaviour models, indicating potential biases and discrepancies in the forecasted market shares, specifically with regards to rare travel time occurrences.

Paper ID: 3158

Daniel Hörcher and Daniel Graham

The spatial variation of travel time valuations: A general equilibrium model and application in project appraisal

Current practices in transport policy appraisal are mostly restricted to partial equilibrium modelling, creating a natural need to explore new ways to understand the spatial general equilibrium impacts of transport interventions. The emerging literature of quantitative spatial models (QSM) offers new opportunities. However, the direct application of the QSM methodology in transport is hindered by the assumption of unidimensional `iceberg' travel costs. Due to the presence of both temporal and pecuniary travel costs, the theoretical characterisation and empirical measurement of the monetary value of travel time savings has been a central theme of transport research for decades. We bridge a gap between spatial and transport economics by developing a quantitative spatial model with endogenous travel time valuations , revealing its previously neglected spatial heterogeneity. The model yields OD-specific values of time in spatial general equilibrium. Numerical implementation of the model highlights the relevance of our contribution in practical transport appraisal.

Paper ID: 3525

Ying-Chuan Ni, Michail Makridis and Anastasios Kouvelas

Investigating Link- and Network-level Bicycle Traffic Flow Characteristics using a Microsimulation Approach

Implementing cycling infrastructure for road users has become a popular transport policy for cities to create a sustainable urban environment nowadays. A thorough understanding of bicycle traffic is required to evaluate new infrastructure designs. To fill the remaining knowledge gap in this aspect, this study aims to investigate bicycle traffic flow characteristics on dedicated bike lanes. A microsimulation tool is used to simulate various scenarios and compute bicycle traffic states. From the simulation results, bicycle flow characteristics presented at both link and network levels are identified and discussed. The findings are expected to be applied to future research regarding large-scale bicycle traffic flow modeling.

Paper ID: 3545

Farnoud Ghasemi, Arkadiusz Drabicki and Rafał Kucharski

Dynamics of the Ride-Sourcing Market: A Coevolutionary Model of Competition between Two-Sided Mobility Platforms

There is a fierce competition between two-sided mobility platforms (e.g., Uber and Lyft) fueled by massive subsidies, yet the underlying dynamics and interactions between the competing platforms are largely unknown. These platforms rely on the cross-side network effects to grow, they need to attract agents from both sides to kick-off: travellers are needed for drivers and drivers are needed for travellers. We use our coevolutionary model featured by the S-shaped learning curves to simulate the day-to-day dynamics of the ride-sourcing market at the microscopic level. We run three scenarios to illustrate the possible equilibria in the market. Our results underline how the correlation inside the ride-sourcing nest of the agents choice set significantly affects the platforms' market shares. While late entry to the market decreases the chance of platform success and possibly results in "winner-takes-all", heavy subsidies can keep the new platform in competition giving rise to "market sharing" regime.

Paper ID: 3552

Louis Balzer and Ludovic Leclercq

Cooperation between Ride-Hailing and Public Transportation with Tradable Credit Schemes

Ride-Hailing (RH) companies have expanded significantly in urban areas in the past decade. However, they may compete with Public Transportation (PT) instead of completing them. This work proposes to use Tradable Credit Scheme (TCS), a quantity-based policy, to encourage RH drivers to operate in parts of the network not well served by PT. Credits are given to the RH drivers. Operating in some regions requires credits. RH drivers can trade credits between themselves. We use a trip-based Macroscopic Fundamental Diagram (MFD) to compute the dynamic and heterogeneous RH trips. Customers choose between different PT and RH alternatives. The RH drivers' decision to operate in a region is a balance between the potential revenue and the credit charge of this region. We evaluate the equilibrium of different TCS on a test case. TCS fosters multimodal trips, which combine PT and RH to complete the trips.

Paper ID: 3758

Manon Seppecher and Ludovic Leclercq

An auctioning process for large-scale ride-hailing vehicles repositioning

On-demand mobility services are transforming urban mobility. They can provide individual and collective benefits when managed optimally, and their successful integration within the existing urban transport system can enhance its performance. In contrast, inadequate fleet management can inflict high pick-up waiting times and passenger drop-out rates. One of the main challenges for on-demand mobility service operators is to proactively rebalance their fleets to ensure that the spatial distribution of supply matches the demand. This paper proposes to address this problem with a distributed auctioning approach. We design an architecture that relies on local controllers interacting with idle vehicles, encouraging them to relocate to their service area. We conduct simulations on the city of Lyon in France, which reveal a substantial increase in the number of passengers served compared to a scenario without rebalancing.

Paper ID: 3890

Menno Yap, Howard Wong and Oded Cats

Public Transport Crowding Valuation in a Post-Pandemic Era

The main contribution of this study is to derive the crowding valuation of public transport passengers in a post-pandemic era entirely based on observed, actual passenger route choices. We derive passengers' crowding valuation for the London metro network based on a revealed preference discrete choice model using maximum likelihood estimation. We find that after the passenger load on-board the metro reaches the seat capacity, the in-vehicle time valuation increases by 0.422 for each increase in the average number of standing passengers per square metre upon boarding. When comparing this result to a variety of crowding valuation studies conducted before the pandemic in London and elsewhere, we can conclude that public transport passengers value crowding more negatively since the pandemic. Our study results contribute to a better understanding on how on-board crowding in urban public transport is perceived in a European context since the outbreak of the COVID-19 pandemic.

Paper ID: 3928

Jingyi Cheng and Shadi Sharif Azadeh

A data-driven dynamic demand hotspots forecasting framework for on-demand meal delivery platforms

Speed and reliability are the keys to high quality on-demand meal delivery service. The rebalancing of couriers locations according to future demand remains an operational challenge in the industry. This study proposes an adaptive framework to identify and predict the near-future demand hotspots, utilizing the semi real-time predictive information as input. This framework provides demand insights to assist meal delivery platforms in making operational forward-looking resource-demand rebalancing decisions in real time, such as fleet management and demand management. To generate fast and accurate demand forecasting, we incorporate time series features and data-driven machine learning methods to create an adaptive forecasting approach. We create a dynamic demand hotspot clustering algorithm which takes predictive and geographic information as input. In the case study, our predictive forecasting model outperforms the time series and deep learning benchmarks in deterministic forecasting. The hotspots clustering performance is improved by using probabilistic predictive input.

Paper ID: 4019

Shadi Haj Yahia, Omar Mansour and Tomer Toledo

Incorporating Domain Knowledge in Deep Neural Networks for Mode Choice Analysis

Discrete choice models (DCM) are widely used in travel demand analysis to understand and predict choice behaviors. However, a priori specification of the utility functions is required for model estimation, leading to subjectivity and potential inaccuracies. Machine learning (ML) approaches have emerged as a promising solution but lack interpretability and may not capture expected relationships. This study proposes a framework that supports the development of interpretable models that incorporate domain knowledge and prior beliefs. The framework includes pseudo data samples and a loss function to measure relationship fulfillment. This approach combines the flexibility of ML structures with econometrics and interpretable behavioral analysis, improving model interpretability. The proposed framework's potential is demonstrated through a case study, providing a promising avenue for the advancement of data-driven approaches in DCM.

Paper ID: 4126

David Kohlrautz and Tobias Kuhnimhof

Modeling the Demand for Bicycle Parking Facilities

Improving opportunities for bicycle parking is essential for promoting cycling. However, there is a lack of approaches for predicting the demand for bicycle parking based on the facility type and the facility's location. Considering both during planning could help improve bicycle parking according to user needs. This is particularly applicable when cyclists face several parking options, such as on university campuses, as in our case study. The paper presents a stated preference-based model, which was additionally calibrated using bicycle parking count data. Considering facility types improves the model fit substantially. Furthermore, the stated preference-based, original model underestimates the sensitivity to walking distances between facilities and buildings. When cyclists can choose between multiple parking facilities, it is critical to consider walking distances to realistically predict the demand for bicycle parking facilities. This confirms previous findings, that positioning parking facilities close to destinations is essential for attractive parking infrastructure.

Paper ID: 4233

Sara Momen, Bart van Arem and Shadi Sharif Azadeh

Dynamic location for charging operations of shared free-floating e-scooters

Shared electric scooters (e-scooters) have recently become a popular mode of micromobility solution and this rapid growth causes significant operational challenges. One of the challenges micromobility companies face is collecting idle low-charge fleets from different corners of the city. The collector is usually a truck that needs to make a tour in town to collect these e-scooters. One solution can be for the operator to dynamically define special zones where e-scooters with low-charge are collected. In this paper, we propose a two-layered approach to tackle the problem. We propose a dynamic programming approach to investigate the required number and locations of designated low-charge drop-off points for the first layer of the problem. A simulated origin-destination data set of 30 e-scooters on TU Delft campus area is used for a time horizon of 8 working days and a time discretization level of 15 minutes. The results suggested consolidating low-charge e-scooters in three low-charge drop-off locations considering the state of charge (SOC) and distance of e-scooters from the low-charge drop-off zones. Then, we discuss the potential implications of our findings on recharging operations and spatial efficiency that are defined dynamically.

Paper ID: 4249

Mingye Luan, S.Travis Waller and David Rey

A non-additive path-based reward credit scheme for traffic congestion management

This study investigates the potential of non-additive path-based pricing for congestion management in urban transportation networks. We propose a novel path-based reward credit scheme to provide commuter incentives with the goal of reducing traffic congestion. We consider that a known proportion of commuters subscribe to this reward credit scheme and may earn credits when traveling in the network. We introduce a bilevel optimization formulation to determine optimal non-additive, path-based reward credits under traffic equilibrium conditions. In this formulation, the follower problem is a parameterized user equilibrium traffic assignment problem with two classes of users and non-additive path costs. We develop a single-level reformulation through its first-order optimality conditions. Customized branch-and-bound algorithms are designed to solve the problem. We conduct a comprehensive evaluation to demonstrate the efficiency of the proposed method in managing congestion compared with link-based road congestion pricing.

