Combining Two Types of Data to Analyze the Effects of Covid-19 on Car Usage

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ABSTRACT

The COVID-19 pandemic shows a major impact on the travel behavior of individuals. Both the fear of infection and political measures lead to a significant decline in the overall travel demand and a modal shift from public transport to individual means of transport. Thus, the car plays a more significant role since the outbreak of the pandemic. To understand the effects on car usage, this study analyzes the car usage before and during the COVID-19 pandemic in spring 2020 in Germany. To identify changes in car mileage, we combine two surveys of the German Mobility Panel: The survey on everyday mobility and the survey on fuel consumption and odometer reading. We develop a method to combine both data sources and explain the mileage differences between them consistently. Based on this, we compare the mileage captured in 2019 and 2020 and identify which types of households in- or decreased their car usage. The results show that most households reduced their mileage. However, differences were found primarily among commuters and urban residents. While many commuters reduced their mileage due to working from home, some urban residents increased their mileage. This can be attributed to mode shifts towards individual means of transport. Overall, it becomes evident that examining identical households and cars before and during the pandemic allows for a deeper understanding of the impacts of the COVID -19 pandemic.

Keywords: COVID-19, car usage, longitudinal data, Germany, German Mobility Panel

INTRODUCTION

Since the spread of the infectious disease with the COVID-19 virus was classified as a pandemic by the World Health Organization (*1*), people in Germany live in an exceptional situation. In order to limit the spread of the virus, federal and regional authorities promoted social distancing and mandated preventive measures (*2*). At different times and with varying scopes of the measures taken, countries worldwide announced mandates to wear masks in public, stay-at-home requirements, social distancing, closing shops and restaurants, school closing, or even workplace closing. The most severe measure was a lockdown enforced in Germany in spring 2020 to restrict public life to bare essentials. After the first lockdown period, a period of cautious easing followed at the beginning of summer 2020.

The COVID-19 pandemic has major effects on the travel behavior of individuals. Since the disease outbreak, people behave differently partly because they are afraid of the infection and partly because they are subject to political measures. Studies show that two effects are primarily evident: On the one hand, a generally lower level of travel and, on the other hand, a change in the choice of means of transport (*3–6*). Eisenmann et al. (*7*) show a growing significance of individual means of transport and especially of the private car compared to public transport. Shamshiripour et al. (*8*) found a shift from public transport to means of transport with less contact, such as the private car as well as walking and cycling. Molloy et al. (*9*) describe similar effects. It was found that the use of public transport has strongly decreased. The study of de Haas et al. (*4*) indicates that the already negative attitude towards public transport increased during the pandemic while the car was positively perceived. Furthermore, the study suggests that with a higher share of walking, the radius of action of individuals decreased. This is in line with the results of Axhausen et al. (*3*). As the radius of action returned to normal in the course of looser measures in summer 2020, it can be assumed that the changes in travel behavior triggered by the pandemic will not necessarily remain in the future. However, some changes induced by the pandemic, such as a higher level of working from home, are considered to have long-term effects on the transport demand and thus on the transport system (*8*).

The car is a flexible means of transport. In Germany, it has already played a significant role before the pandemic. In 2019, people in Germany traveled 54% of their traffic volume by car (*10*). Eisenmann et al. (*11*) used data from the German Mobility Panel (MOP) to determine the annual vehicle kilometers traveled (VKT), which was on average 12,624 VKT in 2014. The data of the MOP was also used in the study of Weiss et al. (*12*). In this study, two types of data sets of the MOP, namely a trip diary on everyday mobility (EM) and data from a fuel consumption and odometer reading survey (FCOR), are combined to explain car usage in Germany. Based on the combination of these two data sets and data of other surveys, such as the survey on long-distance travel in Germany INVERMO (*13*), car usage within German households for a whole year was modeled. This allowed the description of car usage in a longitudinal perspective. For example, it was found that, on average, 33% of VKT is traveled on freeways.

As discussed above, car usage was affected in two directions during the COVID-19 pandemic. During the pandemic, the passenger car has taken on a unique role. However, the overall travel demand has declined during the pandemic because of implemented measures to stop the spread of the disease (*6*). Several studies describe a shift from public transport to private cars (*7; 8; 14–16*). From official statistics, we can indicate a severe decline in car travel during the COVID-19 pandemic. The collected travel volume on German Highways serves as an indicator for describing the decline of car usage and the decline in the long-distance travel demand. Data from permanent counting stations of the Federal Highway Research Institute in Germany show a reduction of 40 to 47% of the number of cars on German Highways in the second half of March compared to February 2020 (*17*). During the Easter holidays in 2020, a reduction by 58% of the number of cars at the measurement points on German highways compared to pre-pandemic conditions was measured. Until mid-July in 2020, the traffic volume was slowly recovering. The official statistics on mineral oil sales in Germany are another data source for roughly describing the decline in car usage. While gasoline sales dropped significantly in April 2020 to just 66% of previous years, gasoline sales recovered quickly and were back to last years' levels by July 2020.

