The 9 EUR-Ticket – A nation-wide experiment: almost fare-free public transport for three months in Germany – First findings

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Word count: 4986 words + 1 table(s) × 250 + 750 words for references = 5986 words

Submitted: May 10, 2024

Paper submitted for presentation at the 102nd Annual Meeting Transportation Research Board, Washington D.C., January 2023

ABSTRACT

In spring 2022, the German federal government offered in response to rising fuel and energy prices a discounted nationwide travel pass, the so-called 9 EUR-Ticket, and a fuel tax cut. Both measures are limited to the period from June to August. For 9 EUR (approx. 9 USD), travel pass holders can travel almost fare-free on all regional, local and urban public transportation networks for an entire month. The 9 EUR-ticket is not valid for long-distance passenger services. While the fuel tax cut reduces fuel prices by only 15-20 %, the discounted travel pass creates an almost unprecedented natural experiment in terms of travel behavior and transport policy.

We observe this natural experiment with a three-wave survey and an app-based travel diary in the Munich metropolitan area. The three survey waves are conducted before, during and after the 9 EUR-ticket, while the app-based travel diary records participants' daily mobility patterns from the end of May to the end of September. In total, 800 people use the app and participate in the survey, while further 400 people only participate in the survey. In this paper, we present first findings from the first weeks of the ongoing experiment. We find that people are using public transport more frequent, but that only 3 % of participants seem to systematically replace car trips by public transport trips. Nevertheless, 25 % of new public transport riders use public transport more than occasionally.

Keywords: 9 EUR-ticket; tracking app; travel behavior; experiment; policy; public transport

INTRODUCTION

In transportation research, it is quite unlikely to observe or even perform real-world experiments in terms of travel behavior or traffic flow. There are few notable exceptions: subway strikes suddenly make one important alternative mode not available anymore (*1, 2*), a global pandemic changes travelers' preferences for traveling at all or traveling collectively with others (*3*), or a bridge collapse forces travelers to alter their daily activities (*4*). Recently, the German federal government created another large-scale natural experiment by provided a drastically discounted nationwide travel pass in response to the rising fuel and energy prices caused by the ongoing geopolitical crisis in Ukraine. For a monthly flat-rate of 9 EUR (approx. 9 USD), travel pass holders can travel almost fare-free during June, July and August 2022 all across the nation using all regional, local and urban public transportation (PT) networks; the 9 EUR-ticket is not valid for long-distance passenger services (e.g., high-speed services like ICE, TGV). The government's relief package also includes a fuel tax cut, reducing fuel prices by 15-20 % (*5*). This rebate is subject to oil price fluctuations, which already partially absorbed it (*6*), and the rebate is by far means not comparable to the extent of the behavioral and policy stimulus provided by the 9 EUR-ticket. Thus, the nationwide experiment is predominantly governed by the 9 EUR-ticket.

This experiment is promising from a travel behavior and transport policy perspective. At the behavioral level, it first allows to reveal preferences under such an almost flat-fare scheme in mode choice (*7*), rebound effects (*8, 9*), and induced demand (*10*). Second, the 9 EUR-ticket is a disruption to the currently fragmented fare structure in Germany: one single fare replaces fares in 60 different and not always contiguous transit districts. This simplification could also be a factor in attracting public transport users (*11*). Third, it is reported in the media that the people's sentiment toward public transportation has changed positively because of the 9 EUR ticket, which could be a further factor in attracting public transport users. At the policy level, it allows the analysis of to which extent in Germany an almost fare-free flat-fare scheme is an effective and efficient policy instrument to promote sustainable mobility, in particularly as it can be seen as an incentive to change from the car to public transport to reduce automobile externalities (*12, 13*). However, as this policy does not address car dependence (*14*) and evidence suggests that a '*coordinated package of mutually reinforcing transport and land-use policies that [...] (make) car use slower, less convenient, and more costly*' is required to reduce the share of car trips (*15*), especially limiting parking supply (*16–18*), it can be expected that this policy cannot be the sole instrument to achieve sustainable mobility.

For the Munich metropolitan region, Germany, we recruited more than thousand participants to analyze this large-scale experiment in the above discussed dimensions, namely the transport policy instrument itself and travel behavior, but also focus energy savings and the impact of inflation. The study has two main elements: a three-wave survey before, during and after the introduction of federal government's energy cost reduction measures, and a smartphone app to automatically measure the individual travel behavior and activities from May to September 2022. In addition, we analyze aggregated traffic counts in the city of Munich. We use (pre-COVID-19) travel diary and traffic flow data from 2017 and 2019, respectively, and data from shortly before the introduction of cost reduction measures as a reference. In addition, the three-wave survey is presented to a nationwide representative sample which allows us to weight the observations in the own-recruited sample in the Munich metropolitan region. These participants, however, do not receive access to the travel diary app. The three-wave survey design has also been selected by other researchers in Germany to analyze the effects of the 9 EUR-ticket[1]. However, no study is collecting in-situ revealed preference mobility data as our study does.

In this paper, we review fare-free and flat-rate public transport to understand the expected impacts on travel behavior, present the study design and report on the first findings of the study with data recorded until mid-July. As the study is ongoing and data collection targeted to end in October 2022, an first results of the entire experiment can be expected to be available at the beginning of January 2023. However, as this is a natural experiment, partially governed by the ongoing geopolitical crisis in Ukraine, unplanned interference into the experiment cannot be ruled out, e.g., extending the 9 EUR-ticket into the winter, fuel price shocks or an even stronger escalation of the energy crisis.

