



Transport Research Arena (TRA) Conference

Towards a resilient and attractive future public transport: Insights from a study on public transport usage patterns during the COVID-19 pandemic

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Abstract

The global Corona virus pandemic affected strongly travel behavior with expected long-term changes which will run counter to a sustainable development of mobility. One main issue is the setback experienced by public transport. This paper analyses the change in public transport, the reasons behind and potential measures. It is based on a quantitative survey, mobility data for the time before Corona and a focus groups discussion. The results suggest notable reduction in public transport use during the pandemic and critical evaluation of implemented measures. A reduction in public transport season ticket can be observed with variation in the values depending on subjective evaluation of public transport, type of settlement, and teleworking frequency. The paper discusses strategies for the development of a more resilient public transport system.

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1. Introduction

The global pandemic of the Corona virus (COVID-19) and the implemented measures to limit the spread of the virus have a major impact on all areas of the everyday life, including travel behaviour. In the beginning, the reduced traffic volume had a positive impact on the environment. In the long term, however, new mobility routines emerged, which run counter to a sustainable development of mobility. One of the main issues in this context is a setback experienced in the use of public transport. As sustainable mobility solutions that aim to increase the number of

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multimodal trips and reduce the use of individual motorized modes of transport are based on a strong and attractive public transport, the effects of the pandemic have strong negative implications.

Against this background, the paper analyses the changes in use of public transport and the reasons behind in order to regain lost public transport customers and to develop strategies for a higher resilience of public transport in times of crisis.

2. Literature Review

Since the worldwide COVID-19 outbreak in 2020, there is an increasing number of studies that are looking on the changes in travel behavior due to the pandemic. Most of the studies focus on the general travel behavior, including daily mileage and mode choices, or focus on changes in trips for specific purposes (e.g., commuting trips and teleworking impacts). Several studies focus explicitly on the effect of the Corona pandemic on public transport, mainly looking at the changes and challenges for the public transport of regional (city) or national level. We focus the literature review on (1) changes in public use in different regional contexts (mainly case studies for specific EU city or country) and (2) policy and practice implications of the changed mobility patterns due to the pandemic discussed currently in the scientific community.

The majority of studies on the impact of COVID-19 on public transport are case studies which focus on certain city or region. Despite the different context-specific factors, a common trend can be seen across Europe cities. Travel generally reduced due to pandemic-related measures and changed travel patterns. The public transport suffered from the COVID-19 pandemic most; a shift towards individual transport (shift to cars, but also to bike, walk or micro-mobility) can be observed. A study from Budapest (Hungary) suggest that COVID-19 measures reduced mobility by half; modal share of public transport dropped from 43% to 22% and car use increased from 43% to 60% (Bucsky, 2020). In Poland, there was also a significant drop in travel times regardless of sociodemographic characteristics of travelers (Borkowski et al., 2021). Two further independent case studies in the show a drop down in the usage of public transport by more than 90% in Gdansk (Przybylowski et al., 2021) and 68% in Warsaw (Kłos-Adamkiewicz & Gutowski, 2022). Also in Sicily (Italy), a significant shift from public transport to micro-mobility and/or cycling (Campisi et al., 2020). Similar trend was registered also in a survey in Netherlands; the use of car as driver reduced here slightly (de Haas et al., 2020). Swedish study showed that highest ridership decreases in Stockholm (by 60%), smallest in Västra Götaland (40%), mostly among less public transport users, suggesting that differences in the impact magnitude depend on type of settlement (Jenelius & Cebecauer, 2020). Differences depending on settlement type were also found in a study that compared big and smaller cities in Austria and Norway (Rasca et al., 2021). Smaller urban areas ridership recovered more rapid after lockdown. For Zürich, Switzerland, it was found that people changed route preferences and travel patterns for a recurrent trip with the public transport (Marra et al., 2022). For Germany, an online survey found a shift away from public transport and increase in car usage, but also in walking and cycling during the first lockdown (Anke et al., 2021). Another study for Germany in comparison with other countries found further that high income and high educated groups could avoid using public transport and seek for alternatives compared to other (Fitbom et al., 2021). Risk infection perception was lower among public transport users compared to non-users. Further German study with focus on rural area found that over the half of the respondents did not change their travel mobility practices significantly; less trips by car and public transport and more bike use were reported (König & Dreßler, 2021). However, respondents do not predict long-term effects of the pandemic on their mobility patterns.