The outcomes of the presented literature lead to two consequences that will be explored in this study: First, increased car usage induced by the pandemic is assumed because other means of transport with a higher risk of infection were less used. In addition, destination choice was affected. For example, holiday trips abroad by plane were replaced by domestic trips by car increasing car usage. Second, less car usage is expected, since the overall activity space of individuals has been reduced in the course of the pandemic, e.g. by working from home or by canceling long-distance travel. Our study looks at these two effects and examines what type of cars and households are affected by each. By analyzing car usage in pre-pandemic conditions, we also aim to identify the changes during the spring 2020 lockdown depending on usage patterns. For our analyses, we use data from the MOP. Following the approach of Weiß et al (*12*), a combination of the EM survey and the FCOR allows for a more detailed description of car usage in German households. We build on this finding and also use these data sets of the MOP for our study. Our study pursues two goals:

1. The combination of the two unique data sets (EM and FCOR) from the MOP, considering everyday mobility and occasional events included in the VKT of cars.
2. Tracing the effects of the COVID-19 pandemic on car usage by comparing the FCOR of 2019 and 2020 in combination with the reported car usage in the EM 2019

The paper is structured as follows: First, we describe the MOP survey in detail and the collected information in both parts of the survey. Second, we present our method to combine both datasets of 2019 (FCOR and EM) to describe car usage in more detail, including trip purposes. Based on this, we use the FCOR data of 2020 to analyze the effects of COVID-19 on car usage. We use the characteristics of households and cars to identify changes in car usage during the pandemic. This is followed by a discussion of the results and our method. Finally, we give a conclusion and refer to further research.

DATA

Our study is based on the German Mobility Panel (MOP) data, which provides a yearly account of the everyday mobility of the German population. Since 1994, the survey is carried out on behalf of and funded by the German Federal Ministry of Transport and Digital Infrastructure. The Institute for Transport Studies of the Karlsruhe Institute of Technology (KIT) is responsible for the design and scientific supervision of the survey (*10; 18*). The MOP is designed as a rotating panel. People participate for a maximum of three consecutive years. The study allows insights in longitudinal perspectives for everyday mobility, car mileage and fuel consumption of private households. To this aim, the survey consists of two parts: A survey about everyday mobility (EM) (yearly in autumn) and a survey about fuel consumption and odometer reading (FCOR) (about five months later, in late spring/early summer the following year). The EM provides information about all trips during seven consecutive days (one week) and sociodemographic data on household and individual levels.

Furthermore, the survey participants report on illness, vacation, days their car was in the shop and other abnormalities within the survey period. Around 1,800-2,000 households with 3,000-3,400 respondents aged ten years and older contribute to the MOP. The yearly survey period excludes any holidays to best capture everyday mobility. In addition, a subsample that consists of households owning at least one car is asked to report the refueling of their cars and the respective odometer readings. The FCOR survey covers a survey period of eight weeks (April to June). This period represents a typical period for car usage observation because standard workweeks and periods with public holidays (e.g. Whitsun, Ascension Day) are included. About 1,600 cars of 1,200 different households contribute to this part of the survey every year. The participants are asked to fill in a diary reporting all refueling events (date, odometer reading, amount of gasoline dispensed, refueling cost). Furthermore, information on car characteristics and car usage patterns are reported.

Data collection during the pandemic was conducted in the planned survey process. We use three years of data (2018-2020) for the analyses. The data sets of FCOR of 2019 and 2018 and EM of 2019 serve as pre- COVID-19 references. The FCOR data set of 2020 was collected in spring 2020 during the

pandemic. The survey periods in 2019 and 2020 are displayed in Figure 1. The 2019 MOP survey data were collected before the declaration of the pandemic. In January and February 2020, hardly any infections were reported in Germany. The FCOR survey in spring 2020 was conducted during the first lockdown period of the COVID-19 pandemic. During this period, the infection rates decreased after the implementation of preventive measures. It was followed by a period of cautious easing of the restrictions.

