Will telework reduce travel? An evaluation of empirical evidence with meta-analysis

Laísa Braga Kappler,[1] João de Abreu e Silva,[2] Patrícia C. Melo[3]

[1] CERIS, Instituto Superior Técnico, University of Lisbon, 1 Rovisco Pais Ave, Lisbon, 1049-001, Portugal; laisakappler@tecnico.ulisboa.pt; Corresponding author.
[2] CERIS, Instituto Superior Técnico, University of Lisbon, 1 Rovisco Pais Ave, Lisbon, 1049-001, Portugal; jabreu@tecnico.ulisboa.pt.
[3] REM/UECE & ISEG-Lisbon School of Economics and Management, University of Lisbon, Rua do Quelhas 1200-781, Lisbon, Portugal; pmelo@iseg.ulisboa.pt.

Telework has been pointed out as a potential demand management strategy since the 1970s when Information and Communication Technologies (ICTs) emerged and allowed flexible ways of organizing work practices (Choo et al., 2005; Helminen & Ristimäki, 2007; O'Keefe et al., 2016). It was envisioned that telework could potentially eliminate commuting trips. Since then, several studies have focused on the effects of telework on travel, but the results are mixed. Earlier, the studies focused on analyzing telework effects on travel behavior confirmed the early expectations about telework effects on travel: a drastic reduction in travel (Harkness, 1977), distances traveled, and peak-hour traffic congestion (Mokhtarian et al., 1995). They used simple modeling methods and small samples, limiting the conclusions about why people telework and why teleworkers travel or not (Salomon, 1994). At the end of the 1990s, some researchers argued that teleworkers' commute trips could be longer than those of conventional workers (Mokhtarian et al., 1995). They designed specific questionnaires, which included three to seven days travel diaries.

More recent studies concluded that the impacts of telework on travel are negative or neutral at best (e.g., Zhu, 2012; Melo & de Abreu e Silva, 2017; Zhu et al., 2018; de Abreu e Silva & Melo, 2018a; de Abreu e Silva & Melo, 2018b; Cerqueira et al., 2020). They tend to suggest that teleworkers travel longer distances (Mokhtarian et al., 2004; Zhu, 2012; Melo & de Abreu e Silva, 2017; de Abreu e Silva & Melo, 2018a; de Abreu e Silva & Melo, 2018b; Yum, 2021; de Abreu e Silva, 2022), use cars more frequently (Yen, 2000; Shakibaei et al., 2021) or active modes of transport (Yum, 2021; Ozbilen & Akar, 2021; Echaniz, 2021), make more trips for leisure purposes (Yum, 2021; Wöhner, 2022; Costa et al., 2022), and make more non-work and business-related trips (de Abreu e Silva & Melo, 2018a). But still, some recent studies conclude that telework reduces travel (e.g., Elldér, 2020; Wöhner, 2022; Foltýnová & Brůha, 2024).

Until 2020, the conclusions drawn from the different empirical studies can be considered ambiguous, indicating that differences in sample sizes, data collection methods, questionnaire design and variables definition, modeling methods, and control variables used could partly explain the differences between studies with the same objective. Furthermore, until the COVID-19 pandemic, telework

adoption was marginal. Nonetheless, the pandemic (with government-imposed social distancing measures, including curfews and mandatory telework) made telework a vast worldwide experiment, resulting in substantial changes in urban travel patterns. More recent studies developed during the pandemic and post-pandemic period focused on modal shift, indicating an increase in car use and active modes (Wöhner, 2022; Costa et al., 2022) and a decrease in public transport use (Shakibaei et al., 2021; Echaniz, 2021). The high telework adoption and substantial travel reduction were also associated with the pandemic restrictions (Ameen et al., 2023). Including attitudes and perceptions about telework may also influence the results (Jain et al., 2021; Tahlyan et al., 2022).

However, in the aftermath of the pandemic, a decrease in telework engagement was noticed, but it is very unlikely that it will drop to the pre-pandemic level (Soler et al., 2023). But how about the long-term impacts? Once telework frequency increases, it could change the location patterns of households and sprawl, change the total amount of travel by different transport modes, transform activity spaces, and impact the attainment of more sustainable urban mobility patterns. So, what are the challenges to policymakers and planners? How could empirical evidence improve news methods for data collection and analysis of their results? What are the factors that influence conclusions? In this sense, this work aims to evaluate how data collection design; data collection methods; sampling and sample size; modelling approaches and control variables influence the conclusions of previous studies. The obtained results are expected to contribute to the design of recommendations for future data collection and empirical analysis of telework.