Looking at the policy and practice implications for a resilient public transport after the pandemic discussed in the literature, various short-, mid- and long-term measures are identified. In Spain, supply and vehicle disinfection were found to increase the stated willingness to use public transport after the pandemic (Awad-Núñez et al., 2021). Moreover, although higher investments are needed for improvements in public transport after the pandemic, users seem to take them as granted and expect prices to remain the same. Public transport operators have to minimize health-risk in their services and increase the understanding of the risk of infection in the services as risk perception play an important role for the recovery time of public transport users after the pandemic (Gutiérrez et al., 2020, Kopsidas et al., 2021, Fitbom et al., 2021). Moreover, multi- and co-modality will be an important tool to increase demand for public transport (Gutiérrez et al., 2020, Ciuffini et al., 2021). Integrated urban planning and review of current urban planning and policy is required. Pandemic accelerated (the need for) sustainable mobility policies and the need to

rethink the whole public transport system as analyses shows that returning to status quo after the pandemic won't be sufficient to ensure resilience (e.g., Vickerman, 2021, Tsvetkova et al., 2021). Among others, adaptive and data-driven governance is needed (Tsvetkova et al., 2021) as well as new policy and practice considerations, e.g., concept of Responsive Transport that includes consideration about sustainability, but also health and well-being (Budd & Ison, 2020).

Overall, the study varies in methodology, sample size and composition, as well as time period. Almost all studies, with few exceptions (e.g., Rasca et al., 2021, Haas et al., 2020, Borkowski et al., 2021), cover the first and/or second corona wave, including lockdowns (spring/ summer 2020). Sample sizes and representativity vary. Various strategies for a more attractive and resilient public transport are discussed in the literature ranging from region-specific implications to general measures for Europe. Against this background, our multi-wave study aims to provide insights on changes during different phases of the COVID-19 pandemic. It focusses on the German case and the public transport users' perspective on the efficiency of measures.

3. Methods

In order to analyse the impact of the Corona virus pandemic on travel behavior, a longitudinal representative study for Germany was set up right at the beginning of the pandemic. So far, five online surveys have been conducted at different stages of the pandemic (spring, summer and autumn of 2020, spring and autumn of 2021) each with 1,000 respondents (the last survey with 2,500 respondents). The sample was weighted in order to ensure that representative conclusions can be derived. The questionnaires address various topics (the use of transport before and during the crisis, mobility in connection with shopping, work and leisure, private and business travel, online-shopping, telework as well as attitudes and personal strategies in dealing with the crisis). Specific questions to former and present public transport users and the use of transport modes before and during the pandemic give insights on changes in the use of public transport. In order to provide an overview about the public transport use before the pandemic, we used data from the German national household travel survey MiD (see Nobis & Kuhnimhof, 2018). Additionally, a focus group discussion was conducted in order to provide deeper insights in the current situation with respect to changes in usage patterns of public transport and the reasons behind. The sample consisted of people who quit their public transport abonnement during the pandemic. Potential measures to increase the public transport attractiveness were discussed in both the quantitative surveys and the group discussion. The focus groups discussion was conducted virtually using an online meeting platform and consists of five persons selected to vary in age, gender, and residential area location. Despite the small sample, the analyses of the data from the focus group discussion provide deeper understanding of decision process and usage context of public transport for these selected persons with their individual backgrounds.

The data from the online survey were analyzed using descriptive and inference statistic methods. In order to analyze impact factors on the decision to quit public transport abonnement and the characteristics of different public transport users and non-users, we used a decision tree. The decision tree is a classification method which allow identifying specific user segments, to discover relationships between them and to predict future events. All statistical analyses were performed using the statistical software IBM SPSS Statistics 26. The focus group discussion was audio and video recorded and fully transcribed. The data from the focus group discussions were analyzed using a content analysis approach. The analyses were performed in the software for qualitative data analysis MAXQDA.