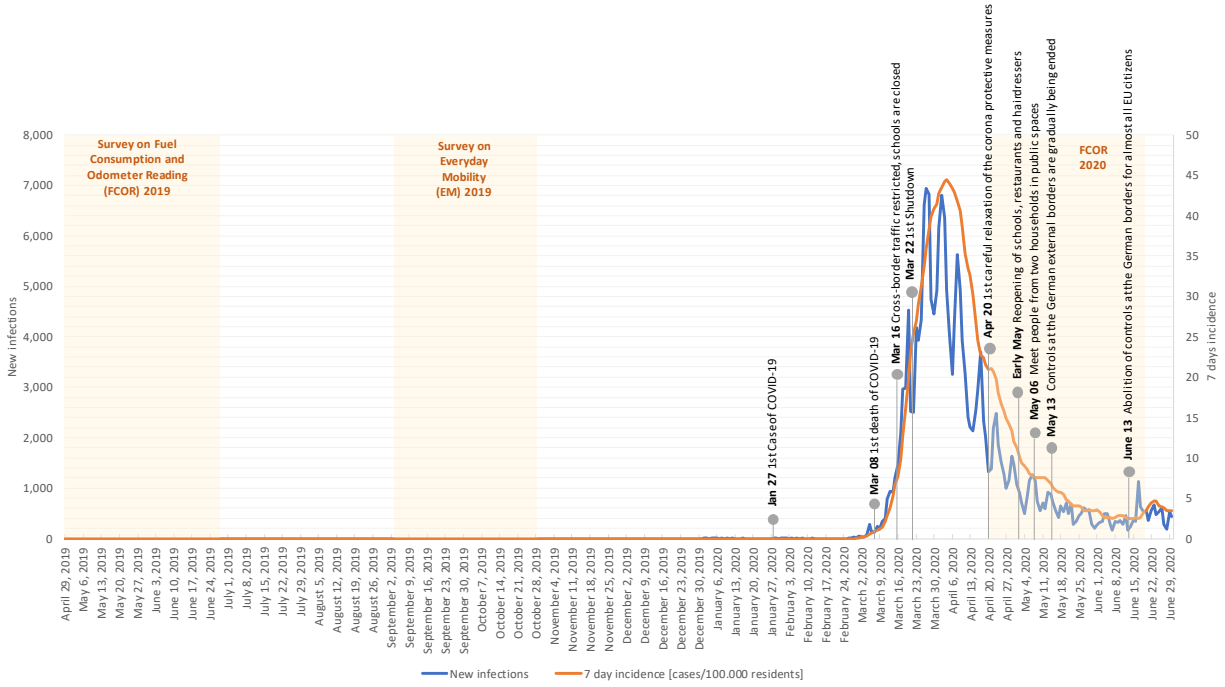

Figure 1 Survey periods of the MOP and development of COVID-19 infections in Germany (2019-2020)

Analyzing longitudinal data of the MOP allows quantifying changes in travel behavior in times of a pandemic. To this aim, we identify consecutive participating households participating in FCOR19, EM and FCOR20. Our study uses a subsample to focus on households where we rely on all trip diaries of driver's license owners and all refueling reports of all household cars. In total, the data we use contains information from 298 different households with 399 cars.

Figure 2 displays the socio-demographics of the sample used. 37% of the households have a high household income. The majority of people in the households is full-/ or part-time working. Furthermore, the share of men to women is nearly balanced. In addition, 71% of households own one car. This is because our sample primarily consists of households with one or two persons.

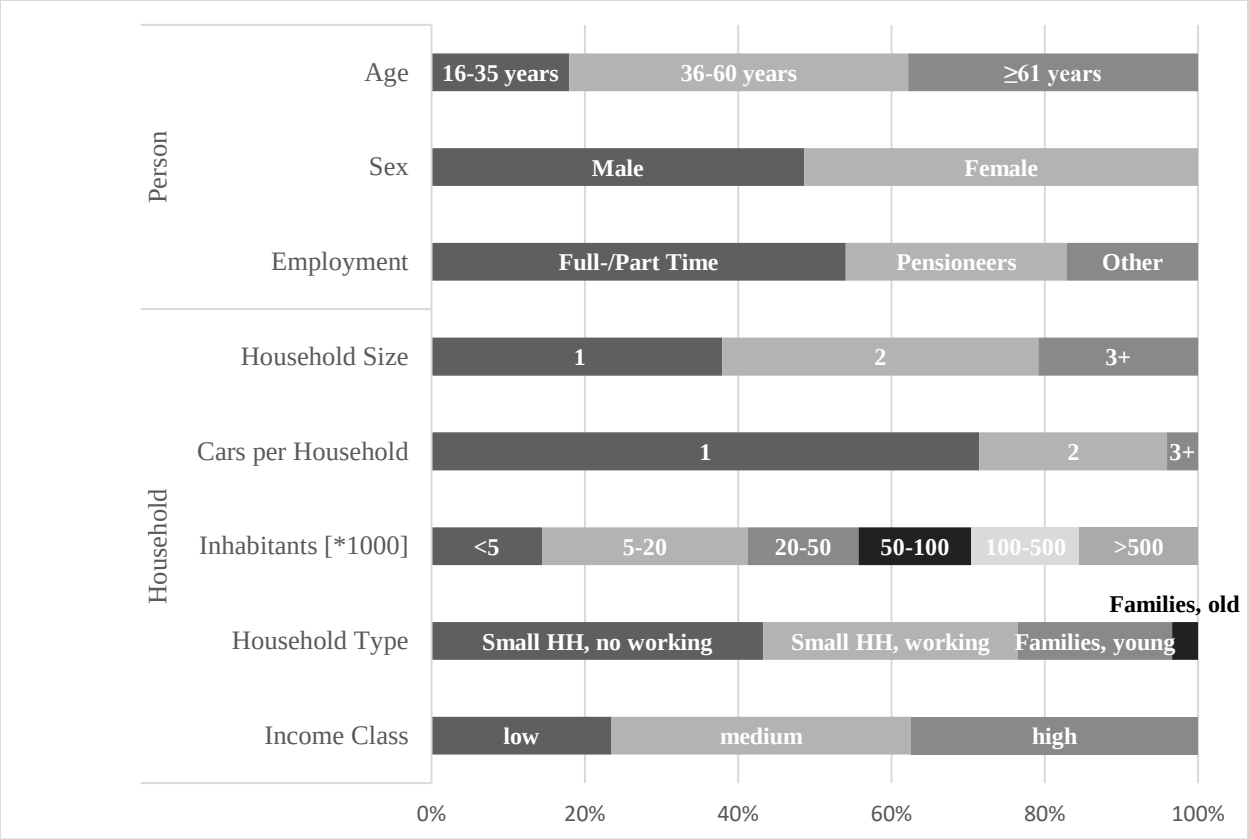

Figure 2 Characteristics of the subsample (N=298)

METHOD

In this section, we describe the methodological approach. Since the two surveys have a different focus and data structure, linking FCOR and EM is challenging. While EM provides information on trips made by each household member within seven days, FCOR exclusively focuses on car travel and monitors fuel consumption and monthly vehicle kilometers traveled (VKT). The report in FCOR and EM is voluntary. Consequently, the data sets partly contain incomplete information. Further, differences and variations on the household level between years occur. Since we know the number of cars that are held in the household, we know how many cars are missing. The analysis on the household level for multi-car households is only reliable for complete household fleets' subsample. We opted for a household-based approach instead of a person-based or car-based approach. Since the FCOR is limited solely to car usage, it is impossible to make any conclusions about other means of transport. Consequently, we cannot assess how overall mobility changed during the lockdown in spring 2020, but only car mobility.

