Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 78 (2024) 40–46

Transportation Research Procedia

www.elsevier.com/locate/procedia

25th Euro Working Group on Transportation Meeting (EWGT 2023)

Evolution and characteristics of shared e-scooters usage in Munich, Germany – Results of an over 8 million trips data analysis

Anis Sellaouti*, Michaela Tiessler, Maryna Pobudzei, Silja Hoffmann

Chair of Intelligent, Multimodal Transport Systems University of the Bundeswehr Munich, Werner-Heisenberg-Weg 39, 85577 Neubiberg, Germany

Abstract

Based on Mobility Data Specification (MDS) data supplied by almost all operating sharing e-scooter companies in Munich, Germany, this study investigates how shared e-scooters have been used in the city.

This research examines how the aspects such as the frequency, duration, and distance of travel have changed. Indeed, variations over time, differences by weekday, and developments throughout the day are investigated more closely. Furthermore, the study addresses the effect of temperature and precipitation on the frequency of use across the entire period.

The analysis of over 8 million trips during 27 months reveals that since shared e-scooters were introduced in Munich, the number of rides using them has gradually risen yearly. Furthermore, the utilization of the services increases noticeably throughout the summer.

According to the investigations, the weather and temperature change significantly impact booking rates. The impact of temperature is directly correlated with the volume of rides. In the case of precipitation, it depends more on whether it is raining at the time or not, while the amount of rain plays a subordinate role. The study shows apparent differences in demand between weekdays and weekends or public holidays: During the week, the number of trips rises earlier, and there is a morning peak. Most journeys occur in the afternoon between 4 and 6 pm. The weekday bookings are generally consistent from Monday through Thursday, slightly higher on Fridays and Saturdays, and again decreasing on Sundays. Another study finding is that the typical journey time has stayed constant over time, ranging between seven and eight minutes.

Keywords: micro-mobility; e-scooters; data-analysis;

* Corresponding author. Tel.: +49 89 6004-2525; *E-mail address:* anis.sellaouti@unibw.de

10.1016/j.trpro.2024.02.006

1. Introduction

Munich, the capital of the German state of Bavaria, is a city in southern Germany with pleasant summer weather and wealthy residents. The city ranks second in Germany for sunshine hours (Vick, 2014) and boasts an average net salary of €2,834, one of the highest in the country (Preis, 2020). With a demographic peak between the ages of 23 and 41 (Stadt Muenchen, 2022), the city's population profile is relatively youthful.

These are favorable conditions for the adoption of innovative transport solutions but no general rules for the actual acceptance and usage of e-scooters in Munich could be made nor deduced. This research focusses on understanding shared e-scooter usage in Munich by examining over 8 million trips recorded over 27 months.

The study investigates the frequency, duration, and distance of e-scooter travels, exploring variations and patterns over time, on different weekdays, and at various times of the day. It also assesses the impact of environmental variables like temperature and precipitation on e-scooter usage throughout the entire duration of the study.

The discussion commences with an overview of current literature on urban e-scooter utilization, followed by an exposition of the research methodology. Subsequent section delves deep into the resultant findings, elucidating the identified patterns, trends in e-scooter usage in Munich and a reflective discussion on the implications of the discovered patterns. The article concludes with summarizing the insights and proposing future directions for urban policy formulation.

Through the analysis of e-scooter utilization patterns and their correlation with environmental variables, this study aims to offer insights that can guide the formulation of informed and effective urban transportation policies in Munich.

2. Literature Review

In 2017, the rental e-scooter was first introduced as a new form of micro-mobility in the United States by Bird in Santa Monica, California (Hall, 2017). The number of e-scooter rides (38.5 million in 2018) far outnumbered the number of station-based bike-sharing rides (two million) in the United States (NACTO, 2018, Shaheen and Cohen, 2019, Mehzabin Tuli et al., 2021). The general attitude towards e-scooters is divided. A study from New Zealand regarding e-scooter sharing stated that there is a general lack of interest and that there are no clear evident motivations to use an e-scooter at all. In contrast, in the studies by Großmüller et al. (2021) and Krauss et al. (2020), it is noticeable that the younger population has a positive attitude towards micro-mobility. Moreover, many respondents of a German Study believe in their potential as a shuttle to public transport stations (BDU, 2019).