A systematic literature review was made on two of the more relevant databases in transportation literature, SCOPUS and Science Direct, in March 2023 to find studies aiming to evaluate the impacts of telework adoption on travel patterns. The search includes the following keywords on the title, abstract, and keywords: ("travel behavior" OR "distances traveled" OR "mode choice" OR "travel patterns" OR "trips purpose" OR "modal share" OR "commuting trips" OR "commuting distance" OR "commuting travel" OR "number of trips" OR "kilometers traveled" OR "trip scheduling" OR "total amount of travel" OR "residential location" OR "residential preferences") AND ("telework" OR "teleworking" OR "telecommuting" OR "work from home" OR "home-based telework" OR "home-based teleworking" OR "home-based telecommuting"). The search only included peer-reviewed journals in English. A total of 664 documents were found on SCOUPS and 158 on Science Direct; 100 of them were repetitive. A total of 822 papers were obtained, and only 183 were selected for a deep read. In the end, we select 134 studies to analyze.

The studies were mainly from Europe (about 41%), North America (almost 31%), and Asia (more than 17%). One study was dated to 1977; there are 14 studies between 1990 and 1999, 14 between 2000 and 2009, 31 between 2010 and 2019, and 74 between 2020 and March 2023. There has been an apparent increase in interest in the topic in the last decades, particularly after the COVID-

19 pandemic outbreak. The few empirical studies until 2010 could be partly explained because, generally, older papers are not easy to find, and they did not use a consistent method, so they were not selected for our analysis. In addition, research is increasing over the years, especially in the last two decades.

More than 88% of the reviewed studies were quantitative, and only three were qualitative. The type of data used in the reviewed papers varies strongly. Travel surveys started to be used in papers published during the 1990s, but there is great variability in the duration of their travel diaries, one to seven days. More recently, some studies have started to include questions about telework engagement. The employed questionnaires are very diverse; ranging from generic questions about telework engagement to specifically linking telework and travel. Sample sizes are very diverse, ranging from 15 respondents to about 50,000 observations. The modeling methods were very different, including scenario analysis, regression-based models, path analysis and Structural Equation Models, before and after analysis, and descriptive analysis. More than 90% of the studies included socioeconomic control variables (gender, age, and occupation were extensively considered), but only the more recent considered attitudinal variables and preferences about telework in the analysis. The most common dependent variables used were the number of trips, travel distances, and mode choice.

Regarding the results, 49,25% of the studies concluded that telework adoption reduces travel, 26,12% showed ambiguous results, 16,42% indicated travel increase, and 8,2% considered the conclusions neutral. Table 1 shows the conclusions of the studies by period in our sample.

Table 1 — A number of studies that reduce or increase travel or showed neutral or ambiguous results, by period, in our sample.

Period	**Reduces**	**Neutral**	**Ambiguous**	**Increases**	**Total**
1977	1	0	0	0	1
1990-1999	10	0	4	0	14
2000-2009	9	3	0	2	14
2010-2019	8	4	12	7	31
2020-2023	38	4	19	13	74
Total	66	11	35	22	134

From this systematic literature review a meta-analysis will be developed. The meta-analysis will consider the capacity of telework to reduce travel, thus employing a binary variable (decreases versus increases, is neutral or ambiguous). Due to the diversity of the studies regarding sample, methodology, data collection, and other characteristics, we will test the heterogeneity of this variability by applying Cochran's Q test and applying the more adequate method, either meta-regression (if there is heterogeneity) or random effects (if the variability is random). The obtained results will be discussed based on the capacity of different characteristics influencing the conclusions of the different

reviewed empirical studies. Based on this discussion, recommendations for future data collection and empirical analysis about telework will be provided.

References

Cerqueira, E. D. V., Motte-Baumvol, B., Chevallier, L. B., Bonin, O. (2020). Does Working From Home Reduce CO2 Emissions? An Analysis of Travel Patterns as Dictated by Workplaces. Transportation Research Part D: Transport and Environment, 83. https://doi.org/10.1016/j.trd.2020.102338

Choo, S., Mokhtarian, P.L. & Salomon, I. Does telecommuting reduce vehicle-miles traveled? An aggregate time series analysis for the U.S. Transportation 32, 37–64 (2005). https://doi.org/10.1007/s11116-004-3046-7

Costa, C. S., Pitombo, C. S., & de Souza, F. L. U. (2022). Travel Behavior before and during the COVID-19 Pandemic in Brazil: Mobility Changes and Transport Policies for a Sustainable Transportation System in the Post-Pandemic Period. Sustainability (Switzerland), 14(8). https://doi.org/10.3390/su14084573

de Abreu e Silva, J. (2022). Residential Preferences, Telework Perceptions, and The Intention to Telework: Insights from The Lisbon Metropolitan Area During The COVID-19 Pandemic. Regional Science Policy & Practice, 1–20. https://doi.org/10.1111/rsp3.12558

de Abreu e Silva, J., Melo, P. (2018a). Home Telework, Travel Behavior, and Land Use Patterns: A Path Analysis of British Single-Worker Households. Journal of Transport and Land Use, 11(1), 419-441. https://dx.doi.org/10.5198/jtlu.2018.1134

de Abreu e Silva, J., Melo, P. (2018b). Does Home-Based Telework Reduces Household Total Travel? A Path Analysis Approach of One and Two Worker British Households. Journal of Transport Geography, V37, 148-162. https://doi.org/10.1016/j.jtrangeo.2018.10.009