To narrow the differences in VKT between EM and FCOR, we introduce *ordinary days* when reporting individuals do not have mobility constraints such as illness, vacations, or other limitations. In addition to these constraints, we also examine the effects of long-distance travel events and weekend travel. However, the best fit between EM and FCOR was found for *ordinary days*, which also allow for long-distance travel. To minimize the effects of rare occasions, an *ordinary week* consists of at least three *ordinary days*. This measure aims to minimize the differences between the FCOR and EM in terms of VKT.

For combining EM and FCOR, it has to be considered that EM and FCOR survey household car usage differently. First, the different reporting periods need to be mentioned. The FCOR is surveyed in spring (Figure 1). This period is reasonably used for short vacation trips because of the convenient timing of public holidays. Therefore, an increase in long-distance travel is more likely due to vacations than in

autumn. Second, non-everyday travel events such as vacation trips or business trips are more likely to be captured in FCOR due to the longer reporting period. However, Eisenmann and Kuhnimhof (11) show that the annual VKT calculated from FCOR represents the average annual VKT in Germany reasonably well and seasonality is not a big concern. Domestic sales of gasoline in Germany confirm the representativeness of the survey period of the FCOR (20).

Table 1 Mileage of all passenger cars in households for various purposes in the fall of 2019

Variable		Mean/HH [km]			Mean/Pers [km]			Standard Deviation			CV		
	Group	0	1	2	0	1	2	0	1	2	0	1	2
FCOR monthly by car		1,152	1,427	1,104	613	718	561	840	900	985	0.73	0.63	0.89
EM monthly by car		178	1,247	2,646	95	627	1,345	156	937	2,067	0.88	0.75	0.78
	total	250	492	970	133	248	493	277	390	884	1.11	0.79	0.91
	thereof by car	41	291	617	22	146	314	37	219	482	0.88	0.75	0.78
EM, weekly	work	6	109	125	3	55	63	17	148	174	2.95	1.36	1.4
	business	-	23	151	-	11	77	-	91	376	-	4.00	2.50
	leisure short-distance	15	40	51	8	20	26	24	48	79	1.62	1.18	1.54
	leisure long-distance	-	16	54	-	8	28	-	50	130	-	3.06	2.40
	private	21	102	221	11	51	113	27	98	252	1.27	0.97	1.14
	Secondary residence	-	1	15	-	0	8	-	11	60	-	12.41	3.88

HH = Household, Pers = Person, CV = Coefficient of variation
EM = Survey on everyday mobility , FCOR = Survey on fuel consumption and odometer reading
group 0 (n=33), group 1 (n=235), group 2 (n=30)

However, despite these measures to achieve comparability, some households still show large differences in mileage between EM and FCOR19. Therefore, we investigated the reasons for these differences by calculating the monthly and weekly VKT based on EM and FCOR19. An overview of these measures is shown in Table 1. Among households that traveled significantly fewer miles in EM than in FCOR19, it is notable that they generally travel only a few kilometers in their EM. Possible reasons for this are unknown, unreported irregularities. Hence, they are classified as group 0. They reported no long-distance leisure activities in their EM as well as no business trips either. However, since they report much more VKT in FCOR19 than in EM, it can be assumed that the reported week in EM is not representative for an *ordinary week* of the household. Therefore, these households are excluded from our further investigation. In particular, pensioners are found in group 0. We assume that their irregular driving behavior means that their mobility greatly varies within a week. For the households with over 1.7 times the VKT in EM than in FCOR19, we found that they undertake many business trips. Long-distance leisure trips are also more frequent than for other households. Overall, they travel on average twice as many kilometers by car as households of group 1, who have a balanced ratio between EM and FCOR19. Due to the differences between EM and FCOR19, we decided to exclude these households from further investigation. The large differences indicate that normal behavior was not reported in at least one survey. Since both surveys are used as references for basic mobility, no conclusions can be drawn about these households. Households with children are mostly found in group 1. Because of the children, these households are likely to be tied into daily routines (e.g. commuting, child care) and making few exceptions. In total, 235 households remain for further analyses.

Figure 3 shows the ratio of EM and FCOR19. The distribution resembles a bell curve, but shifted slightly to the left, which means that the median reported VKT is lower in EM than in FCOR19, while the mean VKT is approximately the same. Households that are sorted into Group 0 and Group 2 are not included in the further analysis due to uncertainties in their EM or FCOR19. While we are aware that irregularities in mobility patterns are part of normal behavior, these irregularities do not make the data usable for the evaluation of *ordinary weeks* and thus unusable for examining shifts in mobility patterns due to the pandemic.