4. Results and discussion

4.1 Public transport use before Corona

For the period before Corona, data from the 2017 MiD study provide a very comprehensive picture of the use of public transport. At that time, the share of public transport in transport volume and transport performance was at 10%. The share of public transport users in the total population is nevertheless higher. In 2017, almost a quarter of all people aged 14 and above used public transport in the normal course of the week: 13% said they used public transport almost every day, and a further 10% once to three times a week. There are major differences according to city size: in cities with 500.000 inhabitants and more, almost half of the respondents said they used public transport at least once a week. In small cities with fewer than 20.000 people, the proportion was 12%. There are also major differences in the trip

purpose: While public transport in large cities is used for a wide range of purposes, in small cities it is mainly used for educational and commuter purposes. If we look at the popularity of the means of transport, public transport comes off worst. Only 34% of the respondents aged 16 and over said they liked using public transport. By contrast, 60% reported this for bicycles, 77% for cars and even 83% for walking. The values differ depending on how they are used. In general, the appreciation increases with the frequency of use. For example, 78% of people who frequently use public transportation said they enjoy using it. However, public transportation scores lower even when viewed from this perspective, as e.g. 96% of bicyclists said they enjoy riding a bicycle.

Prior to Corona, the development of public transport demand was characterized by in primarily one aspect: stagnation. Compared to the MiD results from 2002 and 2008, very little has changed. The situation is different for passenger cars. The passenger car fleet in Germany increased by 6 million vehicles from 2010 to 2020 to a total of 48 million (statistics from KBA - Federal Motor Transport Authority). The increasing multiple motorization of many households has resulted in more and more people being able to dispose of a passenger car without consulting other household members. The consequences are clearly visible: from 2002 to 2017, the average daily distance traveled by car increased significantly (Nobis & Kuhnimhof, 2018, Nobis et al. 2019, Nobis & Eisenmann, 2021). Against this background, the stagnation of public transport can definitely be seen as positive, even if public transport had already failed to fulfill its role as the backbone of the mobility transition before Corona.

4.2 Change of mobility behavior during the pandemic

As a result of the measures taken in March 2020 to contain the spread of the Corona virus, the overall volume of transport has fallen sharply. At this low level, there was a simultaneous modal shift in favor of the car. Before the Corona virus outbreak, it was normal everyday life for half of all respondents to use the car exclusively in the course of a normal week. One third of all respondents were multimodal and used within a week a mix of at least two of the modes bicycle, public transport and car. With the beginning of the pandemic, the share of monomodal car users increased. In the first lockdown in spring 2020, the share of people using exclusively the car was at its highest, with 66%. In summer 2020, mobility behaviour had already largely returned to normal, with a share of monomodal car users at 55%. However, with measures tightening again in the fall of 2020 and the ongoing exceptional situation, the share of monomodal car users has levelled off at around 60% since then. Even today, its share is still 10% points higher than the pre-Corona level. In contrast, public transport use has declined. There are both fewer people who use public transportation exclusively and people who use over the course of a week a mix of public transportation and other modes. Especially among multimodal persons, there was a strong trend towards the use of safe transport modes - the bicycle, but especially the car. The results align with previous studies conducted in European countries during the pandemic (summarized above) and show a stable continuing trend in mode choices.

The declining importance of public transport in Corona's everyday life is also manifested in the loss of regular customers and the declining sales of season tickets for public transport: before Corona, 26% of all respondents owned a season ticket for public transport; currently, the share is by 23%. This decline seems small at first. However, in relation to the group of people with a public transport season ticket, this represents a decrease of 10%. The decline is more evident if only people who had a season ticket before Corona are considered: 27% of the former season ticket users have given up their season ticket in the meantime. 42% of them cited Corona as the main reason for cancelling. This means that other reasons have outweighed. However, Corona is clearly taking its toll.

One of the biggest problems public transport operators are facing is the discomfort reported by the vast majority of the population. While the respondents mostly feel just as comfortable, and in some cases more comfortable, when using individual means of transport such as bicycles or their own cars, the dissatisfaction factor clearly predominates for the collectively used means of transport public transport, trains, airplanes and, to a more limited extent, car sharing. In all surveys, more than half of the respondents stated that they feel (significantly) less comfortable in public transport. Over the course of the five surveys, there are only minor changes. For example, public transportation discomfort was most pronounced at the beginning of the pandemic, declined slightly in the summer of 2020, and then increased again in the fall of 2020. Since then, discomfort has decreased slightly. This is most evident in the small shift between the two categories "more unwell than before" and "significantly more unwell than before." As an overall conclusion, however, it can be noted: Feeling uncomfortable on public transportation has become deeply embedded in people's minds.