FARE-FREE PUBLIC TRANSPORT

The 9 EUR-ticket can be considered to make Germany's local, regional and urban public transport system almost fare-free because its price is very low an it has a substantial discount compared to many local monthly travel passes of more than 90 % without considering the added value through its nationwide validity. In addition, the 9 EUR-ticket is a nationwide flat-rate travel pass. For both aspects, precedent around the world exists that is discussed in the following.

Fare-free public transport

Fare-free public transport exists or existed in more than 100 locations (*19*). Fare-free public transport can be full or socially or temporally limited, e.g., to the elderly or to weekends. It is usually found in small urban areas with a population of less than 100 000, where recently larger areas have started fare-free public transport schemes as well. For example, Tallinn (Estonia) with a population of 400 000, started in 2013, a study reported that the free-fare only increased passenger demand by 1.2 % when controlling for other effects (*20*), while the overall usage increased by 14 % (*21*). Right amid in the beginning of the COVID-19 pandemic, three more locations started fare-free public transport. The entire country of Luxembourg (*22*), population of 630 000, but so far no report on the outcomes exists; Cascais (Portugal), population of 220 000, reported an increase in 10 %, while the scheme is funded by parking fees [2]; Augsburg (Germany), population of 300 000, defined a fare-free public transport zone in the city center, [3], but so far no report on the outcomes exists.

In an controlled experiment in Santiago (Chile), some workers got randomly assigned fare-free travel passes for two weeks (*23*). The authors find that travel increases by 12 %, while they find no evidence for mode or period substitution. The effect on public transport trips entirely explained by subway trips and by a residence location next to a subway station. In Templin (Germany), a similar pattern was observed with limited shift from the car, while a positive net benefit remains caused by a reduction in fatalities and casualties of pedestrians and cyclists (*24*).

Generally, findings suggest that free-fare public transport schemes have the risk of gener-

[1] c.f., https://verkehrslage.vkw.tu-dresden.de/en/research/survey-takes-a-look-at-9-euro-ticket and https://www.uni-kassel.de/fb14bau/institute/institut-fuer-verkehrswesen-ifv/radverkehr-und-nahmobilitaet/infothek/alle-meldungen/detailansicht-news/2022/05/25/umfrage-zum-9-euro-ticket?cHash=a849f66048d1937e95685bf61741d392

[2] https://www.eltis.org/in-brief/news/cascais-free-public-transit-services-result-10-more-users

[3] https://www.sw-augsburg.de/magazin/detail/gratis-durch-die-city-zone/

ating additional travel demand, while do not necessarily encourage a shift from the car to public transport (*19*, *24*). It is further argued that such schemes are rarely implemented in a response to solve economic, sustainability, or socio-economic problems, which would be usually expected when implementing a transport policy, but rather did the institutions have different targets in mind (*19*, *22*).

Flat-rate travel passes

At the beginning of public transport, fares were collected on a per-trip basis in cash, while the idea of a travel pass arose later, partly due to operating convenience. This introduction changed the product from a trip to access to a whole network. With marginal cost for each trip becoming zero, its cost perception thus became similar to that for the car (*25*). If travelers have a choice between pay-per-use and a flat-rate ticket, many choose the latter despite not reaching the break-even point. This flat-rate bias can be addressed mostly to an insurance and convenience effect (*26*). It is noted that travel choices and economic outcomes for operators depend on the fare structure and distribution of travel demand (*27*).

Nationwide travel passes exist in many cities and even entire countries, e.g., in Switzerland with the well-known *abonnement général* (**?**) and since 2021 the *KlimaTicket* in Austria. The latter travel pass builds on the idea of travel passes for 1 EUR per day or 365 EUR per year (1 EUR $\approx$ 1 USD), which has seen much interest worldwide and has been implemented, e.g., in Vienna. It is reported that the volume of sold annual travel passes grew substantially, but that no direct significant increase in ridership or change in modal split resulted [4]. Nevertheless, Vienna continued to employ accompanying measures to restrict car traffic and parking that together with an increasing awareness for the high cost of parking, led to a decrease in car travel and increase in public transport use (*15*, *28*).