Paper ID: 4260

Joanna Ji, Qin Zhang, Ana Tsui Moreno and Rolf Moeckel

The impact of social networks and coordinated destination choice on the spread of epidemics using Episim

Person-to-person contact is fundamental to the spread of epidemics. Human mobility is important for understanding the pattern of person-to-person contact. Therefore, understanding human travel behavior is crucial to the understanding of the geographic spread of infectious diseases. Transportation models built to give details on human movement and contact can then be used to simulate epidemic spread. Such has been done in the epidemic model Episim. In addition, there is also research showing people's social networks have strong influence on their travel behavior, such as destination choice. Therefore this study sets out to verify whether adding social network and coordinated destination choice to the epidemic model has impact on the spatio-temporal transmission progression of epidemics. Results show that though the total number of infections do not change, the addition of a social network and coordinated destination help capture during what kind of activities infection events are taking place. Coordinated travel with social networks contribute to a more rapid spread in the beginning. Moreover, results emphasize that social networks should be integrated in conjuncture with joint-travel to better capture social travel behavior and in turn epidemic spread.

Paper ID: 4339

Laurent Cazor, Mirosława Łukawska, Mads Paulsen, Thomas Rasmussen and Otto Nielsen

Whose preferences matter more? Handling unbalanced panel data for choice modelling

The emergence of GPS-enabled smartphones and crowdsourcing tools are unique opportunities for understanding transport behaviour. However, the datasets they generate are often unbalanced, as individuals may use the service collecting data at different frequencies and periods. This raises important questions: are typical discrete choice models robust to this unbalance? Are model estimates biased towards over-represented individuals? This paper tackles the issue of handling unbalanced panel datasets for route choice modelling. It first develops a simulation experiment to study to which degree Mixed Logit Models with panel effects reproduce the population preferences using unbalanced data. It then investigates bias reduction strategies, including subsampling and likelihood weighting, which are compared to give guidelines that fit the model purpose. We show that weighting and subsampling techniques can reduce the bias when interpreting the model output for tastes. Combining these techniques helps to find an optimal trade-off between bias and variance of the estimates.

Paper ID: 4378

Christina Iliopoulou, Michail Makridis and Anastasios Kouvelas

Resilience-Oriented Design for Public Transport Networks

Public transport systems are typically designed based on estimated passenger demand and supply patterns, yet may often be called to operate under vastly different operational settings. To systematically design resilient transit systems, it is necessary to "weave" resilience-oriented thinking into the established public transport network design process, moving from an abstract concept to an implementable methodology. This study aims to effectively and efficiently design resilient public transport networks through the integration of Reinforcement Learning (RL), Local Search operators and Particle Swarm Optimization. We present a redundancy indicator and integrate it within a hybrid RL-enhanced metaheuristic solution framework to design more resilient route structures. We apply the proposed Memetic algorithm to an established benchmark from the literature and validate the proposed approach under a series of random and targeted attacks, simulating link disruptions. Results demonstrate that resilience can be enhanced through redundancy without adversely impacting average travel times.

Paper ID: 4390

Filippos Adamidis, Sara Moghavem Ghaffari and Constantinos Antoniou

Acceptance of car-reducing measures: observed factors and latent attitudes

Major cities are increasingly willing to reclaim public space from cars. This paper analyses the acceptance of car-reducing measures by different segments of the population. The respondents of a stated preference survey in Munich, Germany, were asked whether they accept one or more measures designed to decrease the ownership and use of private cars, and to state their opinion on theoretical statements regarding private cars and the environment. Factor analysis and binomial regression were employed to model the relationship between the established travel behaviour, socio-demographics and latent attitudinal con-structs on the one side, with acceptance on the other. The results showed that age, education, occupation and income, as well as environmentally friendly travel behaviour and attitudes play a major role in acceptance, thus providing valuable policy recommendations.

Paper ID: 4391

Han Zhou, Yashar Araghi, Bachtijar Ashari and Maaike Snelder

An activity-based latent class modelling approach to assess the impact of hybrid working on travel demand in the Netherlands after COVID-19

After COVID some employees can continue to work from home or at their work location. This hybrid way of working can impact transport demand and traffic conditions. Current models can not fully capture mobility patterns caused by hybrid working. We developed a dedicated latent class hybrid working model to predict which individuals will choose to WFH and how frequently they will WFH and integrated it into an activity-based model. We illustrate the potential of the model by simulating travel demand in a metropolitan region in the Netherlands. The results show that under some scenarios hybrid working can reduce mobility demand but under other scenarios these gains in work-home travel is lost by additional activities.

Paper ID: 4427

Léa Ricard, Guy Desaulniers, Andrea Lodi and Louis-Martin Rousseau

The stochastic multiple depot electric vehicle scheduling problem with recourse

Zero emission policies in urban centers are promoting the conversion of transit agencies fleets to battery electric buses (BEBs). This transition raises questions about battery management and more specifically about the best way to mathematically model this resource in order to respect energy feasibility constraints while being as little conservative as possible. In an attempt to partially answer these questions, this work presents a two-stage stochastic model with recourse for the multiple depot electric vehicle scheduling problem with stochastic travel time and energy consumption (S-MDEVSP). Vehicles are allowed to be partially recharged and a non-linear charging function is considered. Our model takes advantage of the full information on the current state of charge that is available in operation by allowing planned charge time to be extended when energy consumption deviations are observed. We propose a column-generation-based heuristic featuring stochastic pricing problems to solve a real-life instance from the city of Montréal, Canada. An analysis of the relevance of our approach for different commercially available BEBs is also provided.

Paper ID: 4434

Inneke Van Hoeck and Pieter Vansteenwegen

A heuristic approach to improve the robustness of a railway timetable in a bottleneck area

In this paper, a heuristic is presented to improve the robustness of a given railway timetable in a bottleneck area. The timetable can be adapted by adjusting the timing and routing of trains, but cannot deviate too much from the current timetable. Robustness is measured with an objective function that considers the buffer times between train pairs. The developed algorithm updates the routing and the timing in separate steps. It is applied to a bottleneck area of the Belgian network. The results show that the objective can be improved by about 10% when alternative routing options are considered. Additional experiments with smaller instances indicate that the heuristic is capable of finding near-optimal solutions.

Paper ID: 4477

Niousha Bagheri Khoulenjani, Milad Ghasri and Michael Barlow

Post-hoc explanation methods for deep neural networks in choice analysis

Deep Neural Networks (DNNs) are accurate and powerful tools for modeling travel decisions. Nonetheless, the black-box characteristic of DNNs has decreased their potential implication in discrete choice modeling. In this study, we investigate the potentials of cutting-edge post-hoc interpretation tools in providing behavioral insight into DNN architectures. We evaluate the relationship between the output probabilities and input features using the Shapely Additive explanations (SHAP) and Local Interpretable Model-agnostic Explanations (LIME). Using Swiss-Metro dataset, we demonstrate that the outputs of SHAP and LIME are consistent with theory when the architecture of DNN is designed based on the Random Utility Maximization (RUM) theory. However, for a fully connected DNN architecture, SHAP and LIME do not provide behaviorally interpretable outputs. Additionally, the prediction accuracy shows the DNN model based on RUM avoids overfitting.

Paper ID: 4548

Vishal Mahajan, Guido Cantelmo and Constantinos Antoniou

An open-source framework for the robust calibration of large-scale traffic simulation models

Large-scale traffic simulation models are a crucial tool for simulating and evaluating different transport solutions. However, due to the scale and complexity of these models, numerous parameters exist that can significantly influence their outputs. The problem of estimating these parameters is referred to as the Dynamic Traffic Assignment (DTA) calibration problem. After more than 30 years of research, several algorithms have been proposed that can - with a certain degree of success - address this challenge, even for large instances or in the presence of noisy data. Two challenges, however, remain critical today and are addressed in this paper. From a purely methodological perspective, DTA calibration is a highly under-determined problem, meaning multiple plausible solutions exist. This is particularly relevant when calibrating demand parameters. Therefore, in this paper, we propose two techniques inspired by the field of computer science that allow for enhancing robustness: bagging and Stochastic Parameter Averaging (or SPA). The second contribution of this research is more practical. While many algorithms have been proposed, the source codes of these algorithms are often not shared with the scientific community. As a consequence, most papers still use as a benchmark model the SPSA, an algorithm proposed roughly 30 years ago. Therefore, this study introduces an end-to-end open-source framework for DTA calibration. The model can calibrate supply and demand parameters, include state-of-the-art optimizers (W-SPSA, SPSA, Bayesian Optimization), an auto-tuning option to calibrate their parameters, and the bagging/SPA extension already mentioned. The conceptual framework proposed in this research is general and includes a few algorithms already. It is currently linked with the open traffic simulator SUMO to demonstrate its effectiveness. Researchers can use this framework as a benchmark or extend it using new simulators and optimizers. The method is tested both in controlled settings, as well as using the real-world large-scale network of Munich.