In the last three surveys, people who used public transportation at least one to three days a month before Corona were also asked to rate items related to public transportation on a five-point scale. The results show the importance of mouth-nose coverage on public transport. Three quarters of people are disturbed when people do not wear masks properly on public transport. Two-thirds of respondents are therefore in favour of better controls of the obligation to wear masks. The same share of respondents report that they repeatedly see people who do not wear masks properly.

Half of the respondents say they currently avoid public transportation. 44% of the people are afraid of getting infected on public transport. In addition, 56% of the respondents report that it is too crowded for them on buses and trains at present. Only 27% of respondents feel that the hygiene measures currently implemented on public transport are sufficient.

Since the results were identical in each of the three waves except for slight seasonal fluctuations, there is an urgent need of action for public transport operators to prevent the negative image from becoming even more deeply anchored.

The results of the analyses of the qualitative data from the focus group discussions reveal various reasons behind changes in the use of public transport depending, among others, on hypersensitivity and health concern during the pandemic as well as changed patterns – work- and leisure one: *„The trips have changed, inevitably so to say. And if they change again in the reverse direction when everything normalized, I really can't say this yet.”* For some participants, besides the travel patterns, also the value, i.e. the importance, of public transport seems to be changed due to the pandemic: *„I use public transport despite the current situation, but its value has changed completely. It is now just a mode of transportation which one uses when necessary and not because it is easy to use and comfortable.”*

4.3. Characteristics of public transport users and non-users during the pandemic

In the next step of the analyses, we took a closer look at regular public transport customers who quit their abonnement during the pandemic. The prediction accuracy is 78,5% with three effective variables. Adding further or other variables did not improve accuracy. Fig. 1 shows the results of the decision tree analysis. For each node, the frequency and percentage of each classification in the dependent variable are presented. There are fifteen terminal nodes which is relatively detailed segmentation resulting in very small number of persons in some of the identified categories. Nonetheless, interesting patterns can be observed.

First, the most influential variable for the classification is the subjective evaluation of comfort level. 35,3% of the people who feel noticeable more uncomfortable have quit their season ticket (node 2). In other words, while the overall probability to quit abonnement during the pandemic was 22,3%, the probability for people who feel very uncomfortable is about 13% higher. Second important factor is the type of settlement: when people feel noticeably more uncomfortable in public transport, in areas with less than 500.000 inhabitants, the probability of quitting abonnement is 46,2% and in larger city areas 26,5%. Similar trend can be seen on the left side of the tree, where comfortable level seems to be heterogeneous in the group, but reduced public transport abonnement share is with 13,4% the lowest among people who live in larger cities. The results suggest higher dependency of public transport in urban areas and are contrary to some previous studies for Europe which found stronger decline of public transport usage in bigger cities and faster recovery in smaller urban areas (e.g., Jenelius & Cebeauer, 2020, Rasca et al., 2021). For teleworking, in large cities, 10,7% share of people who do not telework, work from home only partly, or are not working at all quitted their public transport abonnement compared to 23% among people who mostly telework. For smaller cities, the trend is less clear. Among people who feel very uncomfortable in public transport and live in areas with less than 500.000 inhabitants, the share of people who quit their abonnement is highest among non-teleworkers and people who are not working at all (54,9%) – a trend which cannot be confirmed looking at the left side of the decision tree. Left we see that in middle size cities, share of people who quitted abonnement is three times higher when people do not travel to work at all (teleworking or not working). The results can be explained again with potentially less dependency on public transport in less dense urban and in non-urban area, but also different job distribution type.