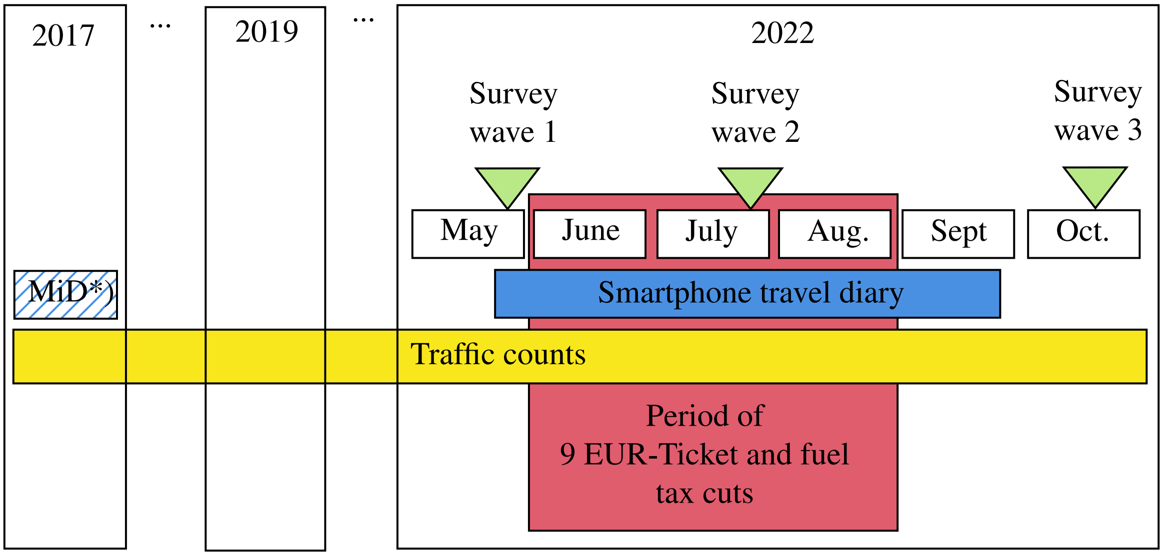
STUDY DESIGN

The overall design and timeline of the study is shown in Figure 1. The main building blocks are a three-wave survey (data collection times shown in green) and a smartphone-based travel diary (data collection duration shown in blue). An additional data source are traffic counts which are available from 2017 onward (shown in yellow) for the entire city of Munich, excluding motorways. We detail elements in the following, but refer to our study reports for more insights (*29*, *30*).

Survey

The three-wave survey has the following structure: in the first wave, we collected information with regard to mobility tool ownership, travel behavior before the beginning of the cost-reduction measures, household spending as well as the impact of energy price increases on economic decisions, and we asked for socio-economic information and socio-political attitudes. The latter included the individual's positioning with respect to the government's cost reduction measures, climate change and the political environment. The second survey, where data is currently being collected, includes personality questions and further political questions next to the same questions on travel behavior as in the first wave. We add more detailed questions on energy savings and the impact of inflation in order to increase the understanding of the interactions between mobility and other economic decisions. The concluding third wave will ask respondents again about travel behavior and household spending. In addition, questions about the the cost reduction measures and adaption of new travel

[4] https://www.vgn.de/5ef141c9-e1c4-655e-a3de-196f385b0e70



*) Mobilität in Deutschland, Germany's national travel survey.

FIGURE 1 : Project plan and timeline for analyzing the natural experiment around the 9 EUR ticket in Germany.

and economic behavior as well as future intentions for behavioral change and investments in new technologies will be presented. As the current political situation is dynamic, we will set the design of the third survey in September.

The three-wave survey allows us not only to capture the status quo of participants' mobility behavior, but also to measure within-subject changes in behavior and attitudes toward mobility and related economic decisions. We have the unique possibility to match the stated preferences (and possible changes in these preferences over time) from the surveys with real behavioral data revealed through the smartphone app.

App-based travel diary

For our study, we created a dedicated travel diary smartphone app called '*Mobilität.Leben*', meaning *Mobility & Life*. Installed on both iOS and Android devices, it automatically collects participants' waypoints and infers the chosen transport mode as well as the type of activity based on sensor data, information available from OpenStreetMap, and public transport network data. Except for asking participants to occasionally validate their data, there is no need for further interaction with the app. The app records data from the end of May to the end of September 2022. Participants can pause the data collection at any time. The main benefit of using a smartphone app instead of a paper-and-pencil travel diary is that almost every trip gets recorded and measured precisely. Such GPS-based travel diary apps are becoming more popular in research, e.g., (*3, 31, 32*) and transit agencies are exploring possibilities to use them to replace in-vehicle surveys.

Traffic counts

To corroborate the findings at the individual levels from the survey and the smartphone travel diary, we rely on aggregated mobility indicators that allow to draw conclusions about traffic volumes on the urban streets in Munich. Traffic volumes are collected through approximately 6'000 inductive loop detectors spread across the entire city of Munich. These data have successfully shown their capability in explaining the performance of entire road networks (*33*).

Recruiting strategy

The recruiting strategy of our study has two parts. First, in the Munich metropolitan area, we approached individuals using several media channels, e.g., reports in newspapers, social media, and press conferences. Recruiting started on May 23, 2022. Participants who complete the three-wave survey as well as collect at least one week of app data per month until September 2022 will receive a reward of 30 EUR (voucher). Participants who contribute with at least two weeks of data per month will enter a lottery for one of three 200 EUR vouchers. There is no experimental variation in the incentives.

Second, we recruited 921 participants from all over Germany through a professional panel agency to take part in the three-wave survey in order to obtain an unbiased and representative sample as much as possible. Here, recruiting started on May 25, 2022. Participants receive financial incentives directly through the panel agency for complete participation.

FIRST FINDINGS

The registration for the study started at the end of May before the start of the cost reduction measures on the 1st of June, 2022, namely the 9 EUR-ticket and fuel tax cuts. The registration continued until the 9th of June, 2022. As seen in Figure 2A, 1084 out of 1345 study participants registered before the 1st of June, 2022, (80 %). More than 82 % of all respondents were living in the Munich Metropolitan area, while the others were living elsewhere in Germany. The first wave of the survey has been completed before the 1st of June, 2022 by 857 out of 1226 completed surveys (70 %). All out of the 921 participants recruited through the panel agency completed the survey before the 1st of June, 2022. The travel diary app has been completely installed and activated by 480 out of 936 (51 %) participants before the 1st of June, 2022. In total, 1093 registered participants (80 %) agreed to participate in the survey and the app, while the remaining registered participants agreed to participate only in the survey. In the end, 157 participants did not or were not able to install or activate the app on their smartphones. These participants, however, remain in our panel and participate only in the survey. The iOS-App was available from the 25th of May, 2022, onwards and the Android-App from the 30th of May, 2022, onwards. This progression explained the delay in app activations seen in Figure 2A compared to the user registrations. The app activity during the ongoing experiment is shown in Figure 2B, where the ramp-up phase can be seen as well. Since the second week of the experiment, around 790 to 800 participants were constantly providing data, i.e., around 130 participants either de-installed the app or their app was not providing data for technical reasons. Regarding the share of immobile people (*34*), we found that during weekdays around 10 % of participants are immobile, while during the weekend around 20 % are immobile. This share matches the reported share in Germany's national travel survey (*35*). Nevertheless, we have to still verify that the smartphone on a certain day immobility was not due to technical problems or due to an intentional user deactivation of the app.