Paper ID: 4553

Benoit Matet, Etienne Côme, Angelo Furno, Sebastian Hörl and Latifa Oukhellou

Use of Origin-Destination data for calibration and spatialization of synthetic travel demand

The dynamics of urban transportations can be understood with activity-based models, which rely on synthetic travel demand data to get a comprehensive understanding of urban mobility. These data are usually derived from small population samples and surveys, which may be expensive and do not adequately cover the spatial trajectories of the users. In this paper, we explore the use of a time-dependent origin-destination (OD) matrix derived from mobile phone data for the attribution of locations in a synthetic population for the city of Lyon, France. OD matrix data can also mitigate uncertainties or outdated information in travel surveys regarding flows by time of day and between zones. The resulting population enrichment is measured in terms of fit to the input mobility data.

Paper ID: 4604

Federico Bigi, Nicola Schwemmle and Francesco Viti

Evaluating the impact of Free Public Transport using agent-based modeling: the case-study of Luxembourg

Luxembourg's high car ownership per household, combined with a strong population growth and high share of cross-border commuters, led to systematic traffic congestion issues all over the country. To address this problem, the government made public transport (PT) free in 2020 by eliminating second-class fares, a policy that attracted great interest but also led to controversial opinions on its real impact on car use. Notably, since free PT requires no ticketing, there is a problematic lack of passenger data that would allow assessing the policy impacts. Therefore, in this study a MATSim scenario was developed and used to evaluate the impact of this policy under realistic settings. The population was generated using data from a national travel survey collected in 2017 and the free PT scenario was compared against a benchmarking scenario where public transport was still not free, allowing to collect and analyse different KPIs. The simulation showed that the policy brought significant benefits in terms of Passenger Kilometer (PKT) and Hours (PHT) Travelled for PT, and a decrease in car usage in favor of PT especially for cross-border commuters for the parts of their journey that take place inside of Luxembourg. Nonetheless, this study found that the overall impact of Free PT was not significant enough to strongly impact the congestion levels, with the high car ownership rates being one possible reason for this resistance.

Paper ID: 4639

Gülin Göksu Başaran, Jesper Bláfoss Ingvardson and Otto Anker Nielsen

Influence of station characteristics, urban surroundings and perceived safety on satisfaction and public transport ridership

Public transport (PT) is essential to fulfill travel needs in urban areas. Predictors of PT ridership and satisfaction provide a good understanding of how new users can be attracted and existing users can be retained. Among these predictors, perceived safety and built environment (BE) attributes of stations and their surroundings still require further research. Using data from a tailor-made survey on train trips in East Denmark (1,004 respondents), we investigate the relationship between perceived safety, satisfaction and PT ridership and highlight the influence of BE attributes. Based on a structural equation model, we find a significant relationship between (i) perceived safety and satisfaction with trip-ends, and (ii) satisfaction with trip-ends and overall trip satisfaction. Lighting, maintenance and wayfinding are some of the essential attributes of stations, and their surroundings should not have isolated areas. No significant effect was found for trip satisfaction on PT ridership, but further research will consider this relationship.

Paper ID: 5245

Rong Cheng, Andreas Fessler, Allan Larsen, Otto Anker Nielsen and Yu Jiang

Assessing the Impacts of Public Transport-Based Crowdshipping: A Case Study in Nørrebro District in Copenhagen

This paper proposes a public transport-based crowdshipping concept as a complementary solution to the traditional parcel delivery system, where public transport users utilize their existing trips to carry out crowdsourced deliveries. To analyze the impact of public transport-based crowdshipping, we conduct a case study in Nørrebro district in Copenhagen using real-world data. Three scenarios with varying percentages of crowdshipped parcels are developed to be compared with the traditional distribution mode. For each scenario, the distribution of non-crowdshipped parcels is formulated as a capacitated vehicle routing problem and solved by the adaptive large neighborhood search metaheuristic. Results show that applying public transport-based crowdshipping could reduce the total vehicle kilometers traveled, the total working time of drivers, and the number of used vans (drivers) to perform last-mile deliveries. Moreover, public transport-based crowdshipping has great potential to reduce the total costs including driving costs, external costs, labor costs, and compensation.

Paper ID: 5254

Hassan Idoudi, Mostafa Ameli, Cyril Nguyen Van Phu, Mahdi Zargayouna and Abderrezak Rachedi

Enhancing Evacuation Planning and Management through Vehicular Communication

The current study presents a novel framework that aims to solve dynamic population evacuation (DPE) problems, divided into two phases: planning and online evacuation management, utilizing vehicular communication. During the planning phase, an initial evacuation plan is created by dynamically solving the shelter allocation problem (SAP) to determine destination choices and dynamic traffic assignment (DTA) to choose the best path to the selected destinations. Once the evacuation process begins, the vehicular ad hoc network (VANET) enables communication between evacuees, providing an opportunity to update initial decisions in real-time using VANET under the vehicular cloud computing (VCC) architecture, which considers the dynamic evolution of the hazard and traffic congestion levels. We apply the proposed online DPE framework to a test case in Luxembourg City to benchmark with existing planning methods. The results demonstrate that the proposed framework surpasses existing solution methods by more than 10\% in network clearance time. Furthermore, the proposed framework's performance is evaluated by changing the penetration rate of connected vehicles in VANET, which provides additional insight into the framework's effectiveness.

Paper ID: 5316

Liang Ma, Daniel J. Graham and Marc E.J. Stettler

Using Explainable Machine Learning to Interpret the Effects of Policies on Air Pollution: COVID-19 Lockdown in London

Activity changes during the COVID-19 lockdown brought an unprecedented opportunity to understand the likely effectiveness of prospective air quality management policies on reducing air pollution. Using a regression discontinuity design for causal analysis, we show that the first UK national lockdown led to unprecedented decreases in road traffic yet incommensurate and heterogeneous responses in air pollution in London. At different locations, changes in air pollution attributable to the lockdown ranged from -50% to 0% for NO2, 0% to +4% for O3, -5% to +0% for PM10 and there was no response for PM2.5. Using explainable machine learning, we show that the degree to which NO2 pollution was reduced in an area was correlated with spatial features (including road freight traffic and proximity to a major airport and the city centre), and that existing inequalities in air pollution exposure were exacerbated: pollution reductions were greater in places with more affluent residents and better access to public transport services.

Paper ID: 5382

Nicola Ortelli, Matthieu de Lapparent and Michel Bierlaire

Faster estimation of discrete choice models via weighted dataset reduction

When estimating discrete choice models, the prospect of using ever-larger datasets is limited by the poor scalability of maximum likelihood estimation. This paper proposes a simple and fast dataset reduction method that is specifically designed to preserve the richness of observations originally present in a dataset, while reducing its size. Our approach leverages locality-sensitive hashing to create clusters of similar observations, from which representative observations are then sampled and weighted. We demonstrate the efficacy of our approach by applying it on a real-world mode choice dataset; the obtained results confirm that a carefully selected and weighted subsample of observations is capable of providing close-to-identical estimation results while being, by definition, less computationally demanding.

Paper ID: 5383

Lubing Li, Ka Fai Ng, Jacob Lo and Hong Lo

Adaptive Traffic Signal Control: A Novel Modelling Approach

We develop a novel cell-based two-stage stochastic program to address spatial, dynamic and stochastic features of traffic flow for adaptive signal control. Cell transmission model (CTM) is employed to capture the dynamic feature of traffic flow, with certain CTM cells designated as detector cells to capture real-time spatial queuing effects. We formulate a two-stage stochastic program to address uncertain demand for signal control. In stage 1, a base timing plan (BTP) is determined as the long-term default plan. In stage 2, cycle-based adaptive policies, i.e., green extension/cut-off based on the BTP, are implemented accord-ing to the detector cell states. We develop a specialised GA algorithm to search for the op-timal BTP and adaptive policies. A case study of Tai Tam reservoir is conducted to elabo-rate the property of the proposed approach. The adaptive control plan can have 17% delay reduction compared to the optimal fixed-time plan.

Paper ID: 5388

Fábio Hipólito, Jeppe Rich and Peter Bach Andersen

Charging demand for the unserved — an agent-based model approach

Deploying charging infrastructure requires identifying the most effective placement and size of charging facilities. This is particularly challenging when electric vehicles (EVs) are gradually introduced, as it creates a dynamic target that must be met to ensure successful adoption of EVs. This paper introduces an agent-based simulation model that tracks movements of EVs in space and time. Our model is based on a choice model of charging behaviour, which is integrated with non-parametric queues and information-sharing of waiting time. Our simulation captures demand resulting from choice of charging and the unserved demand represented as charging intentions that were not met. It is demonstrated that unserved demand varies over time and across locations, and that it can be greatly reduced by our information-sharing strategy. The model is applied to Copenhagen where we examine changes in charging infrastructure requirements between 2021-2030 when going from EV shares of 2% to 30%.

Paper ID: 5528

Yiru Jiao, Simeon Calvert, Sander van Cranenburgh and Hans van Lint

Varying critical time to collision: a perspective of driver space

Collision warnings play a crucial role in preventing crashes based on estimating the critical time to potential accidents. Existing research and applications mainly focus on longitudinal vehicle interaction and headway keeping on highways. However, urban driving with frequent lateral interaction may have different critical time to collision. This study considers both longitudinal and lateral interaction through a two-dimensional spacing measure, driver space, to estimate the average critical time for drivers to respond to a potential collision. With the average spacing between vehicles at different levels of discomfort and in different relative speeds, we estimate the critical time via linear regression. Our experiments on two trajectory datasets find that drivers are more alert to collision dangers on highways compared to urban intersections, and drivers respond to potential collisions more quickly during lateral interaction than longitudinal. These findings emphasise the need of tailored collision warning systems for further improving road safety.