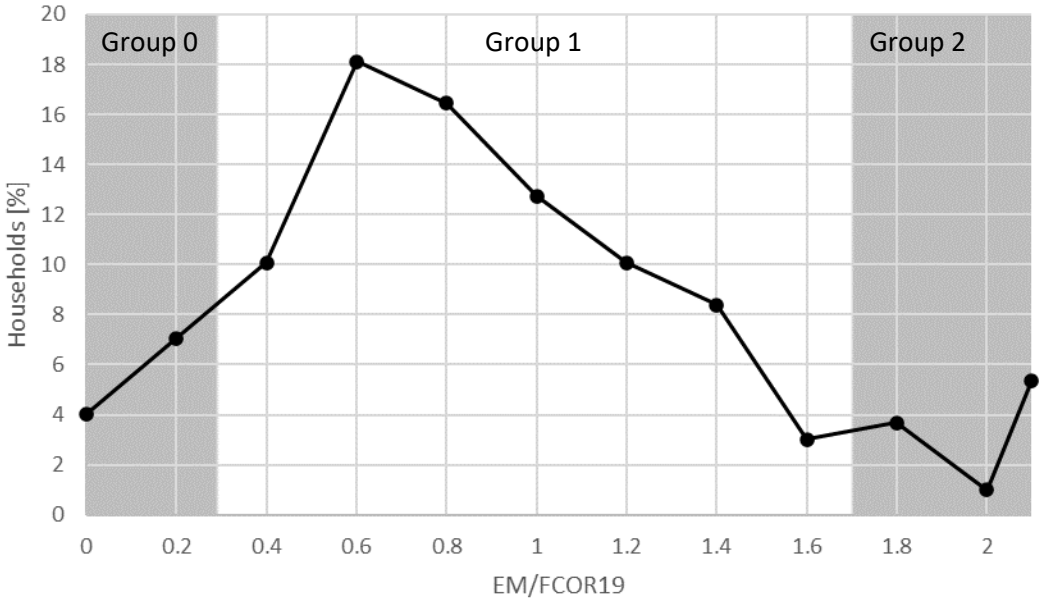

Figure 3 Ratio of EM divided by FCOR19

To put the differences in VKT into perspective, the differences in VKT between surveys FCOR18 and FCOR19 and FCOR19 and FCOR20, respectively, are displayed in Figure 4. For the analysis, the household VKT of the previous year is subtracted from the VKT of the reference year. In the transition from 2018 to 2019, which was not affected by the pandemic, households are evenly spread, and no particular trends are observed. The distribution resembles a bell curve. The variations result from irregularities in mobility patterns due to holidays, especially in spring. For the transition from 2019 to 2020, however, the bell curve is shifted to the left, indicating a decrease in car travel. While there are still some households that have increased their mileage, these are within the expected range of variation.

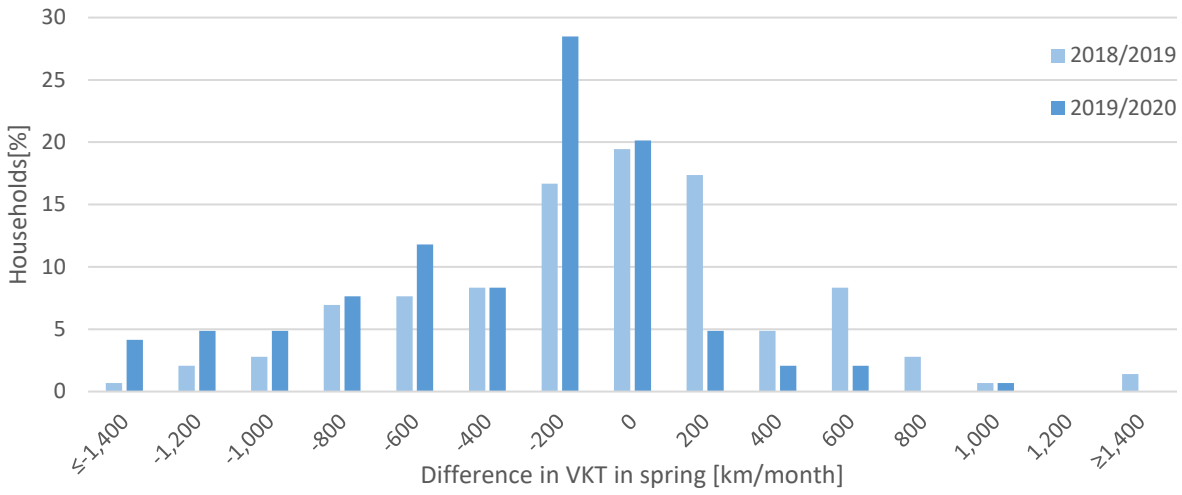

Figure 4 Distribution of the difference in household VKT between FCOR18/19 and FCOR19/20 (N=144)

RESULTS

To understand the dynamics in car usage of private households that resulted from the COVID-19 pandemic, it is of interest how the distances traveled changed between 2019 and 2020. Table 2 provides an overview of the mean monthly VKT of the cars differentiated by household characteristics. Next to the mean monthly VKT in spring 2019 (FCOR19) and spring 2020 (FCOR20), the mean monthly VKT resulting from the reported car usage in the survey on everyday mobility (EM) is presented. For better interpretation, the coefficients of variation and the differences between the three surveys are presented.

The total results indicate that the FCOR19 is, on average, 180 km higher than the EM. With the lower mobility during the COVID-19 pandemic measured with FCOR20, we see a decline of about 450 km compared to the previous year. In addition, we see a higher variation in the FCOR20 than in the FCOR19. This indicates a more diverse use of cars during the pandemic. It has to be considered that the results describe the monthly mileage on the household level and not on the individual car level.