The first survey of our study focused on travel behavior and 9 EUR-ticket support and buying intentions before the natural experiment started on the 1st of June, 2022. In the pooled sample (the 921 participants from the panel agency and the 1345 participants from the Munich metropolitan area sample), we found overwhelming support for the 9 EUR-ticket. Support was

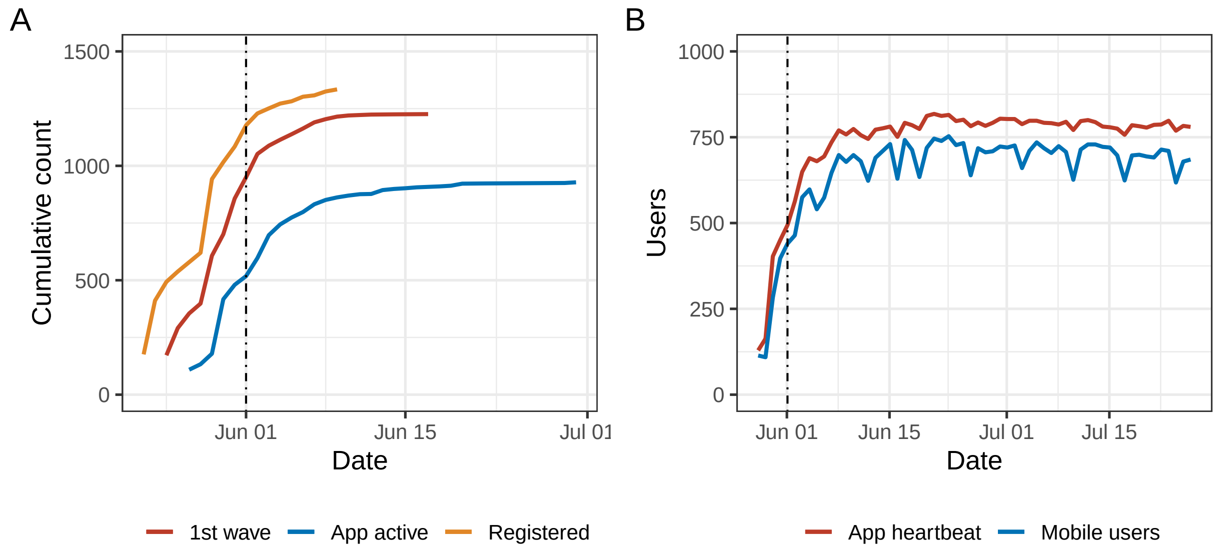


FIGURE 2 : Study registration (A) and app participation (B).

less for those who oppose the concept of the welfare state and who are less convinced that combating climate change is important. Nevertheless, the intention to acquire the ticket was higher for respondents living in urban areas compared to rural areas as it was for respondents who did not own a car. Interestingly, we found no income effect on the general support for the ticket or buying intention, but we found slightly higher support levels for households dealing badly with the recent price increases. Nevertheless, this was not reflected in higher buying intentions. When comparing the samples from the panel agency and our own recruited sample in the Munich metropolitan area, we observed that the Munich sample has higher shares of individuals with higher income and higher education, while the age distribution shows more people below the age of 40 and less *baby boomers*. Nevertheless, the own-recruited sample in the Munich metropolitan area is heterogeneous enough to allow weighting the observations to become representative. Further details are provided in (*30*).

Average daily travel behavior

In the following, we focus on those respondents, who provided their travel diary through the smartphone app, around 800 participants. In Figure 3 we show the average total travel distance per day and the travel distances by car, public transport and bicycle. Note that the first two weeks of the experiment in June included public and school holidays. Across all participants we found that public transport did not replace the car as the primary mode of transport in terms of kilometers, while on few days the gap was narrowed substantially. Generally, we observed larger average daily travel distances compared to Germany's travel survey, which expects around 44 km per day for all modes together (*35*). The lower part of Figure 3 provides one possible explanation for this as we have had around 4-5 percent of the mobile participants who traveled more than 500 km a day that is 2-3 times more than reported in the travel survey; this was consequently increasing the average travel distance.