Paper ID: 5543

Xiaowei Zhu, Anupriya Anupriya and Daniel Graham

Understanding the cycle traffic impacts of Cycle Superhighways in London

Cycle Superhighways (CS) are the cycle routes that run between central London and outer London. They were introduced in 2008 as a way to encourage cycling and improve safety. This paper investigates the causal cycling demand and safety impacts arising from the introduction of CS. The analysis uses road traffic and accident data from the Department for Transport in the UK. Propensity score matching and panel outcome regression models are employed and compared to estimate the effects of CS for two different infrastructure types - segregated and non-segregated. Our results suggest that, on average, the intervention had a positive effect on cycle flow volume and cycle accidents, but no statistically significant effect on the cycle accident rate. Nevertheless, we find that segregated CS show a statistically significant decrease in cycle accident rate.

Paper ID: 5563

Khashayar Khavarian, Shaghayegh Vosough and Claudio Roncoli

How do electric bikes affect the route choice of cyclists? A case study of Greater Helsinki

Cycling as a clean, green, and environmentally friendly mode of transportation plays a crucial role in society by fostering physical activity and a healthy lifestyle, reducing traffic congestion, and improving mobility. To create more efficient strategies for promoting cycling, there is a need to gain a better understanding of the influential factors on cyclists' route choice behaviour. Electric bikes (e-bikes) are an emerging technology that appeared to assist cycling by using battery-powered motors. Researchers consider e-bikes as an emerging technology with its most certain effect being easing up cycling. Hence, investigating individual route choice behaviour with respect to their bike type can unveil new insights for cycling promotion. To this end, we used data collected via a stated preference (SP) survey in Finland not only to investigate the factors affecting cyclists' route choice behaviour but also to compare the behaviour of e-bikers with regular bike users (r-bikers) in order to identify the changes that may happen by easing the pedalling fatigue due to the pedal-assist feature of e-bikes. Our results indicate that low interaction with traffic, fewer intersections, and separated bike facilities are the main factors unchanged to promote cycling among r-bikers and e-bikers. Furthermore, we compare the outputs of simple Logit models (SLMs) and random parameter Logit models (RPLMs) for r-bikers' and e-bikers' route choices to address the impact of error correlation among observations in SP data. Our findings imply that the SP data is well-designed to capture the preferences of the individuals accurately, so the observations are not severely correlated, i.e., the IID assumption is held. This suggests that using SLMs can lead to similar outputs with RPLMs, without increasing the complexity of the estimation process.

Paper ID: 5618

Léon Sobrie, Marijn Verschelde and Bart Roets

Explainable predictions for real-time employee workload management in railway control rooms

Industry 5.0 targets a resilient, sustainable and human-centric European industry. A key initiative to reach this target is adopting a human-centric approach to digital technologies, which places the well-being of the worker at the center. As workload peaks/lows contribute to lower employee well-being, predictive employee workload analytics can empower management to undertake proactive prevention. For this purpose, we develop a real-time machine learning framework to predict and explain future workload. Our feature importance analysis demonstrates the value of human-machine interactions and partner workload exposure. The proposed 2-stage framework, inspired by deep Tobit models, is developed and implemented in an environment with a variable and imbalanced workload: the digital control rooms for railway traffic management of Infrabel, Belgium's railway infrastructure company. The related application is tailored towards the managers, for whom it provides real-time and explainable insights.

Paper ID: 5830

Camila Balbontin, John Nelson, David Hensher and Matthew Beck

Identifying main drivers for students and staff members' mode choice or to work/study from home: A case study in Australia

Universities are major trip attractors and generators in large cities, and they have a significant influence in the transport network particularly in high-density areas. The trips to and from university campus are made by staff, students and visitors, with an important daily rotation of people (e.g., students that leave early, arrive later, etc.). In this study, we aim to improve our understanding of the trips made to the University of Sydney campuses, one of the largest universities in Australia, how individuals (namely, staff and students) choose to study/work from home and their modes of transport used since the start of COVID-19. We have collected two sets of data in 2022 from a survey which was answered by both staff and students at the University of Sydney. A mixed logit model is estimated to understand the motivations and main drivers to work/study from home or to choose different modes of transport when attending campus.

Paper ID: 5954

Michal Bujak and Rafal Kucharski

Assessing expected ride-pooling performance with non-deterministic, heterogeneous travellers' behaviour.

Ride-pooling remains a promising emerging mode with a potential to contribute towards urban sustainability and emission reductions. However, recent studies revealed complexity and diversity among travellers' ride-pooling aptitudes. So far, ride-poling analyses assumed homogeneity and/or determinism of ride-pooling travellers. This, as we demonstrate, leads to a false assessment of ride-pooling system performance. We experiment with an actual NYC demand from 2016 and classify travellers into four groups of various ride-pooling behaviour (value of time and penalty for sharing), as reported in the recent SP study. We replicate their random behaviour to obtain meaningful distributions. Heterogeneity assumption proves to have a significant impact on the system. The performance indicators are shifted compared to the deterministic scenario. Albeit the high variability of travellers' preferences, system-wide results remain within reasonably narrow confidence intervals.

Paper ID: 5957

Gabriel Hannon, Joanna Ji, Qin Zhang, Ana Tsui Moreno and Rolf Moeckel

Implementing an Agent-Based Formation of Social Networks for Joint Travel

Introducing social networks to travel demand models could better capture socially induced travel behavior. This paper presents an agent-based approach to forming social networks that match important global characteristics and egocentric homophilies in distance, age, and gender for a population on the order of 10^6. Based on data from an egocentric snowball sample, this methodology successfully reproduces homophilies in age and gender, as well as an expected power-law distribution of geographic distance between connections. An initial clique formation heuristic is implemented on top of the homophily calculations. The generated network exhibits preferential attachment between agents of higher degree, in line with more general literature on network formation.

Paper ID: 6024

Emily Morey, R. Eddie Wilson and Kevin Galvin

Simulation of Mixtures of Legacy and Autonomous Mainline Rail Operations

This paper describes the analysis and development of a prototype (and first of its kind) simulator which models mixtures of legacy and autonomous mainline rail operations. This is achieved by using linked blocks to virtually superimpose occupancy information on two identical length tracks, one operating purely legacy trains and the other purely autonomous trains. These combine to form a single track running mixed operations. There are some surprising findings: the introduction of autonomous trains is not beneficial to system operations at all parameter settings, and moreover, there is a question of fairness to legacy train operations that may be adversely affected.

Paper ID: 6043

Kenan Zhang, Andres Fielbaum and Javier Alonso-Mora

What do walking and e-hailing bring to scale economies? A general microeconomic model for on-demand mobility

This paper investigates the impact of walking and e-hailing on the scale economies of on-demand mobility services. A microeconomic model is developed to explicitly characterize the physical interactions between passengers and vehicles in the matching, pickup, and walking processes under different market conditions and matching mechanisms. We show that passenger competition plays a critical role in scale economies. When unmatched passengers do not compete for idle vehicles, both street-hailing and e-hailing exhibit increasing returns to scale, although such property in e-hailing is less significant. In contrast, when there exists passenger competition, e-hailing service shows decreasing returns to scale. Street-hailing, however, is free of this detrimental effect thanks to its limited matching radius. While walking does not change the scale economies, it does benefit the system by reducing the total vehicle supply required to serve the same level of demand and improving the overall vehicle utilization rate.

Paper ID: 6199

Giancarlos Parady, Yuki Oyama and Makoto Chikaraishi

Text-aided Group Decision-making Process Observation Method (x-GDP): A novel methodology for observing the joint decision-making process of travel choices

Joint travel decisions remain poorly explained in behavioral models due to lack of empirical data. To address this problem, we propose a novel survey methodology to collect data on joint activities, from all members of a given clique. Through this method we are able to observe not only the outcome, but also the decision-making process itself, including the alternatives that compose the choice set, individual and clique characteristics that might affect the choice process, and the discussion behind the choice via texts. This will allow researchers to gain a deeper understanding of the joint decision-making process, including how alternatives are weighted, how members interact with each other, and how joint choices are made. Here we introduce the results of an implementation focusing on joint eating-out activities in Tokyo, focusing on survey components, execution, and insights on the data.

Paper ID: 6443

Tai-Yu Ma, Yumeng Fang, Richard Connors, Francesco Viti and Haruko Nakao

A fast algorithm to optimize meeting-point-based electric first-mile feeder services with capacitated charging stations

This paper addresses the meeting-point-based electric demand-responsive-transport routing and charging scheduling problem under charging synchronization constraints. The problem considered exhibits the structure of the location-routing problem, which is more difficult to solve than conventional electric vehicle routing problems. We propose to model the problem using a mixed integer linear programming approach based on a layered graph structure. A two-stage simulated annealing-based algorithm is proposed to solve the problem efficiently. A mixture of randomness and greedy partial recharge scheduling strategy is proposed to find feasible charging schedules under the synchronization constraints. The algorithm is tested on 20 instances with up to 100 customers and 49 bus stops. The results show that the proposed algorithm outperforms the best solutions found by a commercial mixed-integer linear programming solver (with a 2-hour computational time limit imposed) for 12/20 test instances and with less than 1-minute computational time on average.