Many cities in the U.S. and Europe are experiencing a rapid shift in micro-mobility with the introduction of scooter sharing (Mehzabin Tuli et al., 2021). Estimations assume a total of 20 million users in Europe, and the adoption of scooter sharing is four times that of bike sharing (Cardell and Moller, 2020, Latinopoulos et al., 2021). E-scooters are becoming an attractive mode of transport in urban environments. As a result, researchers expect a further increase in the number of users in the coming years (Gossling, 2020, Mehzabin Tuli et al., 2021). Some mobility researchers believe that shared scooters have the potential to transform urban transport systems by reducing congestion and fuel consumption (Shaheen and Cohen, 2019, Mehzabin Tuli et al., 2021). Early observations suggest that they have already positively impacted reducing pollution (Hollingsworth et al., 2019, Latinopoulos et al., 2021, Shaheen and Cohen).

Compared to bike-sharing services, rental e-scooters seem less attractive to city commuters (McKenzie, 2019; Reck et al., 2021; Younes et al., 2020). Most e-scooters are used for leisure and tourism purposes (Sellaouti et al., 2020, McKenzie, 2019, Gubman et al., 2019, Reinz-Zettler, 2019, Köllner, 2019). Statistics on e-scooter use at specific times of the day are inconclusive: some studies identify two commuter peaks (Caspi et al., 2020, McKenzie, 2019), while others find one peak in the afternoon (Bai and Jiao, 2020, Younes et al., 2020, Liu et al., 2019, Reck et al., 2021, Reck et al., 2022). For example, Liu et al. (2019) find low use of e-scooters for the morning commute to work in Indianapolis, peak lending hours on weekdays between 16:00 and 20:00, and increased activity just before midday. The same study found an excess of 150 active trips per minute during peak hours on weekends but only 70 on weekdays. According to Bai et al. (2021), there is a substantial correlation between daily eating, drinking, shopping, and leisure activities in Austin, Texas, and e-scooter use. While Younes et al. (2020) report observing more electric scooters on weekends, Hawa et al. (2021) report noticing more on weekdays (Mehzabin Tuli et al., 2021).

All micro-mobility sharing services are negatively impacted by precipitation and cold weather (El-Assi et al., 2017; Gebhart and Noland, 2014; Noland, 2019; Noland, 2021; Zhu et al., 2020, Reck et al., 2022), specifically for e-scooters. Noland (2019) finds that rain and snow reduce daily trips, while higher wind speeds are responsible for reducing e-scooter trip distances. Mathew et al. (2019) also conclude that precipitation amount and average temperature are essential variables in modeling the hourly number of e-scooter trips (Mehzabin Tuli et al., 2021).

3. Methodology

The evaluation is based on the Mobility Data Specification (MDS) provided by the sharing e-scooter operators. MDS defines a series of interfaces, especially for sharing operators, to standardize and thus facilitate data exchange (Open Mobility Foundation, 2021). Data from all in Munich operating sharing e-scooters companies except one (this provider joined Munich lately and should not impact our analysis) was made available. The evaluation period extends from the date of the introduction of the e-scooters by the respective provider up to and including September 2021.

Despite the underlying specification of MDS data, it was necessary to first process the information into a standard format before merging the data from various providers. Subsequently, the data was cleaned to produce the most accurate possible data. Among other things, duplicates were filtered out, and journeys during which the e-scooter was not moved were eliminated. As a result, 8,160,634 trips in total between June 2019 and September 2021 were examined.

In addition, meteorological data from the German Weather Service and usage data of the MVG Rad were included in the analysis. MVG Rad is a bike sharing service of the public transportation providers in Munich "MVG". MVG Rad provides approximately 4,500 bicycles in Munich and the surrounding communes (MVG, 2022).

4. Results & Discussion

The analysis reveals that since shared e-scooters were introduced in Munich, the number of rides using them has gradually risen yearly. Furthermore, the utilization of the services increases noticeably throughout the summer.
In Figure 1, orange bars represent the monthly number of e-scooter trips in Munich for 2019, 2020, and 2021. In addition, the number of trips with MVG-shared bikes is plotted as a black curve (Münchner Verkehrsgesellschaft, 2021). The trips made by MVG bikes include trips within the city area and throughout the entire business area extending to the suburbs.