In Figure 4 we compare the average daily travel distances by public transport usage before

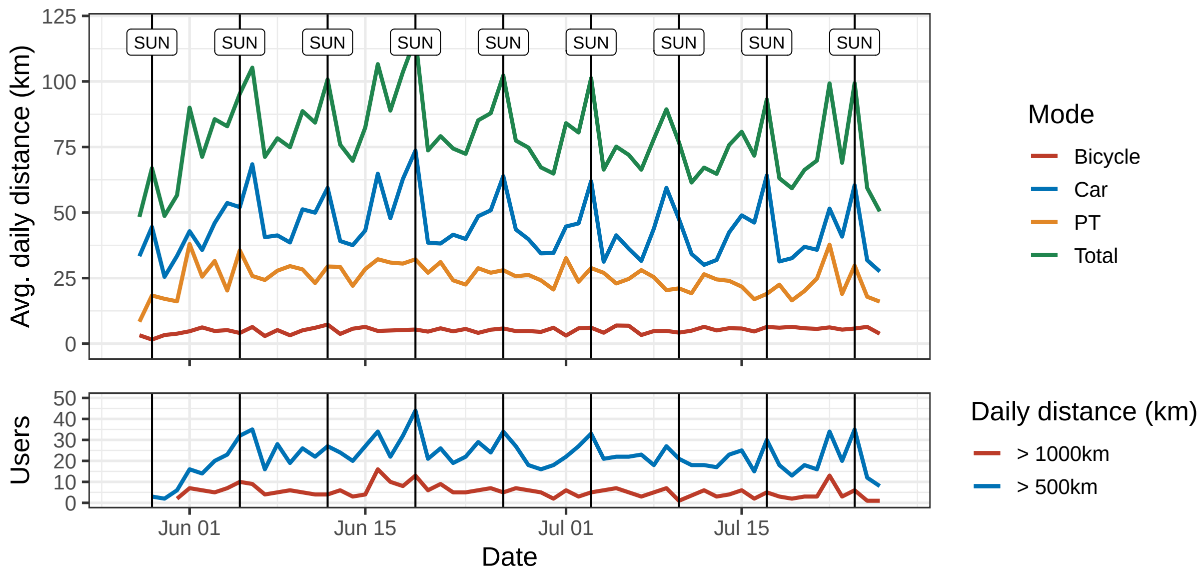


FIGURE 3 : Average daily distances by mode.

the introduction of the 9 EUR-ticket. Here, we considered a participant a frequent public transport user if she or he was using public transport at least once per week on a regular basis. We found that overall frequent public transport users had on average higher travel distances by public transport, while they used the car for longer trips on weekends and public holidays. Contrary, the travel behavior of non-frequent public transport users suggests that they have explored public transport during the first weeks of the experiment on weekends and public holidays, while their interest seems to have attenuated over time, though they still used public transport.

Tuesday mobility

Tuesday is considered a typical day for weekday travel behavior in transport planning. Therefore, we investigated the travel behavior of 360 participants who have activated their smartphone app successfully before Tuesday, May 31st, 2022. Their travel behavior on Tuesdays in shown in Figure 5, where travel distances are indexed to the travel behavior on May 31st, 2022 (week 0). The corresponding travel distances are given in Table 5. We found that the travel distances in May 2022 were close to the values reported in Germany's national travel survey for higher income individuals in the Munich metropolitan area of around 49 km (*35*). At the beginning of June, their average total daily travel distance as well as their average travel distance by public transport and car increased by around 50 %. While the average car travel distance decreased thereafter again to May 2022 levels until mid-July, Figure 5 suggests that app users either used the bicycle or public transport for their additional mobility. It can be considered additional as total travel distances are above reference levels during the considered time periods.

Weekly usage

In the first survey, respondents were asked about their weekly usage of public transport and cars before the introduction of the 9 EUR-ticket and the fuel tax cut on June 1st, 2022. We used this stated travel behavior to compare it against the observed travel behavior in the first weeks of the

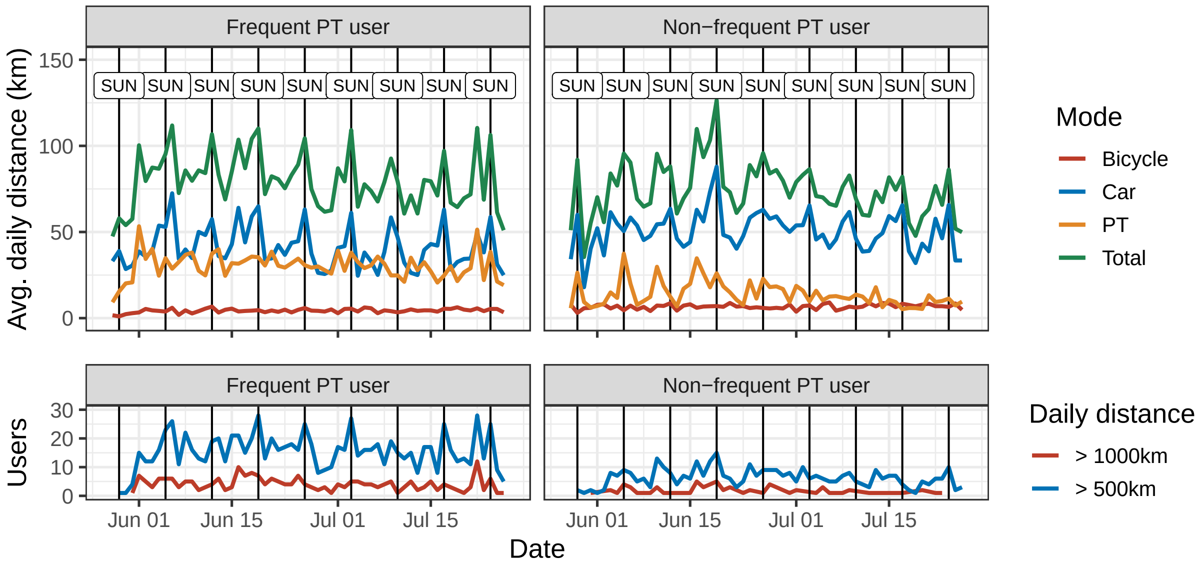


FIGURE 4 : Average daily distances by mode and by previous usage of public transport.