Paper ID: 6449

Dimitrios Argyros, Renming Liu, Ravi Seshadri, Felipe Rodrigues and Carlos Lima Azevedo

Bayesian Optimization of Road Pricing using Agent-based Mobility Simulation

Road pricing policies are frequently debated but not widely adopted. Tools for designing near practice-ready policies are still missing, especially considering the complex dynamics between the different levels of traveller decision-making and the networks' performance. We couple an agent- and activity-driven mobility simulator with a Bayesian Optimization (BO) framework for designing optimal road pricing policy in a daily mobility and transportation network system. We extend the literature with a BO-framework application to distance-based road pricing under a departure-time and route-choice sensitive demand model combined with a detailed mesoscopic network. We then tested a general BO and a recently proposed contextual BO algorithm for SimMobility and computational performance. Both identified a similar optimum distance-based pricing, with the second being more computationally efficient. Nonetheless, iterations number, increasing search space and dimensionality could limit their performance. Lastly, the effects of the identified policy were analyzed by leveraging the outcome capabilities of SimMobility.

Paper ID: 6461

Hao Yin and Elisabetta Cherchi

A stated choice experiment to estimate preference for fully automated taxis: comparison between immersive virtual reality and online surveys

In this paper, we aim to study the role of the immersive Virtual Reality (VR) experience in the preferences elicited with standard Stated Choice (SC) experiments embedded into a VR environment. For this purpose, a SC was built and implemented both online and within a VR environment and respondents were asked to reply to both surveys. The SC experiment consists of a binary choice between a normal taxi with the driver (NT) and a fully automated taxi (AT). The context is a well-known street in the city centre of Newcastle upon Tyne (UK). Hybrid choice models were estimated and results compared. Results suggest that VR experience in-deed has significant effects on some attributes examined (waiting time and good reviews) and on the role of the latent variables in the choice of AT. Trust is significant only online, while injunctive norms and perceived safety only in the VR environment.

Paper ID: 6466

Fernanda Guajardo and Sebastián Raveau

Travel mode choice modelling of visually impair people through latent variables

It has been shown that people with disabilities perceive certain travel attributes differently, affecting their behaviour. It is relevant to understand the behaviour of people with disabilities to support public policies that address their needs. The objective of this research is to identify the factors that affect the mobility decisions of blind or visually impaired people, taking Santiago de Chile as a case study. With information from a total of 1,322 trips in Santiago made by people with and without disabilities, hybrid models of modal choice were estimated, including two latent variables: human interactions and use of technology. People who use more technology prefer ride hailing. Modes with direct contact with the driver are perceived more positively by people who assign importance to human interactions. Additionally, there is a significant difference in the perception of walking time. Walking time affects approximately 30% more blind or visually impaired people than people without visual impairment. Based on the results, there is proof of the relevance of having public policies that ensure subsidized taxi trips for people with visual disabilities or people with reduced mobility.

Paper ID: 6488

Milad Malekzadeh, Dimitrios Troullinos, Ioannis Papamichail and Markos Papageorgiou

Microscopic Simulation-based Testing of Internal Boundary Control of Lane-free Automated Vehicle Traffic

The TrafficFluid concept allows vehicles to move in a lane-free environment and enables capacity sharing between two directions without lane restrictions. In this context, Internal Boundary Control (IBC) has recently been introduced by the authors and its application has been investigated using macroscopic models. This paper presents a microscopic simu-lation-based validation of IBC using SUMO TrafficFluid-Sim, i.e. a simulation tool able to implement lane-free traffic. A Linear Quadratic Regulator (LQR), that is a feedback con-trol scheme, is employed for IBC. An extension of the well-known Cell Transmission Model (CTM) is utilized for the design of the controller. Simulation investigations confirm the effectiveness of the proposed scheme.

Paper ID: 6556

Cristian Domarchi and Elisabetta Cherchi

Changes in car ownership due to life events: Insights from the UK Longitudinal Household Survey

The decision of how many vehicles should a household have –if any– is likely to depend on life events that change the transport requirements of the household, such as the birth of a child, the change of employment status, a significant income variation, or a child moving out of the household to start living in another one. In this paper, we model changes in car ownership level as a function of socioeconomic individual and household attributes, as well as significant life events using a large sample of UK households sourced from the Understanding Society survey. We estimate a discrete choice model with specific parameters for increasing or de-creasing car ownership levels and considering panel and dynamic effects. Results show that life events play a significant role in predicting car ownership levels, and that households are relatively stable over time in terms of car holdings.

Paper ID: 6563

Caio Vitor Beojone and Nikolas Geroliminis

Providing a Revenue-forecasting Scheme to Relocate Groups of Ride-Sourcing Drivers

Proper positioning of ride-sourcing drivers may improve vacant travel times, waiting times, and matching opportunities. Herein, we evaluate the potential repositioning response of drivers when provided a guidance based on estimates of their earnings in a system offering ride-hailing (solo) and ridesplitting (shared) rides. We develop a strategy that enumerates the best regional repositioning destination based on the expected number of requests. A mixed continuous-discrete time Markov Chain (MDCTMC) is developed to predict drivers activities and the revenues associated with them. Our main findings indicate that the proposed approach is likely to retain drivers confidence by improving their earnings compared to other drivers. We also show that it manages to decrease the number of unserved requests compared to several state-of-art benchmarks and decreased the deadheading.

Paper ID: 6772

Severin Diepolder, Andrea Araldo, Tarek Chouaki, Santa Maiti, Sebastian Horl and Costantinos Antoniou

On the Computation of Accessibility Provided by Shared Mobility

Shared Mobility Services (SMS), e.g., Demand-Responsive Transit (DRT) or ride-sharing, can improve mobility in low-density areas, often poorly served by conventional Public Transport (PT). Such improvement is mostly quantified via basic performance indicators, like wait or travel time. However, accessibility indicators, measuring the ease of reaching surrounding opportunities (e.g., jobs, schools, shops, ...), would be a more comprehensive indicator. To date, no method exists to quantify the accessibility of SMS based on empirical measurements. Indeed, accessibility is generally computed on graph representations of PT networks, but SMS are dynamic and do not follow a predefined network. We propose a spatial-temporal statistical method that summarizes observed SMS trips in a graph on which accessibility can be computed. We apply our method to a MATSim simulation study concerning DRT in Paris-Saclay.

Paper ID: 7012

Andrea Pellegrini and John Rose

On allowing endogenous minimum consumption bounds in the Multiple Discrete Continuous Choice Model: An application to expenditure patterns

This study develops a novel econometric model that allows for the endogenous identifica-tion of minimum bounds on consumption. This is done by combining a censored Tobit model with a Multiple Discrete Continuous Extreme Value model. Whilst the former is employed to identify the minimum consumption of a good/service based upon the socio-demographic characteristics of the consumer, the latter is used to assess multiple discrete continuous consumption patterns. The proposed modelling framework is applied to inves-tigate individuals' expenditure behaviour with the attention being placed on the following expenditure categories: Transport, Shopping, Child Care, Entertainment, Household Bills, and Rent/Mortgage.

Paper ID: 7263

Hamoun Pourroshanfekr Arabani, Mattias Ingelström, Mats Alaküla and Francisco J. Márquez-Fernández

MATSim-based assessment of fast charging infrastructure needs for a full-electric passenger car fleet on long-distance trips in Sweden

This paper assesses the fast-charging infrastructure requirements to satisfy all long-distance trips by fully electric passenger cars. The main goals of this study are developing an accurate model for electric vehicle (EV) owner trips and their charging behavior, identifying candidate charging station locations and the number of chargers per station for fast charging infrastructure based on the developed model. The transition to EVs is gaining momentum, but the success of this shift relies heavily on the availability and accessibility of charging infrastructure. Several aspects of the fast-charging infrastructure planning problem are investigated based on the developed multi-agent model of EVs' usage using MATSim. The main contribution of this study is the introduction of a novel methodology to identify candidate locations for fast-charging infrastructure needs based on the missing energy event (MEE) in the MATSim EVcontrib and its application to assess the fast-charging infrastructure needs for passenger cars in Sweden.

Paper ID: 7360

Elham Hajhashemi, Patricia Lavieri and Neema Nassir

Applying a latent class cluster analysis to identify consumer segments of electric vehicle charging styles

Electric vehicle market growth makes understanding user charging behaviour essential for policy design and EV adoption facilitation. In this study, we examined the heterogeneity in charging preferences of 994 respondents across Australia, using a latent class cluster model that considers indicators of charging behaviour as outcomes of interest. We used sociodemographic characteristics, travel needs, and EV adoption status as covariates to predict class membership. Our findings identify five segments of consumers with distinct charging style preferences: cost-sensitive planners, cost-sensitive on-demanders, predictability seekers, flexibility seekers, and indifferent late adopters. We provide targeted policies for each segment based on their charging style and profile, aimed at facilitating EV adoption and meeting their charging needs. Our results suggest that two broad categories of action are necessary to facilitate EV adoption and meet charging needs of upcoming EV users: improving EV-related knowledge and providing economical home charging options.

Paper ID: 7441

Janody Pougala, Tim Hillel and Michel Bierlaire

Modelling the impact of activity duration on utility-based scheduling decisions: a comparative analysis

There exist two major categories of activity-based models: on one side, utility-based or econometric models are founded on the principles of random utility maximisation, and use discrete choice modelling techniques to solve activity-based problems. On the other hand, rule based approaches refute the assumption that decision-makers are perfect optimisers and their activity-travel behaviour is the product of context-dependent rules. Recently hybrid models (e.g. OASIS) combine both approaches, to keep the flexibility and theoretical robustness of utility-based models, with the addition of spatio-temporal constraints which increase the behavioural realism and simplify the estimations. However, hybrid models suffer from two main issues: specifying a utility function that accurately reflects the decision-making process, and estimating parameters in a highly complex space due to the constraints. In this paper, we answer these questions within the context of the OASIS framework (Pougala et al., 2022). We first estimate the parameters of two state-of-the-art utility functions (Charypar & Nagel, 2005; Feil, 2010), using data from the Swiss Mobility and Transport Microcensus (BFS & ARE, 2015) and compare them with OASIS' default linear-in-parameters utility function of the model.