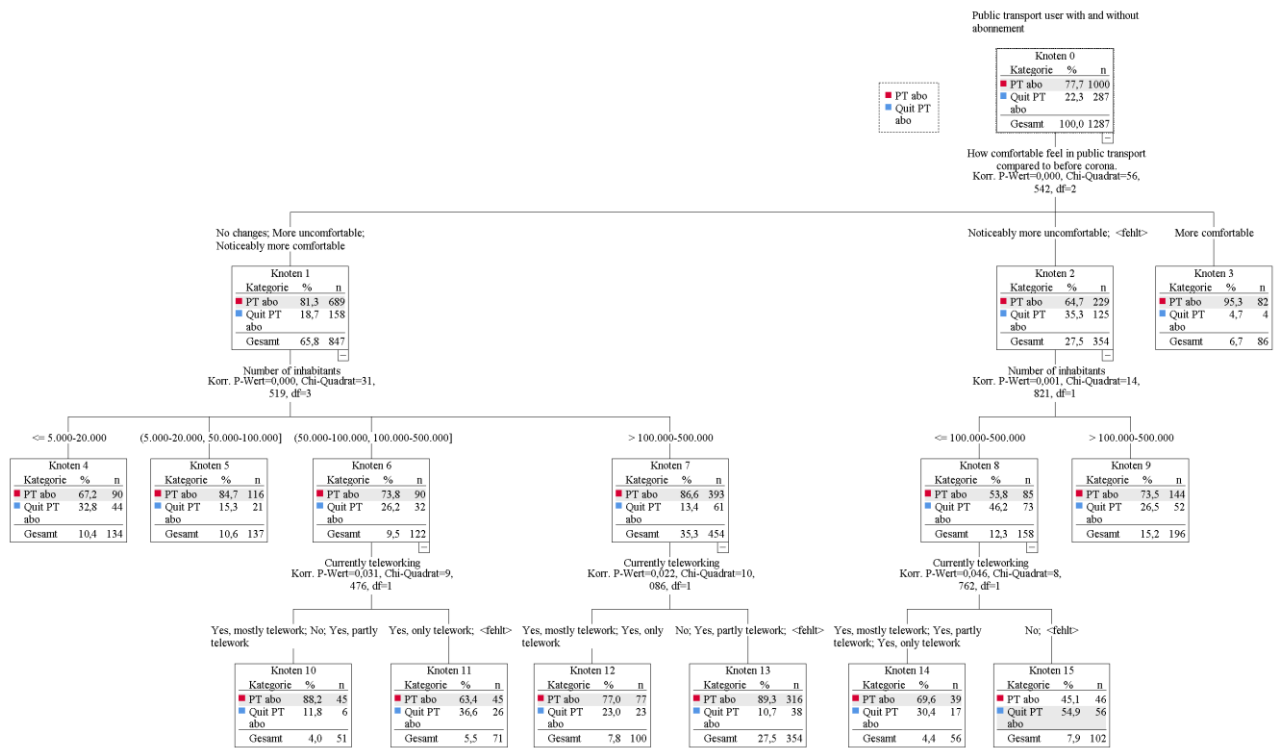


Fig. 1. The proposed decision tree for people who quit their public transport abonnement during the corona pandemic.

While the focus group discussion participants cannot be a representative for the population due to the small size of the sample, several patterns can be identified also here. First, the analyses indicate that changed travel patterns during the pandemic plays an important role for quitting the abonnement and use of public transport. 4 out of the 5 persons stated quitting the abonnement because of not commuting to work currently and/or due to changed leisure travel patterns. Thus, working people whose job tasks allows to work from were more likely to move away from the use of public transport. This included also people with changing working place – two of the participants reported being as consultant less often by customers on site. People who felt uncomfortable in public transport during the pandemic seems mostly to have already a good alternative to it – bike and/or car in the household or carsharing. These alternatives were already used also before the pandemic; however, the pandemic have led to an increase in their use. Single participants reported that they have purchased an e-bike or subscribed for carsharing during the pandemic.

4.4 Measures to increase attractiveness of public transport from public transport users’ point of view

In view of the declining use of public transport and the high share of people who feel uncomfortable on public transport, the question arises which measures can help to improve the situation. In the 2nd DLR survey, the respondents were therefore asked to rate a total of seven measures on the basis of a five-point scale. The results show: All suggested measures to prevent the risk of infection in buses and trains and to reduce discomfort during their use are rated positively. With the exception of one measure, more than half of the respondents described each measure as (very) helpful. The measures ranking is as follows: From the respondents' point of view, the most helpful measures are regular disinfection of vehicles and the obligation to wear masks. The third and fourth place are the use of more vehicles to reduce the number of passengers per vehicle and more staff at stations and stops to ensure that the required distance is maintained. Contactless ticketing is also considered (very) helpful by just over 50 percent of respondents. Only the provision of information on current occupancy of vehicles via smartphone is just below the 50 percent mark.

People who frequently use public transport (at least weekly) assess the measures only slightly different. Here, the use of more vehicles is ranked ahead of the mask requirement, which thus falls to third place. Contactless ticketing is also considered slightly more helpful by this group than additional staff at stations and stops. In an open question, the respondents were able to name further measures. Technical aids such as automatic doors, dividing partitions and better ventilation were mentioned. However, with 26% of all mentions, compliance with existing measures - in particular the obligation to wear masks - and their control were mentioned most frequently. A small group, however, is disturbed by the wearing of masks on public transport.