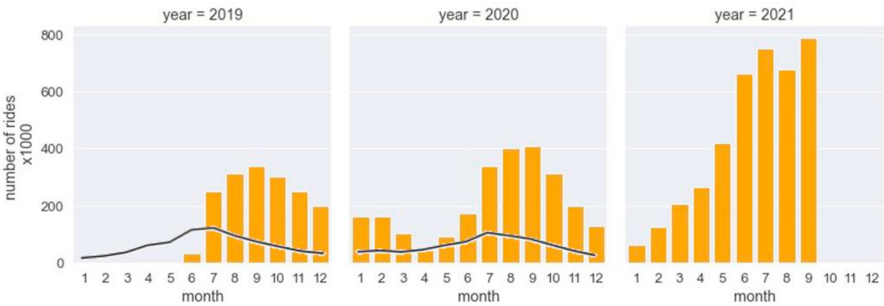

Fig. 1. Monthly number of e-scooters trips in 2019, 2020, and 2021, black curve: MVG bike trips in comparison

According to the investigations, the weather and temperature change significantly impact booking rates. The impact of temperature is directly correlated with the volume of rides. In the case of precipitation, it depends more on whether it is raining at the time or not, while the amount of rain plays a subordinate role. Figure 2 (a) shows the hourly trips and the respective prevailing temperatures over the entire evaluation period. Here it can be observed that the number of trips increases not only over the years but also with increasing temperature. At low temperatures, a little increase in the number of trips exists as the temperature rises and the slope steepens at around 10 °C.

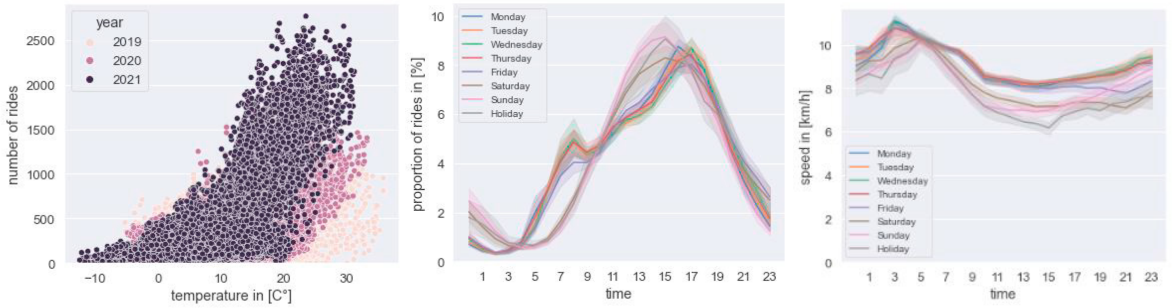

Fig. 2. (a) Temperature and number of trips in total; (b) Daily trend lines of e-scooter rides with differentiation by weekday; (c) Median speed over the day, differentiated by weekday

Equivalent results are found in the literature for Europe and USA. Indeed, a comparison of 30 European cities by Li and colleagues led to the conclusion that e-scooters tend to be more affected by weather conditions than cars or transit (Li et al., 2022). Furthermore, a substitution pattern study of micro-mobility in Zurich (Reck et al., 2022) revealed that precipitation negatively influenced mode choice for shared e-scooters. On the other side of the Atlantic Ocean, more precisely: in Washington, humidity, wind speed, and precipitation also negatively impacted the number of trips per hour, although warmer temperatures and better visibility were associated with more trips (Younes et al., 2020). Furthermore, in Indianapolis, the negative binomial model showed that snow, rain, wind speed, and freezing temperatures negatively affected the number of shared e-scooters trips (Mathew et al., 2019). In Chicago, the demand was higher on days with a higher average temperature, lower wind speed, and less precipitation (Mehzabin Tuli et al., 2021). In Louisville, rain and snow decreased the use of shared e-scooters (Noland, 2019). Also, in Kelowna a higher demand during summer and on days without rainfall is detected (Orvin et al., 2022).