Travel distances in kilometers by mode									
	Tuesday into the experiment								
Mode	0	1	2	3	4	5	6	7	8
Total	54.05	81.94	79.83	79.11	76.01	70.40	64.76	56.44	49.64
Car	31.04	50.39	46.36	39.27	37.28	40.00	32.34	32.55	29.31
Public transport	15.96	25.06	23.56	30.72	30.42	19.38	23.12	13.57	13.17
Bicycle	3.83	2.97	5.42	5.13	4.89	7.32	5.38	6.43	3.91

TABLE 1 : Average Tuesday travel distances in kilometers by mode for N=360 study participants

experiment. In Figure 6A we compare public transport usage. Generally, we found that around 35 % of respondents were using public transport more frequently during the first weeks of the experiment than before the experiment. However, there were also participants who reduced public transport usage. Nevertheless, it should be noted stated travel behavior in the survey could be biased and the revealed usage through the app might not correspond to the week the respondent had in mind when filling out the questionnaire, e.g., as she or he was on vacation.

Focusing on those study participants who used public transport more frequently, we found changes in their revealed car usage during the experiment compared to their stated car usage before as seen in Figure 6B. Overall, we found that only around 3 % of participants reduced car usage and increased public transport usage systematically, i.e., at least one day more public transport usage and at least one less car usage per week. Figure 6B also shows that many who used public transport more frequently, also used the car more frequently, corroborating the findings from Figure 5.

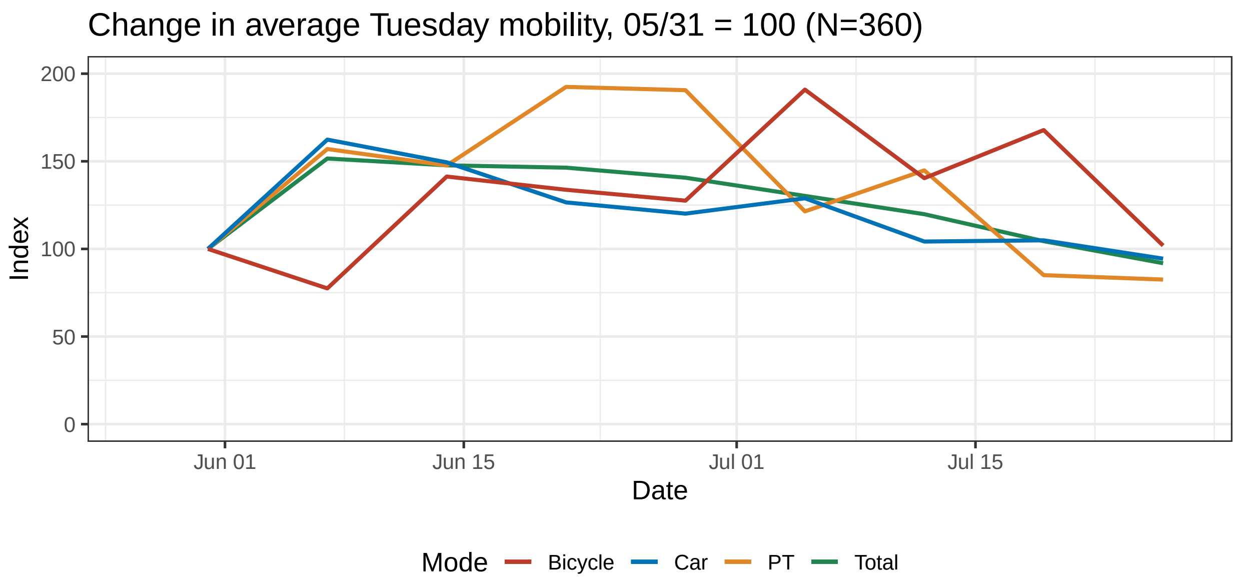


FIGURE 5 : Travel behavior on Tuesdays (representative working day) during the experiment.

User groups

We used the information on stated and revealed public transport usage to define public transport user groups. If a participant used public transport before and during the observed weeks of the natural experiment, she or he was classified as *PT user*; if a participant did neither used public transport before nor during the observed weeks of the natural experiment, she or he was classified as *No PT user*; if a participant did not public transport before, but during the observed weeks of the natural experiment, she or he was classified as *New PT user*; If a participant used public transport before, but not during the observed weeks of the natural experiment, she or he was classified as *Currently no PT*. We show in Figure 7A how these user groups distributed across our sample by household car ownership. We found that the share of new PT users was twice as large for car-owning households compared to car-free households, while the share of PT users was twice as large for car-free households. Nevertheless, Figure 7A suggests that in car-free households a slightly larger share of previously no PT users has turned into PT users compared to car-owning households.

In Figure 7B, we investigate the weekly public transport usage for all new public transport users in our sample. We found that around 75 % of participants used public transport only for a few days per week, while only less than 5 % used public transport almost every day.