Several measures were discussed also in the focus group discussion. The results are in line with the results from the quantitative survey and provide additional insights on the key pain points for using public transport before, during, and after the pandemic. Short term measures include disinfectant in vehicles, air filter equipment or in general transparent hygienic concepts and staff to control compliance of passengers with corona-related rules. Crowded vehicles were among the main issues also prior the Corona for the participants along with the time schedule that needs improvement to carry the demand during different times of the day. These issues deteriorated with the pandemic as people became more sensitive to travelling with other passengers. Free or cheap public transport was also one of the main discussed topics: *“And I am of course a fan of free public transport, because I think that then much more people would use it if they don’t have to pay for it. Of course, the money have to come from somewhere – taxes or I don’t know where. But then we can take significant more people away from the car to the public transport, because they can get in and out of the bus wherever they want.”*

Along these lines, easier, contract-free and individual ticketing system was seen as the next necessary step to make using public transport more easier – a topic which participants reported became also more sensitive about due to the pandemic. For the use of public transport, also independently from the pandemic, the participants reported to expect that it is secure and accessible also for mobility-constrained people. Modern vehicles and free wireless internet are discussed to increased comfortable level and thus the personal willingness of using public transport. Controversially discussed was the potential of a digital mobility platform which allows choosing, booking, and using all modes of transport (including public transport, car or bike share mobility services). It was a common view that this would be most challengeable to be implemented given the number of different providers which have to get together. All participants agreed that the various measures to increase attractiveness of public transport are necessary and needed as soon as possible. One participant brought it to the point: *„I think that it would be pity when only these things are implemented by 2035. That would be for me Germany 1990 again, this is way too little. I would expect that these things are available in the next two years and not in 13 years.”*

4. Conclusions

The results confirm that public transport has lost ground during the pandemic. Simultaneously, an increase in the use of private vehicles as well as in the perceived attractiveness of using individual motorized transport can be observed. In the last two years, these new mobility habits have developed into stable routines that cannot easily be changed. Therefore, significant efforts are needed from public transport operators and politicians to increase the attractiveness of public transport. This need already existed before the pandemic and has become even more urgent.

Many transport companies are reacting by developing new tariffs, as monthly tickets are no longer profitable for people who mainly work from home. In some German cities, monthly tickets are offered that are limited to the use of a certain number of days, but are cheaper. This may help to retain customer groups, but these new offers also mean a loss of revenue. Therefore, an ongoing support from the official authorities – as during the lockdown phases – is needed to compensate for the losses caused by the pandemic, so that investments can still be made.

However, financial support alone is not enough. Instead, the right framework conditions have to be created. This includes, for example, the systematic restructuring of cities by reducing the public space used for private motorized transport and a city-wide management of parking space. This can create attractive urban spaces with a high quality of stay. In this way, the use of active modes of transport such as cycling and walking, but also the use of public transport, is promoted.

In this context, future research is needed to analyze the short-term impact of the indicated new ticket offerings. In addition, continuous monitoring is important in order to keep an eye on the development of public transport as a basis

for decisions on public funding. Finally, experimental designs and computations using traffic models help to estimate the impact of changes in urban space on mobility behavior.