The study shows apparent differences in demand between weekdays and weekends or public holidays, as represented in Figure 2 (b): During the week, the number of trips rises earlier, and there is a morning peak. Most journeys occur in the afternoon between 4 and 6 pm. The weekday bookings are generally consistent from Monday through Thursday, and are slightly higher on Fridays and Saturdays, and again decreasing on Sundays. On public holidays, regardless of the day of the week, there are by far the fewest bookings. On Fridays and Saturdays in the evening hours the most Trips occurs in areas with high density of bars (Schreier et al., 2022). Results confirm literature findings such as a higher e-scooter demand during, mid-day on weekends, and afternoons of weekdays in Kelowna (Orvin et al., 2022) and fewer e-scooter bookings on weekends in Washington (Hawa et al., 2021). Another study finding is that the typical journey duration has stayed constant over time, ranging between seven and eight minutes. Likewise stayed the daily trend lines of e-scooter rides over the years and with differentiation by season and month unchanged. In summer, the e-scooters are not only used more frequently, but the duration of the trips also increases and the distances covered are more significant. The same case is observed in Austin, where colder, rainier, and windier circumstances resulted in shorter shared micro-mobility mode distances and durations (Noland, 2021).

The average speeds were not transmitted in the data but were calculated from the respective aerial distance between start and destination and the duration of the individual journeys. Therefore, these are not actual average speeds traveled but an approximation that does not say much about an individual trip but can be used for comparisons given the high number of trips. In the beginning, the average speeds were the lowest. Over the first few months, the average speed gradually increases. Possible reasons for this could be that the users first had to get used to the system, so that the booking process took longer, that people initially drove more slowly due to a lack of driving experience, or that the booking and return processes were more complicated at the beginning and became simpler over time, or people simply wanted to try out the new vehicles and drove around. The assumption that speeds are reduced in winter due to icy or gritted roads cannot be confirmed based on the data. The opposite is the case. The average speeds in the summer months are lower than in the winter. One possible reason for this could be the higher load on the cycle paths, group, or leisure rides. There are two distinct speed curve groups that could be related to two different trip purposes: commuting (higher speeds) on weekdays, especially in the morning, and leisure (lower speeds) on weekends and weekdays in the afternoon (Figure 2 (c)). The same outcomes were reported by Noland (2019) in his study: average trip distances were larger, and average speeds were slower on Saturdays and Sundays.

In this study straight-line distances were examined as these can be calculated for all providers. Here we discuss briefly how these straight-line distances differ from the distances traveled. Since the trajectories were only partly available, the investigation is based on 40 percent of the trips. The quotient of the sum of the distances traveled and the straight-line distances calculated from the available data is 1.60. This means that, on average, 1.6 kilometers were traveled per kilometer of straight-line distance (The average trip distance routed via the path network in 44 European cities was around 1.84 kilometers (Tack et al., 2019)). If this quotient is calculated for each value, the mean value would be 6.53, and the median would be 1.27. The mean value is high here, as testing and fun rides are particularly significant. Because if scooters were returned near the rental locations, but in between, they were "driven in circles", the quotients quickly became very high. Notably, in the first months, the medians of the quotients are much higher. Following a brief adjustment period, the median has stabilized at an essentially constant level with minor variations. So, it became more reasonable to presume that there were many test drives at the beginning of the operation.

In general, shared e-scooters in Munich are used for short distances. The median of trip length is 0.8 kilometers (straight-line distance). The short distance of trips is also notable by the high number of trips taking place within the same district and starting and ending close to the city center. Outside the central area, an increased shared e-scooter activity can be observed near public transportation hubs.

5. Conclusion

This research investigated the utilization patterns of shared e-scooters in Munich, Germany, using MDS data provided by almost all operating sharing e-scooter companies in the city. The study illuminated several aspects of e-scooter utilization, including frequency, duration, and distance of travel. It unveiled a noticeable augmentation in the annual number of e-scooter rides, exhibiting explicit temporal variations and pronounced discrepancies in demand, determined by the day (weekdays, weekends, and public holidays) and the time of the day. It confirmed the prevailing literature by confirming the influence of weather variations and temperature fluctuations on e-scooter usage.

This study combines the findings from existing literature, highlighting that usage patterns of e-scooters differ significantly based on the day and time. E-scooters serve dual purposes: they are utilized for both commuting and leisure or tourism activities. Centering the analysis on specific days or times would have substantially influenced the outcomes. Within the city's core regions, e-scooters are emerging as competitors to public transport; however, in the outskirts, they complement public transport by filling the gaps in service.