Traffic counts

From the available traffic count data, we selected around 280 inductive loop detectors distributed along main streets in the city of Munich. We compared traffic counts per day in the months May and June from 2019 to 2022. We removed all school and public holidays from the sample for a better comparison of average traffic. Compared to 2019 levels, we found that traffic volumes in May 2022 were on average 4 % below pre-COVID-19 levels (reference May 2019). Traffic volumes in June 2022 were 8 % below pre-COVID-19 levels (reference June 2019). Typically, there was an increase in traffic volumes on Munich's streets from May to June. However, in 2022

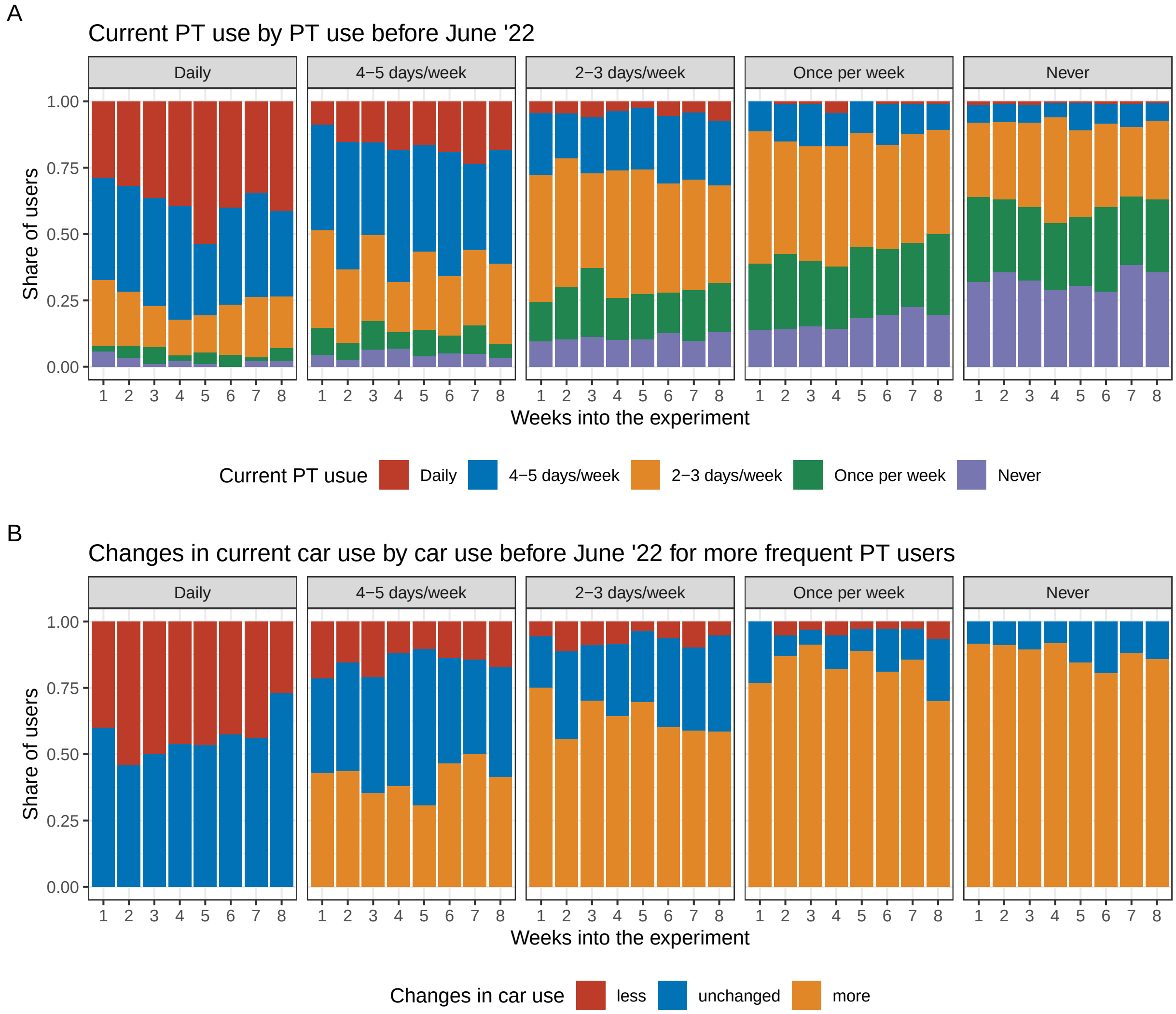


FIGURE 6 : Changes in public transport usage during the experiment (A) and changes in car use during the experiment for those who use public transport more frequently since June 2022 (B).

we did not find this effect, rather did traffic volumes on average decrease slightly. Considering the introduction of the 9 EUR-ticket on June 1st, 2022, as an incentive to change from the car to public transport, it is possible that the observed reduction in traffic volumes can be attributed to the introduction of the 9 EUR-ticket. Importantly, while car travel seemed to have increased according to Figure 5, the reduced traffic volumes in Munich suggest that car trips did not enter Munich, but rather elsewhere.