The difference in mileage between FCOR19 and EM indicates how well the combination of the data sets works. A low delta indicates a perfect match in the monthly mileage of FCOR19 and EM. We see that if the reported car usage in the household includes primarily trips to work, the Delta FCOR19-EM is smaller. This indicates, that our approach to use *ordinary days* in the EM to approximate the monthly car usage on the household level works the best for such usage types. The greatest difference between the monthly mileages is found for households in which the cars are primarily used for leisure purposes (Table 1). This confirms the assumption that leisure activities, e.g. excursions and long-distance day trips, are the most variable and less regular and are thus the least predictable. The minor difference between FCOR20-EM than FCOR19-EM indicates that during the COVID-19 pandemic, the car usage of 2020 can be better explained by the reported car usage on *ordinary days* in the EM. This allows the conclusion that these cars were used for basic mobility rather than extraordinary leisure trips. Further, we see that households with a low share of distances traveled by car on the weekend but on weekdays have the highest reduction in VKT during spring 2020 compared to 2019. Households with a high share of distances traveled by car on the weekend show both suitable matches of FCOR19-EM and FCOR20-EM and the lowest reduction in mileage during the pandemic compared to the previous year.

Family households use the car more frequently than single households in years not affected by the pandemic. However, the reduction in the year of the pandemic is the same in relation to the VKT of the previous year. Thus, no conclusion can be drawn that different household sizes have reduced their mobility differently. The same is found for high-income households. Although they use the car more frequently in

normal years and restricted their car usage more in the pandemic affected year, the ratio is the same as for low-income households (-30%).

Table 2 Mean monthly VKT in FCOR19, EM and FCOR20 differentiated by household characteristics

Variable	Figure	Sample Size n	FCOR19 [km]	CV	EM [km]	CV	FCOR20 [km]	CV	Delta FCOR19-EM [km]	Delta FCOR20-EM [km]	Delta FCOR20-FCOR19 [km]
Total		235	1,427	0.63	1,247	0.75	976	0.75	180	-271	-451
Household Size	1 person	85	1,008	0.66	917	0.76	715	0.73	91	-202	-294
	2 people	99	1,556	0.54	1,256	0.63	1,006	0.65	300	-250	-550
	3 or more people	51	1,873	0.56	1,779	0.71	1,352	0.71	95	-427	-521
Household Income	1: <2,000€	61	1,035	0.68	855	0.73	726	0.76	180	-129	-309
	2: 2,000€-3,499€	79	1,260	0.71	1,062	0.78	802	0.77	199	-260	-458
	3: >3,500€	95	1,817	0.48	1,653	0.63	1,281	0.62	164	-371	-536
Car Usage Group*	100	43	1,782	0.50	1,807	0.68	1,408	0.72	-25	-399	-374
	110	42	1,784	0.60	1,645	0.60	1,084	0.66	139	-561	-700
	200	38	1,155	0.77	895	0.87	872	0.79	260	-23	-283
	220	43	1,126	0.65	916	0.64	666	0.57	209	-250	-460
	300	45	1,158	0.55	879	0.59	738	0.60	279	-142	-420
	999	24	1,637	0.55	1,384	0.64	1,178	0.57	254	-206	-460
Share of Car in transport volume	1: <50%	66	1,108	0.64	821	0.75	781	0.62	287	-41	-327
	2: 50%-69%	53	1,416	0.53	1,139	0.63	949	0.69	277	-191	-468
	3: 70%-89%	51	1,892	0.59	1,737	0.71	1,239	0.79	155	-498	-652
	4: >90%	65	1,394	0.61	1,382	0.65	990	0.72	12	-392	-404
Weekend Usage	0: <30%	119	1,470	0.60	1,306	0.70	970	0.65	165	-336	-500
	1: 30%-70%	97	1,458	0.66	1,249	0.81	1,030	0.84	209	-219	-428
	2: >70%	19	994	0.48	866	0.64	737	0.54	128	-129	-258

*100: >50% work related 110: >70% work related 200: >50% private (e.g. shopping) 220: >70% private (e.g. shopping) 300: >50% leisure usage 999: no specific car use