These findings are instrumental for policymakers, helping in the integration of e-scooters into Munich's traffic system more cohesively. This study has its limitations. The available data lacks information on the entire fleet's availability, preventing us from deducing whether the number of e-scooters in the city center is excessive. Consequently, this limitation influences our ability to assist policymakers in making informed decisions about the integration of e-scooters in the city's transit system.

Our ongoing research continues to explore the multifaceted dimensions of e-scooter use in Munich. Parallel studies delve into a more detailed spatial analysis and scrutinize the e-scooter-related accidents reported to the Munich police department (Schreier et al., 2022, Pobudzei et al., 2023), aiming to enrich the understanding of e-scooter safety and their interaction with urban landscapes. Additionally, our spatial analysis of e-scooter usage in Munich (Tießler et al., 2023) is aiming to provide deeper insights into whether e-scooters serve as a complement or a substitute to public transportation, a critical consideration for optimizing urban transport networks.

Acknowledgements

The authors thank the City of Munich (Viktor Goebel), team red Deutschland GmbH (Hannes Schreier), and e-scooter operators Bird, Bolt, Dott, Lime, Tier, and Voi for their help in collecting the MDS Data of shared e-scooters in Munich, Germany.

References

BDU (2019). Aktueller Nutzen und Potenziale von E-Scootern Kurz-Auswertung einer BDU-Befragung. BDU, https://www.bdu.de/media/353984/kurzbefragung-e-scooter.pdf

Cardell, M., Moller, T.H. (2020). How micromobility is moving cities into a sustainable future. EY, https://www.ey.com/en_gl/automotive-transportation/how-micromobility-is-moving-cities-into-a-sustainable-future.

Caspi, O., Smart, M. J., Noland, R. B. (2020). Spatial associations of dockless shared e-scooter usage. Transportation Research Part D: Transport and Environment, Volume 86, 102396, ISSN 1361-9209, https://doi.org/10.1016/j.trd.2020.102396.

Cenex (2020). Maximising the benefits of e-scooter deployment in cities. https://www.cenex.co.uk/app/uploads/2020/08/Maximising-the-benefits-of-e-scooter-deployment-in-cities.pdf

El-Assi, W., Salah Mahmoud, M., Nurul Habib, K. (2017). Effects of built environment and weather on bike sharing demand: a station level analysis of commercial bike sharing in Toronto. Transportation 44, 589–613, https://doi.org/10.1007/s11116-015-9669-z

ETSC (2020). Germany and France to regulate e-scooters. European Transport Safety Council, https://etsc.eu/germany-and-france-to-regulate-e-scoot-ers/#:~:text=Germany%20and%20France%20are%20the,but%20not%20on%20the%20pavement.

Gebhart, K., Noland, R.B. (2014). The impact of weather conditions on bikeshare trips in Washington, DC. Transportation 41, 1205–1225, https://doi.org/10.1007/s11116-014-9540-7

Großmüller, T., Heil, C., Hofmann, A., Göl, V. (2021). Datenbasierte Potentialanalyse zur Integration der Mikromobilität in städtische Verkehrssysteme – PaMiMob, https://www.regensburg.de/fm/121/forschungsbericht-mikromobilitaet.pdf

Gubman J., Jung, A., Kiel, T., Jan Strehmann (2019). E-Tretroller im Stadtverkehr Handlungsempfehlungen für deutsche Städte und Gemeinden zum Umgang mit stationslosen Verleihsystemen. Agora Verkehrswende, https://www.agora-verkehrswende.de/fileadmin/Projekte/2019/E-Tretroller_im_Stadtverkehr/Agora-Verkehrswende_e-Tretroller_im_Stadtverkehr_WEB.pdf

Hall, M. (2017). Bird Scooters Flying around Town. Santa Monica Daily Press, 26 September, https://www.smdp.com/bird-scooters-flying-around-town/162647

Hawa, L., Cui, B., Sun, L., El-Geneidy, A. (2021). Scoot over: Determinants of shared electric scooter presence in Washington D.C. Case Studies on Transport Policy, Volume 9, Issue 2, Pages 418-430, ISSN 2213-624X, https://doi.org/10.1016/j.cstp.2021.01.003.