Echaniz, E., Rodríguez, A., Cordera, R., Benavente, J., Alonso, B., & Sañudo, R. (2021). Behavioural changes in transport and future repercussions of the COVID-19 outbreak in Spain. Transport Policy, 111, 38–52. https://doi.org/10.1016/j.tranpol.2021.07.011

Elldér, E. (2020) Telework and daily travel: New evidence from Sweden. Journal of Transport Geography, 86, 102777, ISSN 0966-6923, https://doi.org/10.1016/j.jtrangeo.2020.102777

Foltýnová, H. B. & Brůha, J (2024). Expected long-term impacts of the COVID-19 pandemic on travel behaviour and online activities: Evidence from a Czech panel survey. Travel Behaviour and Society, 34, 100685, ISSN 2214-367X. https://doi.org/10.1016/j.tbs.2023.100685.

Harkness, R. C. (1977). Selected results from a technology assessment of telecommunication-transportation interactions. Habitat International, 2(1–2), 37–48. https://doi.org/10.1016/0197-3975(77)90039-X

Helminen, V., Ristimäki, M. (2007). Relationships Between Commuting Distance, Frequency and Telework in Finland. Journal of Transport Geography 15:331-342. https://doi.org/10.1016/j.jtrangeo.2006.12.004

Jain, T., Currie, G., & Aston, L. (2021). COVID and Working From Home: Long-Term Impacts and Psycho-Social Determinants. Transportation Research Part a: Policy and Practice, 156, 52–68. https://doi.org/10.1016/J.TRA.2021.12.007

Melo, P. C., de Abreu e Silva, J., 2017. Home Telework and Household Commuting Patterns in Great Britain. Transportation Research Part A, 103, 1–24. https://doi.org/10.1016/j.tra.2017.05.011

Mokhtarian, P. L., Collantes, G. O., Gertz, C. (2004). Telecommuting, Residential Location, and Commute-Distance Traveled: Evidence From State of California Employees. Environment and Planning A, 36:1877-1897. https://doi.org/10.1068/a36218

Mokhtarian, P. L., Handy, S. L., & Salomon, I. (1995). Methodological issues in the estimation of the travel, energy, and air quality impacts of telecommuting. Transportation Research Part A, 29(4), 283–302. https://doi.org/10.1016/0965-8564(94)00029-A

O'Keefe, P., Caulfield, B., Brazil, W., White, P. (2016). The Impacts of Telecommuting in Dublin. Research in Transportation Economics, 57, 13–20. https://doi.org/10.1016/j.retrec.2016.06.010

Ozbilen, B., Wang, K., Akar, G. (2021). Revisiting the Impacts of Virtual Mobility on Travel Behavior: An Exploration of Daily Travel Time Expenditures. Transportation Research Part A: Policy and Practice, 145, 49–62. https://doi.org/10.1016/j.tra.2021.01.002

Salomon, I. (1994). How much telecommuting should we count on? A forecast for Tel-Aviv in 2020. Transportation Research Record, (1463), 26–34.

Shakibaei, S., de Jong, G. C., Alpkökin, P., & Rashidi, T. H. (2021). Impact of the COVID-19 pandemic on travel behavior in Istanbul: A panel data analysis. Sustainable Cities and Society, 65. https://doi.org/10.1016/j.scs.2020.102619

Soler, J. R. L., Christidis, P., Vassallo, J. M. (2023). Evolution of teleworking and urban mobility changes driven by the COVID-19 pandemic across European Cities. Transportation Research Procedia, 69, 488-495, 2352-1465. https://doi.org/10.1016/j.trpro.2023.02.199.

Tahlyan, D., Said, M., Mahmassani, H., Stathopoulos, A., Walker, J., & Shaheen, S. (2022). For whom did telework not work during the pandemic? Understanding the factors impacting telework satisfaction in the US using a multiple indicator multiple cause (MIMIC) model. Transportation Research Part a: Policy and Practice, 155, 387–402. https://doi.org/10.1016/J.TRA.2021.11.025

Wöhner, Fabienne, 2022. "Work flexibly, travel less? The impact of telework and flextime on mobility behavior in Switzerland," Journal of Transport Geography, Elsevier, vol. 102(C). https://doi.org/10.1016/j.jtrangeo.2022.103390

Yen, J.R. 2000. Interpreting Employee Telecommuting Adoption: An Economics Perspective. Transportation, 27(1):149–164. https://doi.org/10.1023/A:1005200513201

Yum, S. (2021). Differences Between Telecommuters and Commuters: The Case of the Twin Cities Metropolitan Area. Transportation Planning and Technology, 1–16. https://doi.org/10.1080/03081060.2021.1883229

Zhu, P. (2012). Are Telecommuting and Personal Travel Complements or Substitutes? The Annals of Regional Science, 48:619-639. https://doi.org/10.1007/s00168-011-0460-6

Zhu, P., Wang, L., Jiang, Y., Zhou, J. (2018). Metropolitan Size and The Impacts of Telecommuting on Personal Travel. Transportation, 45, 385–414. https://doi.org/10.1007/s11116-017-9846-3