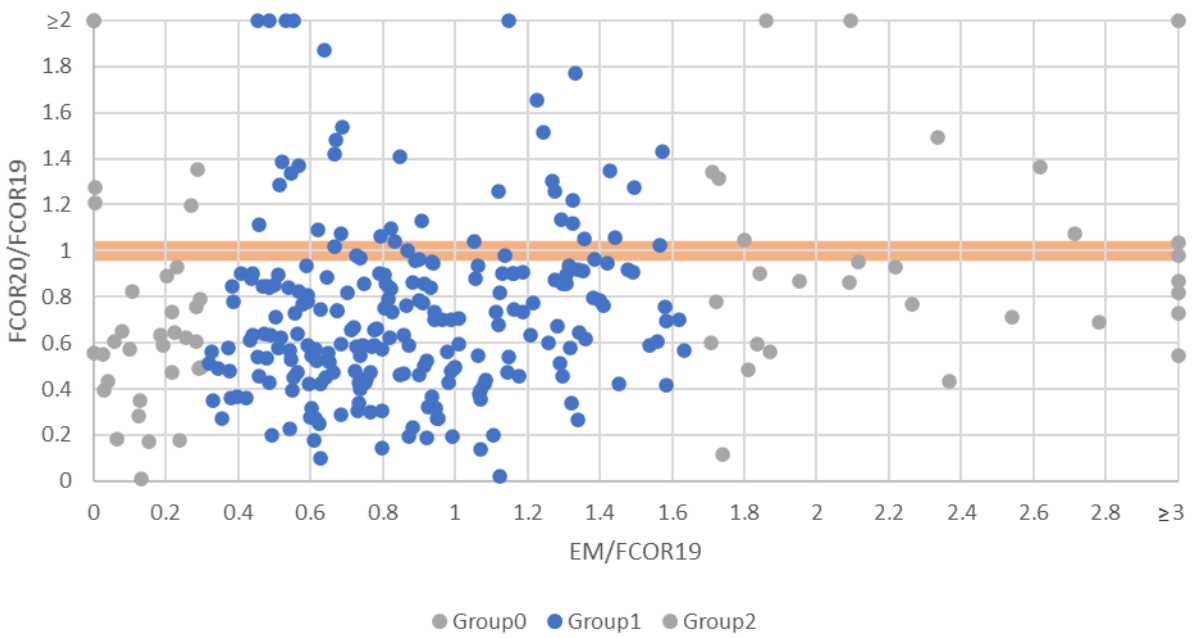

Figure 5 Relation of household VKT for EM/FCOR19 and FCOR20/FCOR19

Figure 5 shows the relation between EM and FCOR19 on the x-axis and the relation between FCOR20 and FCOR19 on the y-axis. A point oriented to the left indicates that the household's VKT is lower in EM than in FCOR19. When a point is located at the top, the household's VKT is higher in FCOR20 than in FCOR19. The orange line in the middle illustrates a balanced ratio between FCOR19 and FCOR20. A gray point indicates large ratio differences between EM and FCOR19 based on the approach described, which can no longer be meaningfully interpreted and thus will not be considered further. Only the blue points can be meaningfully investigated.

The figure shows that most households (73%) have reduced their VKT in 2020 by at least 10% compared to 2019. 14% of the surveyed households increased their VKT by at least 10%. 13% of households did not change their VKT. The reasons for the decrease in car usage include the COVID-19-related restrictions and an increase in working from home, consequently decreasing commuting to work. Also, visits of relatives or friends and recreational trips were deliberately reduced to minimize exposure. Under normal conditions, however, such visits and trips contribute to the VKT.

Figure 6 displays the proportionate change of household VKT by car from FCOR19 to FCOR20 differentiated by the size of the city where the households live in. A value of 1 indicates a balanced ratio of household VKT for both years. A value of less than 1 indicates a decrease in VKT between the years, whereas a value greater than 1 indicates increased mileage. We emphasize that our analysis focuses on mileage on the household level and we focus on households with an equal number of cars in both years which means that households that purchased an additional car and thus achieve higher mileage are not considered. The same applies to households that have reduced the number of cars.

The share of households who reduced their mileage is highest in medium-sized cities. These settlements sizes are considered as to be the most efficient in terms of travel. Medium-sized cities usually provide all opportunities for daily requirements, including workplaces. Commuting to other cities is less relevant. The lower densities allow for a comfortable living which results in fewer leisure trips. Generally, the total of the trip lengths within these cities are comparably low.

In contrast to medium-sized cities, there are some households in large cities that actually increased their VKT. This ensures that the mean VKT ratio is highest in large cities, meaning that the reduction in VKT is lowest.

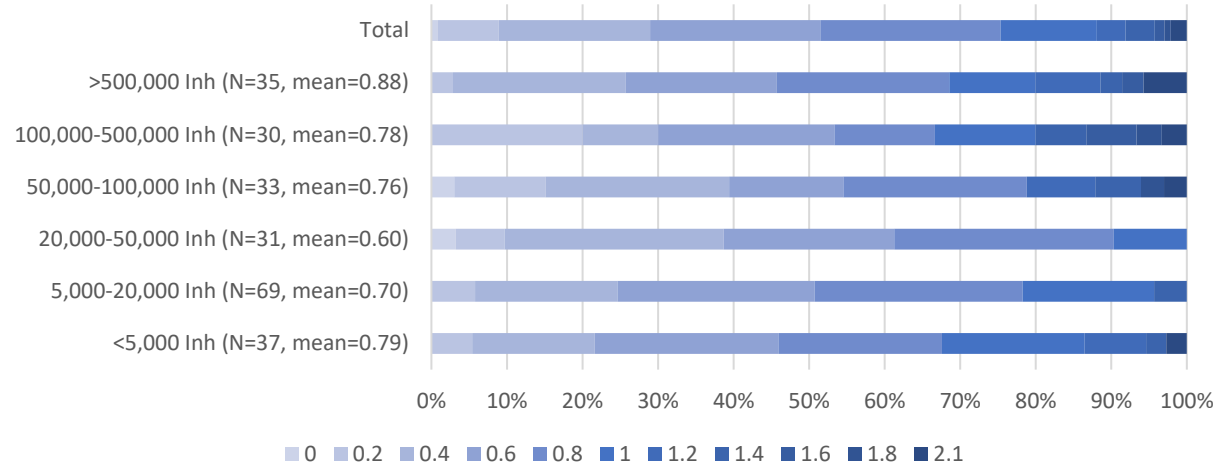

Figure 6: Proportionate change of mileage from 2019 to 2020 on the household level differentiated by city sizes based on FCOR19 and FCOR20

DISCUSSION

This paper presents an approach that allows deriving insights for which areas of life and trip purposes the car usage has changed during the COVID-19 pandemic. Therefore, we separate between the volumes of everyday car travel as basic travel needs in everyday life and „additional mobility", resulting from untypical events such as long-distance travel. An interpretation of the results is only possible by comparing the outcomes for different groups where we can assume behavior adaptions.