Hollingsworth, J., Copeland, B., Johnson, J.X. (2019). Are e-scooters polluters? The environmental impacts of shared dockless electric scooters, Environ. Res. Lett. 14 (2019) 084031, https://doi.org/10.1088/1748-9326/ab2da8

Köllner, C. (2019). E-Scooter werden bislang nur mäßig angenommen. Springer Professional, https://www.springerprofessional.de/mobilitaetskonzepte/mikromobilitaet/was-sie-ueber-e-scooter-wissen-muessen/17156852

Krauss, K., Scherrer, A., Burghard, U., Schuler, J., Burger, A. M., Doll, C. (2020). Sharing Economy in der Mobilität: Potenzielle Nutzung und Akzeptanz geteilter Mobilitätsdienste in urbanen Räumen in Deutschland. Working Paper Sustainability and Innovation No. S06/2020, Fraunhofer Institut für System- und Innovationsforschung ISI, http://hdl.handle.net/10419/215685

Latinopoulos,C., Patrier,A., Sivakumar,A. (2021). Planning for e-scooter use in metropolitan cities: A case study for Paris. Transportation Research Part D: Transport and Environment, Volume 100, 103037, ISSN 1361-9209, https://doi.org/10.1016/j.trd.2021.103037.

Li, A., Zhao, P., Liu, X., Mansourian, A., Axhausen, K. W., Qu, X., (2022). Comprehensive comparison of e-scooter sharing mobility: Evidence from 30 European cities. Transp. Res. Part Transp. Environ., vol. 105, pp. 103–129, 2022, doi: 10.1016/j.trd.2022.103229

Liu, M., Seeder, S., Li, H. (2019). Analysis of e-scooter trips and their temporal usage patterns. Institute of Transportation Engineers. ITE Journal, 89(6), 44-49. https://www.researchgate.net/publication/333634549_Analysis_of_E-Scooter_Trips_and_Their_Temporal_Usage_Patterns#fullTextFileContent.

Mathew, J. K., Liu, M., Bullock, D. M. (2019). Impact of Weather on Shared Electric Scooter Utilization. 2019 IEEE Intelligent Transportation Systems Conference (ITSC), 4512-4516, https://doi.org/10.1109/ITSC.2019.8917121.

McKenzie, G., (2019). Spatiotemporal comparative analysis of scooter-share and bike-share usage patterns in Washington, D.C. Journal of Transport Geography, Volume 78, 19-28, ISSN 0966-6923, https://doi.org/10.1016/j.jtrangeo.2019.05.007.

Mehzabin Tuli, F., Mitra, S., Crews, M. B., (2021). Factors influencing the usage of shared E-scooters in Chicago. Transportation Research Part A: Policy and Practice, Volume 154, Pages 164-185, ISSN 0965-8564, https://doi.org/10.1016/j.tra.2021.10.008.

MVG (2022). MVG Rad Mieträder für München und die Landkreise, https://www.mvg.de/services/mvg-rad.html (accessed Jul. 19, 2022)

NACTO (2018). Shared Micromobility in the U.S.: 2018. National Association of City Transportation Officials, https://nacto.org/shared-micromobility-2018/.

Noland, R. B. (2019). Trip patterns and revenue of shared e-scooters in Louisville, Kentucky. Findings, 7747, https://findingspress.org/article/7747-trip-patterns-and-revenue-of-shared-e-scooters-in-louisville-kentucky.

Noland, R.B. (2021). Scootin' in the rain: Does weather affect micromobility?. Transporta-tion Research Part A: Policy and Practice, Volume 149, 114-123, ISSN 0965-8564, https://doi.org/10.1016/j.tra.2021.05.003.

Open Mobility Foundation (2021). Mobility Data Specification [online]. https://github.com/openmobilityfoundation/mobility-data-specification

Orvin, M., Bachhal, J., Fatmi, M., (2022). Modeling the Demand for Shared E-Scooter Services. Transportation Research Record. 2022;2676(3):429-442. doi:10.1177/03611981211051620

Pobudzei, M., Tießler, M., Sellaouti, A., Hoffmann, S., (2023). E-Scooter and Bicycle Accidents: Spatial, Temporal, and Demographic Characteristics in Munich, Germany. 2023 Transportation Research Board Annual Meeting (TRB).