OUTLOOK

In this paper, we have provided first findings from our study on the effects of the so-called 9 EUR-ticket, a cost-reduction measure introduced by the German federal government in response to the recent fuel and energy price increases caused by the ongoing geopolitical crisis in Ukraine. For 9 EUR (approx. 9 USD) per month, which is almost fare-free, buyers obtain a flat-rate nationwide

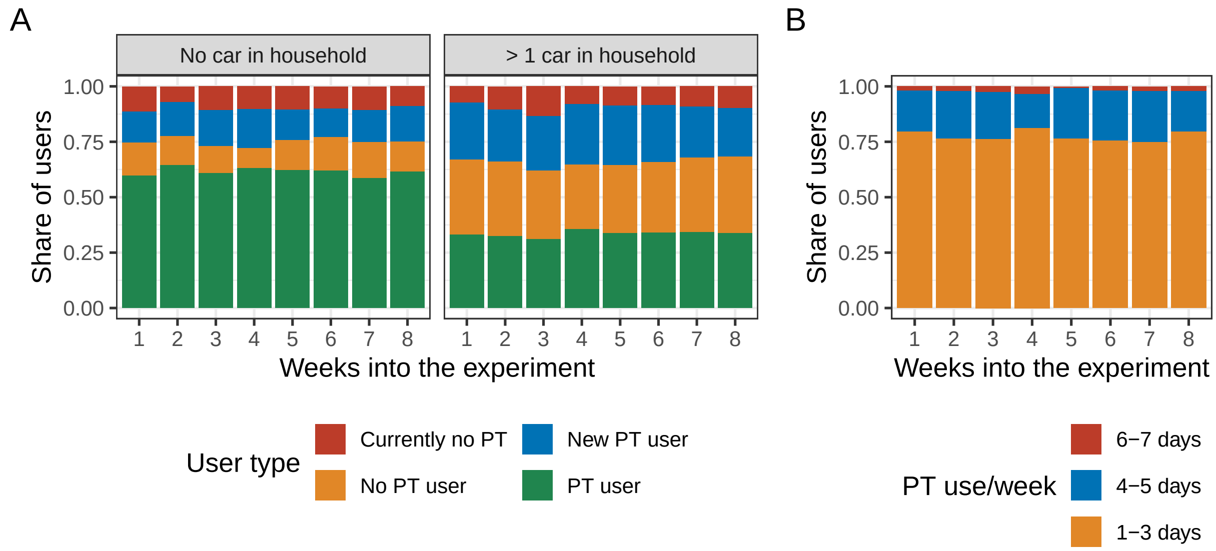


FIGURE 7 : Public transport user groups during the experiment by car ownership (A) and frequency of public transport use of all new public transport users (B).

travel pass that allows them to travel on all regional, local and urban public transport networks during June, July and August 2022. Our study, comprising a three-wave survey and a smartphone travel diary app, has revealed that in the first weeks of the experiment public transport did not replace the car as the primary mode of transport. Data suggested that previously non-public transport users have tried public transport on the first weekends of the experiment with declining interest thereafter. Generally, 35 % of participants used public transport more frequent and around 20 % of participants were new public transport users, though only 25 % of them used it on a regular basis. In the end, the share of participants, who were systematically using more public transport and less cars, was less than five percent. This figure is in line with experience from other flat-rate and free-fare public transport experiences. However, as the experiment is ongoing, these results should be considered as intermediate and preliminary.

The next steps are the continuation of the data collection and the design of the third-wave survey. This survey will contain a stated-choice experiment to investigate, based on the revealed mobility preferences through the smartphone app, the optimal fare characteristics for a successor of the 9 EUR ticket. The collected data will be used to estimate discrete choice and regression models to quantify the treatment effect of the 9 EUR-ticket as well as the intentions of people to buy a successor of the 9 EUR-ticket. The impact of the fuel tax cut will be considered too as it enters the analysis through the car costs during the natural experiment. The availability of mobility and activity information in the collected data also allows to analyze the shifts in time use and activity choices caused by the 9 EUR ticket. In the long run, the collected data and model parameters will be used to calibrate transport policy models to inform decision makers on the impact of inflation and energy price increases.

In closing, the cost reduction measures have wider effects. Our first findings allow a first estimation of impacts on carbon emissions and social outcomes. First, assuming that the 3 % share of users who changed systematically from car to public transport translates proportionally to the annual mileage of cars in Germany, the 9 EUR-ticket would save on an annual basis approximately 19 billion vehicle-kilometers per year. With around 150 g CO_2/km, this results in 3 million tons of avoided carbon emissions. Second, when comparing travel behavior of *poor* and *rich* individuals, we found that compared to Germany's national travel survey, poor individuals increased their public transport usage stronger than rich individuals (around 30 % by first estimates), emphasizing that the 9 EUR-ticket does lead to more social participation with possible benefits. Although these two benefits alone may not outweigh the costs of the 9 EUR-ticket of around 10 billion EUR per year, further investigation of the 9 EUR-ticket's benefits and the people's price sensitivity for a successor of the 9 EUR-ticket will show if and when the benefits exceed the costs.

ACKNOWLEDGMENTS

The authors would like to thank the TUM Think Tank at the Munich School of Politics and Public Policy led by Urs Gasser and Markus B. Siewert for their financial and organizational support and the TUM Board of Management for supporting personally the genesis of the project. The authors thank the company MOTIONTAG for handling the app development at utmost priority. The authors would like thank everyone who supported us in recruiting participants, especially Oliver May-Beckmann and Ulrich Meyer from M Cube and TUM. The authors further acknowledge assistance from Philipp Blum, Andrea Cadavid Isaza, Sebastian Goerg, Thomas Hamacher, Lisa Hamm, Markus Lienkamp, Nico Nachtigall, Thomas Schönhofer, Stefan Wurster, and David Ziegler.

AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: study conception and design: Adenaw, Bogenberger, Cantner, Loder; data collection: Adenaw, Cantner, Loder; analysis and interpretation of results: Adenaw, Cantner, Loder; draft manuscript preparation: Loder. All authors reviewed the results and approved the final version of the manuscript.

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