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Future Mobility Options: Simulation of ownership of autonomous vehicles in an integrated land use/transport model

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EXTENDED ABSTRACT

Autonomous vehicles are receiving increasing attention due to the potential environmental, economic and safety benefits associated with driverless travel. On the other hand, autonomous vehicles are likely to increase travel demand, because travel will become more convenient and – if used as ride share vehicles – less expensive. To assist decision-makers assess the impacts of autonomous vehicles on transport supply and travel demand, it is important to first capture the level of autonomous vehicle ownership and access to shared autonomous vehicles.

Projections by the Victoria Transport Policy Institute indicate that, should autonomous vehicle implementation follow the pattern of other vehicle technologies, autonomous vehicles will represent 50% of vehicle sales, 30% of vehicles, and 40% of all vehicle travel in the 2040s. As autonomous vehicles penetrate and shared mobility gets more popular, cars will not only be owned by households, but also by providers of shared mobility services such as DriveNow and Uber.

At the household level, the possibility of using cars from shared vehicle providers and the possibility of sharing an autonomous vehicle among household members can reduce the number of cars needed by a household. At the same time, the possibility of non-drivers to independently travel in an autonomous car may increase household car ownership.

To identify the true effects of autonomous vehicle on household car ownership, the ownership of autonomous vehicle is modeled as part of car ownership in an integrated land use/transport modeling suite. This modeling suite simulates land use and travel behavior from 2010 through 2050 for the Munich metropolitan area in Germany and it includes the Simple Integrated Land Use Orchestrator (SILO) module, the Microscopic Travel Demand Model Orchestrator (MITO) module, and the MATSim module for traffic assignment. The presentation aims to describe the completed works and the ongoing efforts to integrate autonomous vehicle considerations in this modeling suite.

First, a traditional car ownership model has been estimated with data from the 2008 National household travel survey (Mobilität in Deutschland). The estimation was based on a multinomial logit formulation to find the utilities of a household to own 0, 1, 2, or at least 3 conventional cars. The significant variables included number of license holders in a household,

number of workers in a household, household income, distance to transit, and the area type of the household's zone. Since there were no records of households owning any autonomous vehicle in 2008, there was no explicit consideration of autonomous vehicle in the initial estimation. The model has been implemented in SILO as microsimulation to determine the number of cars owned by each synthetic household in the base year and validated against census data.

For subsequent years, a car ownership update model is being developed to be run each year to adjust the number of cars owned by a household. With an exogenously given share of households that change number of cars in a year, the base year probabilities to own 1, 2, or at least 3 cars are scaled by the level of affordability of shared autonomous vehicles to adjust the number of household cars. For each simulation year, each household can adjust their number of cars by a maximum of 1 car.

Subsequently, an autonomous vehicle ownership model, which has a binomial logit formulation, simulates a household's decision to replace a conventional car with an autonomous vehicle. The decision is influenced by the costs of autonomous vehicles as well as the costs of shared autonomous vehicles. The replacement is assumed to be a one-way process only such that a household may switch from a conventional vehicle to an autonomous vehicle but not the other way round. Depending on exogenously given rates of availability, affordability and acceptance of autonomous vehicles, conventional vehicles will gradually be replaced with autonomous vehicles until all conventional vehicles are replaced in the long run.

In addition to describing the implementation of the autonomous vehicle component in the modeling suite, the presentation provides different scenarios of autonomous vehicle penetration patterns and describes how each will affect household car ownership vis-à-vis ownership by providers of shared mobility services. Once shared autonomous vehicles enter the market, they are assumed to be available to anyone who is willing to pay the fare. The fare will be given exogenously, and scenarios will be used to test the impact of different price schemes.

The ability to consider the ownership of autonomous vehicles in an integrated land-use transport model should enable the assessment of a wide range of impacts such as reduced parking costs, accident and emissions. Since some potential benefits of autonomous vehicles can only be derived when the autonomous vehicle is available on a large scale, the annual run of the car ownership update model will greatly help in determining when to expect these benefits.

So far, car ownership models have not explicitly modeled household's transition from conventional vehicles to private autonomous vehicles or membership of shared autonomous vehicles. To the best of our knowledge, this will be the first attempt to model transitional car ownership considering private and shared autonomous vehicles.