Preis (202). Deutschlands Ausgaben: In welcher Stadt lebst du am günstigsten?, https://www.preis.de/Deutschlands-Ausgaben/ (accessed Jul. 19, 2022).

Reck, D.J., Haitao, H., Guidon, S., Axhausen, K. W., (2021). Explaining shared micromobility usage, competition and mode choice by modelling empirical data from Zurich, Switzerland. Transport. Res. Part C: Emerg. Technol. 124, 102947. https://doi.org/10.1016/j.trc.2020.102947.

Reck, D.J., Guidon, S., Axhausen, K.W., (2021). Modelling shared e-scooters: A spatial regression approach. The 9th Symposium of the European Association for Research in Trans-portation (hEART), Lyon, https://transp-or.epfl.ch/heart/2020/abstracts/HEART_2020_paper_78.pdf

Reck, D.J., Axhausen, K.W. (2021). Who uses shared micro-mobility services? Empirical evidence from Zurich, Switzerland. Transport. Res. Part D: Transp. Environ. 94, 102803. https://doi.org/10.1016/j.trd.2021.102803

Reck, D.J., Martin, H., Axhausen, K.W. (2022). Mode choice, substitution patterns and environmental impacts of shared and personal micro-mobility. Transportation Research Part D: Transport and Environment, Volume 102, 103134, ISSN 1361-9209, https://doi.org/10.1016/j.trd.2021.103134.

Reinz-Zettler, J. (2019). E-Scooter – eine Lösung für unsere Verkehrsprobleme?!. bayern innovativ, https://www.bayern-innovativ.de/services/asset/pdf-dokumente/cluster-automotive/E-Scooter-Eine-Loesung-Unserer-Verkehrsprobleme.pdf

Schreier H, Sellaouti A, Tiessler M, Pobudzei M, Hoffmann S, Hager A, et al. (2022). Evaluierung der verkehrlichen Wirkungen von E-Tretrollern. Landeshauptstadt München, https://muenchenunterwegs.de/content/1423/download/220530-bericht-eva-et-final-web.pdf

Shaheen, S., Cohen A. (2019). Shared Micromoblity Policy Toolkit: Docked and Dockless Bike and Scooter Sharing. eScholarship university of California, https://doi.org/10.7922/G2TH8JW7

Sellaouti, A., Arslan, O., Hoffmann, S. (2020). Analysis of the use or non-use of e-scooters, their integration in the city of Munich (Germany) and their potential as an additional mobility system. 2020 IEEE Intelligent Transportation Systems Conference (ITSC), Rhodes, Greece. DOI: 10.1109/ITSC45102.2020.9294224

Stadt Muenchen (2022). Altersverteilung der Bevölkerung am 31.12.2021 nach Geschlecht und Migrationshintergrund, Bevölkerungspyramide, https://stadt.muenchen.de/dam/jcr:80b8b075-9af7-4be0-a993-da8d1281f676/jp220104.pdf (accessed Jul. 19, 2022)

Tack, A., Klein, A., Bock, B., Stuelpnagel, C., Brockmeyer, F., (2019). E-scooters in Germany , E-Scooters in Germany: a data-driven contribution to the ongoing debate, https://scooters.civity.de/en (accessed Feb. 09, 2022)

Tießler, M., Pobudzei, M., Sellaouti, A., Hoffmann, S., (2023). Electric Scooters and Where to Find Them - A Spatial Analysis of the Utilization of Shared E-Scooter in Munich, Germany. 2023 Transportation Research Board Annual Meeting (TRB).

Vick, K. (2014). So oft scheint die Sonne in München, Merkur, https://www.merkur.de/lokales/muenchen/stadt-muenchen/wetter-muenchen-vergleich-anderen-staedten-deutschlands-mm-3636186.html#:~:text=Die%20drei%20gr%C3%B6%C3%9Ften%20deutschen%20St%C3%A4dte,weist%20die%20Wetterdienst%2DStatisik%20aus (accessed Jul. 19, 2022)

Younes, H., Zhenpeng, Z., Wu, J., Baiocchi, G. (2020). Comparing the Temporal Determinants of Dockless Scooter-share and Station-based Bike-share in Washington, D.C. Transportation Research Part A: Policy and Practice, Volume 134, 308-320, ISSN 0965-8564, https://doi.org/10.1016/j.tra.2020.02.021.