1. The largest reduction in VKT was observed for commuters. Many of them use their cars only to get to work. While their VKT is still higher than for the other groups during the pandemic, this can be attributed to an increase of working from home. While some can work entirely from home, this is not possible for all (e.g. nurses, cashiers and construction workers). This becomes evident by the high coefficient of variation (Table 2).
2. Households using their cars mainly for private purposes and leisure activities show the lowest VKT during the pandemic. Due to the stay-at-home measures announced by the government, the VKT of these households decreased.
3. A reduction in VKT was observed for all households, regardless of the share of cars in total transport volume. Substitution effects, whereby people switched from public transport to car, are not visible. However, Figure 7 shows that in large cities, where the share of public transport is highest, the decrease in VKT is lowest. This is an indication of substitution effects. In addition, it is known from other sources that these effects occurred during the pandemic (*5; 8; 15; 16;*). Therefore, further research is needed in this area.

In summary, it can be said that all household types reduced their VKT to a similar extent, although some differences can be identified. Our approach is limited by the fact that we are working with two different data sets whose only link is at the household level. This means that we cannot draw conclusions about general travel behavior changes but only about car mobility, as captured in both surveys.

1. Even in years without a pandemic, the intra-household comparison of travel volumes and car usage between years is challenging. We distinguish between basic mobility, e.g. commuting and grocery shopping, as necessary mobility in everyday life and leisure trips and vacation trips as additional mobility. This allows for the travel distinction to be regarded as *ordinary* and which is less likely to be reduced under normal conditions.

2. Our approach aims to best approximate the FCOR19 data using the EM data. This ensures that car mobility in a non-pandemic year can best be explained in terms of everyday use. For 21% of households (group 0, group 2), it is impossible to describe the car mobility of FCOR19 based on EM. This indicates that car usage is highly variable. Table 2 shows that the CV for most groups is above 0.5, indicating that the spread relative to the mean is large, regardless of the survey year. For the interpretation of the VKT, it must be taken into account that the VKT scatters at the household level since the households own a different number of cars and cars can also be used in very different ways.
3. Our results indicate that eight weeks are not enough to capture the whole car usage variation even in normal years. The relatively large dispersion of changes in VKT in FCOR shows that even in eight weeks there are still rare events that are not recorded in the next year.

By being designed as a longitudinal survey, the MOP allows to collect and study car mobility even during the unpredictable pandemic. By linking the two surveys, we were able to analyze effects that would otherwise remain undetected. This approach has a great potential to be further exploited.

CONCLUSIONS

This paper presents an approach of combining the data from a survey on fuel consumption and odometer reading with the data from a survey on everyday mobility. These two surveys are parts of the German Mobility Panel and therefore allow for a longitudinal perspective. The combination of these two surveys poses several challenges: One survey focuses on mileage and refueling events, has a survey period of eight weeks and is conducted between April and June. The other survey collects data from individual travel behavior, including all means of transport in a survey period of one week and is conducted in September/October. However, the latter contains information on trip purposes, which describe the reasons for car usage in private households. This paper presents an approach to combine these two data sets by approximating the monthly mileage with both data sets.

It is undisputed that the COVID-19 pandemic has a major impact on habits and daily routines of everyday mobility. The first lockdown in spring 2020 had a great impact on individual mobility, since the number of trips as well as the distances traveled have been reduced. The car was attributed additional importance in this situation, but the higher share of car usage has not resulted in more kilometers traveled since the overall travel demand declined disproportionally. Our results show that using so-called *ordinary days* in the EM data for calculating the monthly mileage of all household members comes closest to the monthly mileage resulting from the FCOR data. However, we see variation between years, meaning that the monthly mileage differs between the years and the surveys. Reasons for this are extraordinary events such as vacations or illnesses that occur randomly in the survey period but are not explicitly reported by the participants in the FCOR survey due to the survey design. We found that pensioners were often classified in group 0, which indicates irregular travel behavior. By contrast, the mileage of households with children can be described very well with our approach. We used data from 2019 and spring 2020 from the same households and cars to provide insights into how the measures of COVID-19 affected car usage. By using the combination of the data sets, we are able not only to describe an increase or decrease of mileage, but also to differentiate car usage on the household level. Cars that are primarily used for commuting to work were stronger affected by the pandemic in spring 2020 than cars that were primarily used for other trip purposes. We additionally see that in total the mileage strongly declined between 2019 and 2020. Reason for this is the overall reduction of travel during the first lockdown of the pandemic, both because of political measures and avoiding exposure.

From our point of view the COVID-19 pandemic can result in an event that triggers sustainable changes in travel behavior and car usage. This can be both – a curse and a blessing. To track the dynamic of these changes, we need to survey car usage continuously.

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AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: study conception and design: J. Vallee, L. Ecke, M. Magdolen, B. Chlond; data analysis: J. Vallee; interpretation of results: J. Vallee, L. Ecke, M. Magdolen, B. Chlond, P. Vortisch; draft manuscript preparation: L. Ecke, M. Magdolen; All authors reviewed the results and approved the final version of the manuscript.

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