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Are cars used differently in Germany than in California? Findings from annual car-use profiles

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ABSTRACT

The personal car is the most important mode of transport in most countries. Many policies are in place in different countries and regions to tackle unsustainable trends associated with car travel. A reason for the varying success of the same measure from one country to another might be different car-usage patterns. Using Germany and California as case studies to investigate differences and similarities in car use, we adapted the CUMILE model both for Germany and California in order to generate detailed profiles of car use over one year. Hierarchical cluster analysis subdivided the sample into clusters with similar car-usage characteristics. Then, we compared clusters of cars with similar usage between Germany and California in terms of cluster size, car properties and sociodemographic characteristics of their owners. The same eight car-usage clusters emerged in both study areas–with varying cluster sizes. We descriptively labeled the clusters: standing cars, moderate-range cars, day-to-day cars, workday cars, weekend cruisers, long-distance cars, short-haul cars and all-rounders. A better understanding of car-use patterns throughout a year and the size and characteristics of car-use clusters is beneficial for the identification of policies to make transport systems more sustainable.

1. Introduction

The personal car is by far the most important mode of transportation in both Germany and in California accounting for 71% and 73% of daily vehicle miles travelled (VMT) as well as for 32% and 34% of VMT in long-distance (LD) travel (Caltrans, 2013; Manz, 2004; Weiss et al., 2016a). Reliance on the car for most trips is associated with unsustainable trends, such as air pollution, GHG emissions, traffic congestion, noise pollution, and space consumption – especially for parking facilities (Banister, 2007; Downs, 2004). Federal, state and local governments in Germany and in California implement policies to increase the sustainability of the transport system. These policies aim either to avoid or reduce the need of car travel (e.g. urban development measures), to shift trips to non-automobile modes (e.g. greater cost of car parking), or to improve vehicle efficiency (e.g. electric vehicles) of motorized transport (Priester et al., 2013).

Policies geared to reduce car usage can either tackle car ownership decisions or car-use decisions. Car ownership is a long-term decision and car use a short-term decision which might be easier to change. National household travel surveys and other travel surveys only provide car-use data of short periods, e.g. one day. These data are not sufficient to understand car-usage patterns and reasons for owning a car, because driving can vary greatly from day to day. Particularly irregular long-distance holiday or leisure trips are not captured during short survey periods. Households may own cars for specific purposes – such as LD trips for example – that are not easily measured with single day travel surveys. Only a few datasets and studies focus on the intensity and frequency of car usage over longer time periods (e.g. one year) (Axhausen et al., 2004; He et al., 2016; Khan and Kockelman, 2012; Pearre et al., 2011). Downsides of these studies are small sample size, not representative samples, and a limited geographic focus on the city or regional level.

To overcome these downsides, we developed the modeling approach CUMILE (Car Use Model Integrating Long-distance Events) to identify intra-car and inter-car variability of car-use patterns over one year for a representative car fleet by combining existing data sources. Knowledge of car-usage patterns throughout a year can be beneficial for the identification of effective sustainable transport policies. Policies could target specific car-usage groups for the promotion of more efficient car drives/engines, including cars that are mainly used for long-distance trips or certain trip-distance ranges for electric vehicles. Policies could provide special incentives to usage groups that are candidates for the substitution of privately owned cars by carsharing memberships, targeting cars that are rarely used or just on weekends. A

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better understanding of specific car-usage groups could also help gauge potential impacts of road-charging schemes and distance-based tolls on different user groups. Moreover, more knowledge of car-usage groups could help identify geographic areas for expansion of public transport networks and active transport infrastructure in areas where cars are mainly used for short hauls.

We apply our approach to data for Germany and California. Germany and California are well suited applications for our study on car use as both are wealthy countries (respectively states) with high standards of living and a comparable geographic size (see also Kühne et al., 2018). Their motorization rates are amongst the highest in the world and both study areas have extensive networks of limited access highways (Buehler, 2011). However, they differ in urban density, the level of infrastructure supply for non-motorized modes and cost structures for transport (e.g. petrol prices) (IEA, 2016). Studying comparably wealthy areas allows controlling for similarities, such as income or motorization, while accounting for differences, such as transport policies or spatial development patterns. Understanding differences in car usage in similarly wealthy areas with different car-usage levels may help inform policy decisions to make transport more sustainable (Kühne et al., 2018).

With this study, we aim to answer why car use differs so much between the two study areas. Our hypothesis is that there are certain groups of car drivers in both study areas, who use their cars similarly but that the size of these groups differs between countries. If this is the case, we may be able to identify what transport policies could work for which groups of cars. Further research questions are: how can these car-use patterns be described? Do cars and car owners in the same usage groups differ between the two study areas in terms of car properties and sociodemographic characteristics? Therefore, we adapt the CUMILE model both for the German and the Californian market in order to generate detailed car-usage profiles over one year. We then cluster these car-usage profiles in order to identify cars with similar usage patterns. Thereafter, we compare the cluster sizes for both study areas as well as car properties and sociodemographic characteristics of car owners in both study areas.