Paper ID: 7561

Haoye Chen, Jan Kronqvist, Wilco Burghout, Erik Jenelius and Zhenliang Ma

Mixed Integer Formulation with Linear Constraints for Integrated Service Operations and Traveler Choices in Multimodal Mobility Systems

Multimodal mobility systems provide seamless travel by integrating different types of transportation modes. Most existing studies model service operations and travelers' choices independently or limited in multimodal travel options. We propose a choice-based optimization model for optimal operations of multimodal mobility systems with embedded travelers' choices using a multinomial logit (MNL) model. We derive a mixed-integer linear formulation for the problem by linearizing transformed MNL constraints with bounded errors. The preliminary experimental test for a small mobility on demand and public transport network shows the model provides a good solution quality.

Paper ID: 7670

Kacper Rossa, Andrew Smith, Richard Batley and Phillip Hudson

The valuation of arrival and departure delays in the UK passenger rail using satisfaction survey data

Stated preference surveys are typically used to derive reliability multipliers, defined as a trade-off between a minute of lateness and scheduled journey time. In this study, travel satisfaction data from the National Rail Passenger Survey in the United Kingdom is used to estimate the impact of scheduled journey length and delays on passenger satisfaction. An ordered logit model with OD fixed effects is estimated and reliability multipliers are subsequently derived. The estimated values are slightly larger than previously suggested, ranging from 4 to 9 for arrival delay and 2 to 6 for departure delay. The study offers some degree of novelty in terms of the type of data used in the estimation process. As a result, some caution is needed in using and interpreting the estimated multipliers. On the other hand, this study highlights the potential that satisfaction surveys may have in transport economics.

Paper ID: 7809

Kailin Chen, Daniel Graham, Richard Anderson, Anupriya Anupriya and Prateek Bansal

Understanding the Capacity of Airport Runways

Understanding the capacity of runway system under different operational conditions is of critical importance to airport operators and planners. The availability of granular data on day-to-day runway operations facilitates the development of models that allow a precise comprehension of runway capacity. However, the exercise is empirically challenging due to statistical biases that emerge via the complex interactions between air traffic control and runway capacity. This paper develops a novel causal statistical framework based on a confounding-adjusted Stochastic Frontier Analysis (SFA) to deliver estimates of runway capacity and its parameters that are robust to such biases. The model captures the key factors and interactions affecting runway capacity in a computationally intensive manner. The performance of the model is demonstrated via benchmarking of the estimated capacities of three major airports around the world.

Paper ID: 7837

Bogdan Kapatsila, Dea van Lierop, Francisco J. Bahamonde-Birke and Emily Grisé

The Effect of Incentives on the Actions Transit Riders Make in Response to Crowding

Public transit crowding influences riders' satisfaction and needs to be tackled using both demand and supply management approaches. In this study, we focus on the policy response to public transit crowding using customer incentive schemes. We used statistical tests and an an Integrated Choice and Latent Variable model to analyze data collected in Metro Vancouver, Canada, during the COVID-19 pandemic. Our findings suggest that people who favor incentives tend to be more likely to change their travel behavior in response to crowding and that incentives that reduce the cost of travel have more potential to shift riders' travel time, while other incentives have a more pronounced effect on the decision to travel via a less crowded route. These findings are aimed at public transit agencies interested in employing policy instruments to manage transit crowding and researchers seeking to advance the knowledge about the influence of personal attitudes on travel behavior.

Paper ID: 7898

Nejc Geržinič, Maurizio van Dalen, Barth Donners and Oded Cats

The impact of covid-19 on modal shift in long-distance travel

This research aims to analyse the perception of covid-19 infection risk in long-distance travel in Europe and how it impacts mode choice and travel behaviour. We make use of an HII variant type experiment and model it by means of a latent class choice model, where we uncover four distinct user groups. For infection risk perception, we apply a novel approach in the field, utilising a weighted least squares regression, to obtain seg-ment-specific regression functions, based on their respective probabilistic segment alloca-tions. Some segments exhibit risk-aversion behaviour that is time-based (longer journeys perceived as more risky), whereas others see it as time-independent. With respect to modal preferences, the four segments either show a strong preference or aversion to one of the two land-based modes: car-loving, car-averse (using train or air), train-loving and train-averse (using car and air).

Paper ID: 7914

Ryota Okazaki, Yuki Oyama, Naoto Imura and Katsuhiro Nishinari

Day-to-day delivery demand management: Evaluation based on routing efficiency and customer satisfaction

As demand for online shopping and home delivery increases rapidly, courier companies often offer services focusing on customer satisfaction. This places strong constraints on the planning of delivery routes for courier vehicles, making delivery routes inefficient. The objective of this study is to present a framework to evaluate demand management policies in terms of the balance between customer satisfaction and delivery efficiency. To this end, we first estimate a delivery option choice model using the stated choice data of e-commerce users. Then, based on day-to-day delivery demand simulated by the estimated model, we optimize a multi-period vehicle routing problem and evaluate the delivery efficiency. We implement two policies: a surcharge for morning delivery and an expansion of the time slot range. The results show that the former significantly reduces customer satisfaction, while the latter achieves higher customer satisfaction and delivery efficiency.

Paper ID: 8134

Anna Reiffer and Peter Vortisch

Estimating Household-Level Time-Use within a Week Activity Scheduling Framework – Application of the MDCEV Model

Activity-based approaches have become state-of-the-art in travel demand modelling due to their behavioural realism. While there have been great advances in modelling techniques, most studies do not consider the household context, and almost all are limited to the generation of single-day activity schedules. Therefore, we propose an activity generation and scheduling approach for one week, considering the household context. This study provides a general overview over the proposed framework, and further details the model used to generate household-level activity time-use for the period of one week. The proposed model contributes to the current state of activity-based models as it goes beyond individual, single-day travel demand and allows for analysis of household-level decisions for the modelling period of one week.

Paper ID: 8170

Aurore Sallard and Milos Balac

Bayesian Networks for travel demand generation: An application to Switzerland

Bayesian Networks (BNs) are probabilistic graphical models representing conditional dependencies existing between variables of interest. Recent studies have employed BNs for population synthesis and daily activity plan generation. Those studies highlight the ability of BNs to efficiently detect the causality links between variables in an easily interpretable way. This short paper aims to propose a further application of BNs for both population and daily activity plan synthesis in Switzerland. We show that understanding the dependency structure linking the population characteristics and its mobility behaviour is key to generating representative synthetic activity patterns. Furthermore, we lay the foundations for the development of temporally transferable travel demand models.

Paper ID: 8358

Nico Kuehnel, Shivam Arora, Felix Zwick and Qin Zhang

Simulated Annealing in a Co-Evolutionary, Agent-Based Transport Modeling Framework - The Example of Ride-pooling Driver Supply Optimization

This paper introduces an integrated simulated annealing optimization method within the co-evolutionary agent-based transport modeling framework MATSim, using a small illustrative ride-pooling service as an example to optimize driver shift supply for a given and static demand. Simulated annealing is a metaheuristic optimization algorithm that has already been employed in a wide range of problems and domains. MATSim makes use of a co-evolutionary design in which individual agents try to optimize their daily schedule by finding optimal transport options. The iterative nature of both simulated annealing and MATSim's co-evolutionary design makes the implementation straightforward and compatible. The outcomes validate the feasibility of the approach in optimizing specific components of the transport model and indicate its potential for future use in comparable applications. The presented case of driver supply optimization may help to design scenarios for new services and to better assess the efficiency and costs of such a service.

Paper ID: 8433

Sijia Sun, Hossam Abdelghaffar, Sérgio Batista, Mónica Menéndez and Yuanqing Wang

Analyzing Network-wide Energy Consumption of Electric Vehicles in a Multimodal Traffic Context: Insights from Drone Data

The environmental benefits and driving range of electric vehicles are closely related to their energy consumption. In this paper, we analyze the energy consumption characteristics of electric mobility systems in a multimodal urban traffic context by establishing the aggregated relationships between macroscopic fundamental diagram (MFD) dynamics and network-wide energy consumption. To do this, we utilize a data-based approach, combining vehicle trajectories collected by a swarm of drones in the downtown areas of Athens, Greece, during the pNEUMA experiment with microscopic energy consumption models. We assume all the trajectories are driven by electric vehicles yet maintain the same behavior observed in the pNEUMA dataset. Preliminary results show well-defined relationships between aggregated traffic parameters and energy consumption at a network level. The total energy consumption of electric cars and buses in the network increases linearly with vehicle accumulation under uncongested traffic conditions. At the same time, the energy consumption per distance traveled by electric buses significantly decreases as the spatial mean speed increases. While for electric cars, the impact of spatial mean speed on energy consumption is marginal, especially when the average speed is above 10 km/h.

Paper ID: 8505

Gaurav Malik and Chris Tampère

Application of a Metamodel-Based Optimization Approach for Toll Optimization and its comparison with Metaheuristics-based Model Optimization via a Case Study.