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References

- Anke, J., Francke, A., Schaefer, L.-M., & Petzoldt, T. (2021). Impact of SARS-CoV-2 on the mobility behaviour in Germany. *European Transport Research Review*, 13(1).
- Awad-Núñez, S., Julio, R., Gomez, J., Moya-Gómez, B., & González, J. S. (2021). Post-COVID-19 travel behaviour patterns: impact on the willingness to pay of users of public transport and shared mobility services in Spain. *European Transport Research Review*, 13(1).
- Borkowski, P., Jażdżewska-Gutta, M., & Szmelter-Jarosz, A. (2021). Lockdowned: Everyday mobility changes in response to COVID-19. *Journal of Transport Geography*, 90, 102906.
- Bucsky, P. (2020). Modal share changes due to COVID-19: The case of Budapest. *Transportation Research Interdisciplinary Perspectives*, 8, 100141.
- Budd, L., & Ison, S. (2020). Responsible Transport: A post-COVID agenda for transport policy and practice. *Transportation Research Interdisciplinary Perspectives*, 6, 100151.
- Campisi, T., Basbas, S., Skoufas, A., Akgün, N., Ticali, D., & Tesoriere, G. (2020). The Impact of COVID-19 Pandemic on the Resilience of Sustainable Mobility in Sicily. *Sustainability*, 12(21), 8829.
- Ciuffini, F., Tengattini, S., & Bigazzi, A. Y. (2021). Mitigating Increased Driving after the COVID-19 Pandemic: An Analysis on Mode Share, Travel Demand, and Public Transport Capacity. *Transportation Research Record: Journal of the Transportation Research Board*, 0361198121110378.
- Finbom, M., Kębłowski, W., Sgibnev, W., Sträuli, L., Timko, P., Tuvikene, T., & Weicker, T. *COVID-19 and public transport: insights from Belgium (Brussels), Estonia (Tallinn), Germany (Berlin, Dresden, Munich), and Sweden (Stockholm)*. Leibniz-Institut für Länderkunde e.V. (IfL).
- Gutiérrez, A., Miravet, D., & Domènech, A. (2020). COVID-19 and urban public transport services: emerging challenges and research agenda. *Cities & Health*, 1–4.
- Haas, M. de, Faber, R., & Hamersma, M. (2020). How COVID-19 and the Dutch 'intelligent lockdown' change activities, work and travel behaviour: Evidence from longitudinal data in the Netherlands. *Transportation Research Interdisciplinary Perspectives*, 6, 100150.
- Jenelius, E., & Cebeceauer, M. (2020). Impacts of COVID-19 on public transport ridership in Sweden: Analysis of ticket validations, sales and passenger counts. *Transportation Research Interdisciplinary Perspectives*, 8, 100242.
- Kłos-Adamkiewicz, Z., & Gutowski, P. (2022). The Outbreak of COVID-19 Pandemic in Relation to Sense of Safety and Mobility Changes in Public Transport Using the Example of Warsaw. *Sustainability*, 14(3), 1780.
- König, A., & Dreßler, A. (2021). A mixed-methods analysis of mobility behavior changes in the COVID-19 era in a rural case study. *European Transport Research Review*, 13(1).
- Kopsidas, A., Milioti, C., Kepaptsoglou, K., & Vlachogianni, E. I. (2021). How did the COVID-19 pandemic impact traveler behavior toward public transport? The case of Athens, Greece. *Transportation Letters*, 13(5-6), 344–352.
- Marra, A. D., Sun, L., & Corman, F. (2022). The impact of COVID-19 pandemic on public transport usage and route choice: Evidences from a long-term tracking study in urban area. *Transport Policy*, 116, 258–268.
- Nobis, C., & Eisenmann, C. (2021). Die Folgen der Corona-Pandemie für den ÖPNV – Ergebnisse einer Langzeitstudie zur Mobilität. *Der Nahverkehr* (1+2/2021), 10–15.
- Nobis, Claudia; Kuhnimhof, Tobias; Follmer, Robert; Bäumer, Marcus (2019): Mobilität in Deutschland – Zeitreihenbericht 2002 – 2008 – 2017. Studie von infas, DLR, IVT und infas 360 im Auftrag des Bundesministeriums für Verkehr und digitale Infrastruktur (FE-Nr. 70.904/15). Bonn/Berlin.
- Nobis, C., & Kuhnimhof, T. (2018). *Die Folgen der Corona-Pandemie für den ÖPNV – Ergebnisse einer Langzeitstudie zur Mobilität*.
- Przybyłowski, A., Stelmak, S., & Suchanek, M. (2021). Mobility Behaviour in View of the Impact of the COVID-19 Pandemic—Public Transport Users in Gdansk Case Study. *Sustainability*, 13(1), 364.
- Rasca, S., Markvica, K., & Ivanschitz, B. P. (2021). Impacts of COVID-19 and pandemic control measures on public transport ridership in European urban areas - The cases of Vienna, Innsbruck, Oslo, and Agder. *Transportation Research Interdisciplinary Perspectives*, 10, 100376
- Tsvetkova, A., Kulkov, I., Busquet, C., Kao, P.-J., & Kamargianni, M. (2022). Implications of COVID-19 pandemic on the governance of passenger mobility innovations in Europe. *Transportation Research Interdisciplinary Perspectives*, 14, 100581.
- Vickerman, R. (2021). Will Covid-19 put the public back in public transport? A UK perspective. *Transport Policy*, 103, 95–102.