2. Literature review

Our paper mainly contributes to the literature about variability in car use over time. Adding to that literature we introduce a new tool for estimating and describing patterns of variability in car use over time. The technical literature on variability in car use over time onbased on GPS or travel surveys are highlighted first and discussed in greatest detail in our literature review. In addition, our analysis of variability in car use also touches on emerging research about irregularity of travel patterns and variability in travel behavior in general. The second part of the literature review summarizes that literature briefly as well.

With few exceptions, studies on variability of car use over time have been published in the last 15 years. Thus, this is an emerging field of research. The main limitation to studying variability of car use over time has been the lack of available data, because most travel surveys focus on just one travel day. In general, there are two approaches towards measuring variability of car usage over time: (1) GPS studies that track specific vehicles or persons and (2) studies that adapt travel surveys to estimate car use over time.

The implementation of GPS based car-use surveys is a newly feasible approach. Pearre et al. (2011) analyzed GPS data of gasoline powered cars in the Atlanta metropolitan region for up to two years in order to assess car use on LD trips and the market potential of electric vehicles (EV) – mainly focusing on range limitations and recharging needs of EVs. Car owners were recruited based on random selection. The sample included 484 vehicles and was representative for the population in the Atlanta Metropolitan Region. Elango et al. (2007) used this dataset for an analysis of day-to-day variability of car use. In this study variability is measured as differences in daily car-trip rates on the household level. Results show that the propensity of car-use variability is higher for high-income households, larger households, multi-vehicle households, households with children and households with students. Similar to the study in Atlanta, Khan and Kockelmann (2012) conducted a GPS survey of 424 cars in Seattle, WA over one year to derive car-use characteristics over longer time periods and to predict the market potential of plug-in electric vehicles (PHEV). Schönfelder (2006) and Axhausen et al. (2004) utilized a GPS survey conducted in Borlänge, Sweden for 80 weeks to analyze variability and repetition in daily travel. The Borlänge sample includes GPS traces of 186 cars traveling within the City of Borlänge plus a 25 km radius. Thus, LD trips are not recorded in this sample. They identify relative stability of car travel over time because they only find an average of 0.2 new destinations per week when analyzing data for multiple weeks. The omission of LD trips may account for the relative stability found by this study. He et al. (2016) analyzed GPS car profiles in Beijing, China. Data were collected for one to six months to assess market acceptance of battery electric vehicles (BEV) and hybrid electric vehicles (HEV). Participants were recruited at car dealerships, drivers' clubs and online. The final sample includes 434 cars. Results suggest that heterogeneity in car use is important when investigating real-world acceptance and benefits of EVs. Comparisons with other countries show that cars in Beijing have a higher share of habitual travel and shorter habitual travel distances compared to cars registered in German and American cities (He et al., 2016).

GPS data have several shortcomings. Samples are often small, tailored to a single city only and not representative. The costs of GPS data collection are high (Elango et al., 2007), sample coverage is limited and data quality problems can occur due to temporary GPS signal loss or signal reflection by tall buildings (He et al., 2016). Another shortcoming of passive travel data collection such as GPS is that certain trip information such as trip purposes are not recorded (Elango et al., 2007).

Another approach to analyze car-use patterns over longer periods is the creation of models adapting data collected from travel surveys. In one early study, Greene (1985) used the National Family Opinion Poll Gasoline Diary Panel as input data for his model identifying car mileage distributions between refueling. This dataset is an odometer reading survey where participants report every refueling of their car(s) over the period of 36 months. The model assumes that daily travel is as a series of independent random values and thus car use (mileage) between one day and the next day does not correlate, and the underlying probability distribution for daily mileage is a gamma distribution. However, other longitudinal travel behavior studies (Elango et al., 2007; Schönfelder, 2006; Susilo and Axhausen, 2014) suggest that part of a person's travel behavior is subject to repetition because persons regularly travel to destinations such as their workplace, gym, or the nearest supermarket and often use the same mode of transportation for their trip. The He et al. (2016) study cited above used a similar approach to predict the probability of the annual frequency of car use for LD travel. The authors developed a mathematical function that consists of both, an exponential distribution and a Gaussian distribution. The Gaussian portion of the distribution is supposed to represent habitual travel patterns and the exponential portion of the distribution depicts rare trips, such as LD trips. Similar to that, Plötz (2014) developed a methodology to assess the number of days per year with LD car trips using data with limited observation periods. He assumes that daily car mileages are lognormal distributed.

Our article also links to a growing body of literature studying variability of daily travel – comparing typical and irregular days. For example, Kuhnimhof et al. (2012) found increases in ‘multimodality’ for daily travel in Germany – indicating that 20–29 year olds, and especially men, in the mid-2000s displayed more varied mode usage for daily travel than the same age group in the 1990s and 1970s. While Kuhnimhof et al.’s study focuses on changes in typical daily travel over time, Reichert and Holz-Rau (2015) study long-distance travel using Germany's national household travel survey from 2008. They find that those with higher incomes, higher education level, in households with