First, a concept of metamodel-based optimization, in which a transport economics inspired model acts as a metamodel over an underlying set-up of directly interfaced transport models, is discussed. Then, a toll optimization scenario including a city and its neighboring rural municipalities is developed and a case study concerning its cooperative version is presented. The metamodel for this case study involves the player(s) optimizing their objective based on a schematic network, and simplified cost and demand functions, whereas the underlying set-up is a Static Traffic Assignment over the physical network with physical origin-destination elastic demand. This new metamodel-based optimization is then compared with traditional metaheuristics-based optimization. Results show that the new approach not only leads to lower computational expense but even outperforms metaheuristics-based optimization in terms of optimality.

Paper ID: 8554

Bingyuan Huang, Hans Wüst and Mathijs de Haas

Assessing the Long-term Impact of E-bikes on Sustainable Mobility: A National-Level Study in the Netherlands

Over the past decade, e-bikes have become increasingly popular, sparking interest in their potential replacement for car use and benefit for the environment. However, studies on e-bike substitution effects have limitations, including a lack of assessments of the effects on mobility on the national level, a narrow focus on commuting travelling, and insufficient consideration of future expected e-bike use. This study proposes a new approach that combines an intention-based method with time-series forecasting to estimate e-bike use and investigate its potential for sustainable mobility in the Netherlands. The results show that e-bike ownership strongly reduces the conventional bicycle use and, to a lesser extent, car and public transport use, especially for commuting travelling. This study provides in-sight into how e-bikes substitute for car use and other modes of transportation, and how the expected growth in e-bike use in coming years may impact national mobility in the Netherlands.

Paper ID: 8572

Lorena Torres Lahoz, Francisco Camara Pereira, Georges Sfeir, Ioanna Arkoud, Mayara Moraes Monteiro and Carlos Lima Azevedo

Attitudes and Latent Class Choice Models using Machine Learning

We present a method of efficiently incorporating attitudinal indicators in the specification of Latent Class Choice Models (LCCM), extensions of Discrete Choice Models (DCMs) that segment populations based on the assumption of preference similarities. We introduce Artificial Neural Networks (ANN) to formulate the latent variables constructs. This formulation overcomes structural equations in its ability to explore the relationship between the attitudinal indicators and the decision choice, given the machine learning (ML) flexibility and power to capture unobserved and complex behavioural features, such as attitudes and beliefs. All of this, while maintaining the consistency of the theoretical assumptions presented in the Generalized Random Utility model and the interpretability of the estimated parameters. We test our proposed framework for estimating a car-sharing service subscription choice with stated preference data. The results show that our proposed approach provides a complete and realistic segmentation, which helps design better policies.

Paper ID: 8690

Ana Tsui Moreno, Matthias Langer and Rolf Moeckel

How mobile are persons with mobility restrictions? Analysis of number of days with activities using one-week activity schedules in Germany

In Germany, 13% of all residents are disabled and 9.3% are even classified as severely disabled, which includes elderly people with limited mobility as well as physically disabled and mentally disabled people. Persons with mobility restrictions often report on barriers to meet daily needs, which is usually reflected on fewer days to perform out-of-home activities. The objective of this research is to evaluate whether persons with mobility restrictions are less mobile using one-week activity schedules. The results of the models confirm that persons with mobility restrictions are generally less mobile; being statistically significant for work, shop and recreation activities. It was found a significant interaction between occupation status and mobility restriction on the number of mobile days of most activity types, as well as an impact of the number of mobile days for mandatory activities on the number of mobile days for discretionary activities.

Paper ID: 8724

Saumya Bhatnagar, Rongge Guo, Jihui Ma and Mauro Vallati

Prediction of Passengers Demand for Customized Bus Systems

The customized bus system is an innovative demand-responsive public transit service with the potential to significantly alleviate congestion and environmental footprint. To fully exploit the flexibility of this approach, it is pivotal to forecast the demand for the service, in order to optimize the use of vehicles and resources. In this paper, with the aim for supporting the use of customized bus systems, we formalize the predictive task and assess the performance of a range of machine learning techniques. We introduce a two-step predictive task aiming at (i) identifying the presence of demand and, if there is actual demand, (ii) estimating the number of passengers to be served. The experimental analysis, based on realistic data from the Beijing area, shed some light into the performance of different classes of approaches.

Paper ID: 8738

Josephine Grau, Lea Fuchs, Torben Lelke and Peter Vortisch

City-wide bottleneck and deficiency analysis on a road network generated from the Open Street Map road network using Floating Car Data (FCD)

The German Highway Capacity Manual (HBS) and the German Guideline for Integrated Network Planning (RIN) rely on travel time distributions to assess the Level-of-Service (LOS) of roads and road networks. Usually, these values are generated by traffic measurements or with the help of traffic flow simulations. In recent years Floating Car Data (FCD) has become an essential data source for analyzing traffic quality because of its easy accessibility and growing coverage. This paper proposes a method to perform a city-wide analysis on the Open Street Map (OSM) road network using raw FCD. Therefore, OSM road segments of a city are aggregated to longer network sections on which travel times are estimated. Performance indicators can be calculated using these travel time distributions. Examples are shown for the cities of Karlsruhe and Hannover.

Paper ID: 8819

Benjamin Gramsch Calvo and Kay W. Axhausen

Exploring the impact of the social network geography on the individual's activity space using structural equation models

Most leisure travel has social motivations, one of them is to be in contact with people from their social network, this means that the decision does not only depends on individual preferences and restrictions but also on the other person (or persons) involved in the activity. This means that the places an individual visits for leisure are strongly correlated with the geographic location of their social network. This hypothesis is tested with a structural equation model that includes social needs and mobility demand as latent variables. The model shows a strong correlation between these two variables, showing a positive impact on the geographic distribution of social networks and the number of contacts with the area of leisure activity space, and the number of frequently visited locations. This model shows the social network's importance in individual mobility decisions and patterns.

Paper ID: 8845

Adrien Nicolet and Bilge Atasoy

Choice-driven Service Network Design and Pricing in Intermodal Transport

In intermodal transport, Service Network Design (SND) problems cover most tactical decisions of a carrier. Nevertheless, among the literature on SND, very few works include pricing decisions and the preferences of the shippers. In this study, we contribute to the existing body of knowledge by proposing a choice-driven and cycle-based formulation of the Service Network Design and Pricing (SNDP) problem which considers different aspects of the mode choice decisions of shippers. This formulation aims at finding the itineraries, frequencies and prices of the services that will maximize the profit of an intermodal carrier. Moreover, the mode choice preferences of shippers are modeled as a utility maximization accounting not only for the logistics costs, but also the frequency of the offered services and the accessibility of the transport mode. This bi-level formulation can be reformulated into a single level linear problem. The proposed model is compared to two other models (one cycled-based and one path-based) where shippers are assumed to be purely cost minimizers. While the latter generate higher profits, they also result in unrealistic mode shares, with road transport being negligible. On the other hand, the proposed formulation leads to mode shares that are considerably closer to reality. In addition, higher revenues can be generated with a cycle-based formulation compared to a path-based as it allows for more consolidation opportunities for the carrier.

Paper ID: 8955

Ida Kristoffersson and Chengxi Liu

Estimation of demand models for long-distance cross-border travel

Although long-distance cross-border travel contributes significantly to global emissions from the transport sector, transport models for this type of travel are scarce. In this study, a dis-aggregated travel demand forecasting model is estimated using Swedish national travel survey data 2011-2016 along with detailed supply data from European road, train, and ferry networks and a World-wide air network, aiming at forecasting Swede's long-distance travel abroad. Mode choice, destination choice and trip generation are modelled by traditional Nested Logit models and Multinomial Logit models. Results show that values of time of long-distance cross-border travel derived from the model estimation are in general higher than values of time of long-distance domestic travel. Furthermore, elasticity estimates of level-of-service attributes for train suggest that infrastructure investments in high-speed rail network may have a profound effect on demand for long-distance cross-border travel, especially for business trips.

Paper ID: 9052

Lynn Fayed, Gustav Nilsson and Nikolas Geroliminis

On the dynamic pricing of pool ride-hailing services in bus lanes

Ride-hailing vehicles contribute to traffic congestion in urban areas, where spatial constraints and uneven multi-modal distribution of infrastructure are a constant problem. In fact, roaming empty vehicles cause additional delays to other concurrent network users without delivering passengers to their destinations. Ride-splitting is one potential solution to counteract the negative impact of ride-hailing on traffic. In this work, we provide a dynamic non-equilibrium modelling framework for ride-splitting, where pool passengers are allowed to use dedicated bus lanes and can potentially travel faster than solo users. The objective is to develop a ride-splitting pricing policy between solo and pool options to encourage trip sharing with the goal of minimizing overall delays in multi-modal networks with bus lanes. Therefore, a Model Predictive Control (MPC) framework is set forward to investigate the price difference between the two ride-hailing alternatives with the objective of reconsidering the space allocation between the available modes. The results show that the proposed strategy is able to adjust the time-dependent fare changes based on the multi-modal demand and speeds in different parts of the network.

Paper ID: 9070

Jaime Soza-Parra and Oded Cats

Who is ready to live a car-independent lifestyle? A latent class cluster analysis of attitudes towards car ownership and usage

The excess use of private cars for transportation has multiple negative effects on our society, and therefore, determining the underlying factors driving car usage among different groups of travellers could contribute to a more sustainable future. In this paper, we aim to identify and characterise traveller groups in terms of their car-related attitudes and how different sociodemographic attributes, behavioural characteristics (such as using cars as the primary mode of transportation), and their residential location accessibility vary amongst different population groups. Through Confirmatory Factor Analysis and Latent Profile Analysis we identify five different classes, namely car detractors, hesitants, positives, friends, and lovers. Overall, . We also see that the farther away households tend to be located from urban areas and public transportation facilities, the closer the relationship with cars. The results of this analysis will provide valuable insights into how to dis- courage the use of cars and promote more sustainable mobility.

Paper ID: 9239

Marko Maljkovic, Gustav Nilsson and Nikolas Geroliminis

On fair discounted charging in electric ride-hailing markets with limited budgets

Coordinated charging of electric vehicles (EVs) has the potential to provide significant benefits to both electric vehicle owners and the wider community. In fact, intelligent, coordinated charging of large electric fleets, such as the ones operated by ride-hailing companies, could be essential in preventing a collapse of the energy market. We study a scenario in which a central body, e.g., the power-providing company or the government, wants to influence how the EVs of different ride-hailing companies spread among different charging stations by offering discounted prices of charging. Compared to previous works in this domain, we investigate a Stackelberg-based mechanism that takes into account potentially limited discount budgets available to the companies. We propose an iterative method to compute the local Stackelberg equilibrium that guarantees fairness in the sense that we have equal prices of charging for all ride-hailing companies. Finally, we test the proposed method in a simulated case study based on taxi data from the city of Shenzhen.

Paper ID: 9272

Daniel Heimgartner and Kay W. Axhausen

Contributions of Can, May and Want to the Home Office Frequency Decision

Camawa. Can, may and want. These are the constituents of the home office frequency decision. Not every job can be done from home nor is it a matter of all or nothing. Every job profile can be positioned on a continuum reflecting its home office feasibility. Further, those who can, might not may: Firms call back employees to the office or set constraints such as a home office budget. Last but not least cama does not mean anything without wa - the preference dimension. This work tries to account for all three dimensions simultaneously by means of a structural equation model (SEM). We find that the may dimension is of most substance and an employee's perception of her employer's point of view plays a crucial role in it. Meanwhile, preferences are governed by several suitability considerations. Personal suitability, residential suitability and the suitability of the home office workstation play into the decision, perceived personal suitability being the most important of the three.

Paper ID: 9280

Margarita Gutjar, Chiara Calastri and Matthias Kowald

Householdfleet adaptation as reaction to price regulations: A stated adaptation experiment on the promotion of electric vehicles

The goal to limit global warming requires a shift to electric vehicles and a reduction of vehicles in total. To achieve this transition, governments could design price regulations effectively. The potential effect of different price regulations has been assessed by surveying 466 respondents. After providing detailed information on all mobility tools in the household, respondents were faced with four scenarios with varying price regulations concerning prices for fuel, CO2, electricity, and public transport. Given the reported mobility tools and supported by live calculation of resulting cost changes, respondents were asked to adapt their household fleet while being allowed to choose the mobility tools at a high level of detail. Results of a multinomial logit model show that increasing fuel prices, very low electricity prices, high EV subsidies and low public transport prices have the potential to decarbonize household fleets (remove conventional vehicles and/or replace by an electric vehicle).

Paper ID: 9291

Jing Lyu, Feixiong Liao and Soora Rasouli

Modeling Visit Probabilities within Space-Time Prisms of Daily Activity-Travel Patterns

Space-time prism (STP) delimits the space-time opportunities reachable by a moving object and is widely applied to measure the ability of individuals to travel and participate in activities. The majority STPs are binary measures in that all locations are considered equally accessible if within the prisms. A few probabilistic STP models discussed heterogeneous interiors, but they focus on the trip level and have not addressed daily activity programs with flexible activity sequences. This study proposes a model framework to construct and estimate the state-dependent probabilistic STP of daily activity-travel patterns based on the multi-state supernetwork representation. Utilizing GPS trajectories, the estimation and simulation results of visit probabilities in the STPs demonstrate the validity of the model framework.

Paper ID: 9370

Gijsbert Koen de Clercq, Maaike Snelder, Arjan van Binsbergen and Bart van Arem

Analysing the Effects of Adding Shared Electric Bicycles as a New Mode on the Modal Split of Multimodal Trips between Delft and Rotterdam Using an Unlabelled Multimodal Supernetwork

Assessing to what extent new modes will change modal split is difficult, since revealed preference data is not available yet to estimate models. To address this, an unlabelled multimodal supernetwork is developed in which mode and route choice are simultaneously modelled. The model has been estimated based on data of existing modes and can be used to assess the impact of any new mode. We applied the model to analyse the effects of shared e-bicycles on one Origin- Destination pair between Delft and Rotterdam. The main scientific contribution of this paper is that it successfully demonstrates how an unlabelled multimodal supernetwork can be used to analyse the effects of shared e-bicycles on the modal split between Delft and Rotterdam. The results show that the modal share of shared e-bicycles is 35.3-40.5% for unimodal trips and occur in 36.2-46.3% of multimodal trips, indicating that shared e-bicycles can significantly change the modal split.

Paper ID: 9406

Allister Loder and Klaus Bogenberger

MobilityCoins - an integrated multimodal Wardropian model for policy analysis

MobilityCoins are a tradable mobility credit (TMC) scheme, where all modes can have link-specific and origin-and-destination-specific charges and incentives. These schemes are alternatives to congestion pricing and fuel excise taxes. Their design as a cap-and-trade scheme means that a fixed market volume is defined based on a to-be-regulated quantity. MobilityCoins are distributed to all travelers, who use them to pay for mobility or sell them on a market. However, the question of how to select policy parameters of such schemes in real-world contexts remains unanswered. In this paper, we develop a multimodal Wardropian transport model with integrated MobilityCoins scheme for transport policy analysis. Travelers have the choice between cars, public transport, and bicycles, where only cars experiences congestion effects. Using a simple model, we illustrate how a MobilityCoins scheme impacts transport outcomes under different system designs, e.g., declining overall market volume of MobilityCoins.

Paper ID: 9449

Gabriel Nova, C. Angelo Guevara, Stephane Hess and Thomas O. Hancock

Random Utility Maximization model considering the information search process

Choice modelling has been dominated by static representations preferences due to their ease of implementation, transparent economic interpretability, and statistical coherency. Unlike, the Decision Field Theory (DFT) model explicitly includes the attribute scrutiny process within the choice decision, making it more closely related to the behaviour that is observed in practice. However, the DFT model lacks the RUM model's microeconomic interpretability and has statistical limitations regarding the identification of the model parameters. This research introduces the RUM-DFT model, encompassing ideas from both approaches. Using Monte Carlo simulations and applying the proposed model to a database of real choices, it is first shown that the proposed approach can properly identify the parameters of the deliberation process, replicate the dynamic behaviour of the utilities during the deliberation process; and retains full economic interpretability since the estimated coefficients correspond to marginal indirect utilities when there is perfect knowledge of the information search process.

Paper ID: 9659

Jose Holguin-Veras, Diana Ramirez-Rios and Trilce Encarnacion

Who is Responsible for the Externalities Produced by Freight Carriers? Hint: The Answer is Not as Simple as it Seems…

This research sheds light into an important and overlooked aspect of urban freight management and planning: the impacts of the decisions made by shippers, receivers, transportation and land use agencies, the real estate sector and other agents—referred to as non-carrier agents, or NCAs—on the generation of freight externalities. The paper is based on the insight that, since freight carriers must meet the constraints set by these agents, NCAs' decisions could force the carriers to create externalities above and beyond those that the carriers would generate if they had complete control over their operations. As part of the research, the authors: identify a number of NCAs' decisions that could negatively affect the operational performance and the externalities produced by freight carriers; and compute the corresponding Shapley Values to allocate the responsibilities for the freight externalities among carriers and NCAs using numerical experiments based on real-life supply chains. The insights gained are used to identify policy implications related to electrification of the trucking sector.

Paper ID: 9818

Eui-Jin Kim and Prateek Bansal

A new flexible and interpretable choice model with monotonicity constraints, non-linearity, and taste heterogeneity

This study proposes a flexible and interpretable discrete choice model (DCM) capturing key behavioural mechanisms simultaneously: (i) interactions between alternative-specific and individual-specific attributes (e.g., taste heterogeneity), (ii) interactions between alternative-specific attributes, (iii) inherent non-linear utility of alternative-specific attributes (e.g., dimin-ishing marginal utility of travel cost). Deep neural networks (DNNs) have been considered as candidates to flexibly capture these mechanisms, but they fail to provide trustworthy and explainable economic information (i.e., interpretability) obeying domain-specific knowledge (e.g., decrease in utility of travel mode due to an increase in its travel cost). We propose a DCM based on a lattice network (LN) that efficiently imposes attribute-specific monotonicity constraints in the utility specification while ensuring the trustworthy interpretation of DNNs. The proposed LN-based DCM is benchmarked against DNN in a Monte Carlo study. The re-sults show that it outperforms even the parametric DCM in terms of interpretability while slightly underperforming the DNN in terms of predictability.

Paper ID: 9852

Nicole Adler, Gianmarco Andreana and Gerben de Jong

Competing on Emissions Charges

This research presents a game-theoretic model to analyse market equilibria in the presence of environmental policies at national and supranational levels. In a two-stage game, regulators maximise welfare over their jurisdiction by setting emission charges, whilst airlines compete through frequencies, fares, and fleet choice. Consequently, airlines decide whether to absorb the costs of the environmental charges, pass them on to consumers, replace part of their fleet with more efficient aircraft or redistribute the inefficient fleet to less regulated itineraries. The equilibria outcomes suggest the presence of several distorting forces that can undermine the effectiveness of environmental policies. To assess the robustness of our results, we apply the model to North American and Western European markets, under different regulatory setting, finding that a reduction in the emissions produced comes at the expense of the welfare and that the effectiveness of the policy is limited when regulators interact in their own interests.