

TRANSPORT FINDINGS

A Meta-analysis of the Induced Travel due to E-scooters

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Findings

The e-scooter is a relatively new transport mode that primarily has replaced other modes. However, e-scooters have also generated some new travel. A meta-analysis was carried out on 192 outcomes of retrospective estimates of the proportion of current e-scooter trips that would not have been carried out if e-scooters were not available. The meta-analysis estimate of induced travel is about four percent, based on the 192 survey outcomes from 95 case-areas. Meta-regression shows that the proportion of induced travel due to e-scooters tends to be higher in areas where travel by car dominates.

1. Questions

E-scooters have gained a share of the daily transport in many parts of the World, especially after the introduction of shared (rental) e-scooters some ten years ago (Cao et al. 2021). Primarily, e-scooters have replaced other transport modes (Badia and Jenelius 2023; Wang et al. 2023). However, they have also induced new travel and mobility. In recent years, numerous studies have asked respondents, retrospectively, what they would have done on their most recent e-scooter trip if an e-scooter were not available. Fearnley and Veisten (2025) presented a meta-analysis of that literature with estimates of the shares of private motorized modes, public transport modes, and active transport modes, that the e-scooter had replaced. They did not, however, analyse new, or generated, trips.

In this paper we carry out meta-analysis of the survey outcomes (effect sizes) from Fearnley and Veisten (2025) that included estimates of the proportions of the last e-scooter trips that would not have been carried out if an e-scooter were not available, i.e., the induced travel due to e-scooters. The meta-analysis is based on 192 outcomes (proportions of e-scooter trips that are induced) from 50 studies, carried out in 95 city areas, in Europe, North America, and Oceania. (The meta-data is listed in the adjoint *Supplemental Information, Section 1.*)

Meta-analytical methods enable statistically weighted estimates that distinguish within-study variance (sampling error) and between-study variance. They can also consider hierarchical structures, i.e., that studies contain different numbers of outcomes (Borenstein et al. 2009; Harrer et al. 2021). Meta-regression enables assessment of whether case-area characteristics or study/outcome features are associated with the level of e-scooters' induced travel.

Thus, the two research questions that we attempt to illuminate in this paper are:

What is the meta-analytic weighted average of induced travel due to e-scooters, i.e. the proportion of e-scooter users who would not have travelled in the absence of e-scooters, in the literature of 192 outcomes in 95 case areas?

What case-area characteristics and/or outcome/study features explain variation in induced travel due to e-scooters?

2. Methods

The 192 outcomes were weighted by the square root of the outcome sample size, as standard errors lack for most of the outcomes (Borenstein et al. 2009). A multilevel meta-analysis model was tested and found appropriate due to the hierarchical structure of the meta-data and the outcome heterogeneity (Harrer et al. 2021). The within-study variance and the between-study variance outweigh the sampling error. A (non-hierarchical) random effects model does not handle the within-study variance and a fixed effects model only takes into account the outcomes' sampling error.

[Table 1](#) lists the averages and distributions of the meta-data.

The proportion of induced travel due to e-scooter availability, in the upper line, shows a simple average of 5% across the 192 outcomes. The sum of the proportion of induced travel plus the proportions of e-scooter mode replacements are normalized to 1.

The table also lists the averages of case area statistics and outcome/study features; all considered as potential moderators of the variation in induced travel due to e-scooter availability.

In the meta-analysis we applied logit-transformation of the proportions of respondents stating that the last trip would not have been carried out if an e-scooter were not available (the outcome). Other proportions, applied as moderators in the meta-regression, were also logit-transformed. These primarily comprise the proportions of three transport mode classes in commuting: private motorized vehicles (PMV), i.e., cars, ridehailing/taxi, MC, etc., public transport (PT), and active transport (AT), i.e., walking and cycling. Logit-transformed proportions can be transformed back by the exponential function (Harrer et al. 2021).

There is a variation in the average induced travel outcome across continents; it is highest in Oceania (ca. 8.5%), and lowest in Europe (ca. 4%), with North America in-between (ca. 6%). The number of outcomes from Oceania is quite low, however ($n_3=8$). The number of outcomes from North America is also much lower than the number of outcomes from Europe ($n_2=24$ vs. $n_1=160$). The overwhelming majority of the outcomes are based on (only) the use of

Table 1. Descriptive statistics of 192 outcomes (N) from 50 survey-based studies of e-scooter mode-replacement, in 95 case areas in Europe (n1=160), North America (n2=24), and Oceania (n3=8). As many studies provide a set of outcomes from different areas (cities), all case area characteristics and most survey features are based on the outcomes rather than the study.

	Mean	SD	Min	Max
Proportion stating non-travel if e-scooter not available (induced travel)	0.04	0.05	0	0.25
Proportion of e-scooter trips that replace private-motorized vehicles (PMV)	0.22	0.12	0.03	0.78
Proportion of e-scooter trips that replace public transport (PT)	0.20	0.12	0.005	0.54
Proportion of e-scooter trips that replace active transport (AT)	0.51	0.10	0.15	0.73
Population of outcome area, in millions	1.0	1.2	0.02	6.5
Size of outcome area, in square km	454	1044	3	9992
Population density of outcome area	4053	4846	146	30,066
The outcome area has metro and/or tram (dummy=1)	0.58	0.49	0	1
The length (km) of metro/tram lines, in outcome area	87	138	0	1215
Km of metro/tram lines relative to area size in outcome area	0.45	1.05	0	8.56
The outcome area has municipality-supported bike rental system (dummy=1)	0.70	0.46	0	1
PMV mode share in commuting in outcome area	0.53	0.20	0.20	0.97
PT mode share in commuting in outcome area	0.19	0.13	0.02	0.60
AT mode share in commuting in outcome area	0.25	0.14	0.01	0.50
Only rental (shared) e-scooter usage (not private or mixed) in the outcome (dummy=1)	0.86	0.34	0	1
Only private (not shared or mixed) e-scooter usage in the outcome (dummy=1)	0.01	0.07	0	1
Outcome sample is e-scooter rental company-registered users (dummy=1)	0.73	0.44	0	1
Study by e-scooter rental company (dummy=1)	0.63	0.49	0	1
Confidential study by e-scooter rental company (dummy=1)	0.56	0.50	0	1
Outcome from peer-review publication or PhD thesis (dummy=1)	0.05	0.21	0	1
Female share in outcome sample	0.31	0.09	0.04	0.52
Age>30 share in outcome sample	0.50	0.13	0.22	0.87
Data collection year	2021		2018	2023
Outcome sample size	2955	10,506	31	80,147
No. of outcomes per study	3.8		1	41

rental e-scooters (88%). Descriptive statistics for the subsets of outcomes from each continent, as well as Egger's test of funnel plot asymmetry are shown in *Supplemental Information, Section 1*. Funnel plot asymmetry is found, which indicates, but does not imply, publication bias (Borenstein et al. 2009).

In the meta-regression we test the case-area characteristics listed in [Table 1](#). These variables will also to some extent reflect continental differences, e.g., the cities' built-environment and transport mode distribution (Cervero 1996; Ewing and Cervero 2010; Conwell et al. 2023). Fearnley and Veisten (2025) found that the case-areas' mode share in commuting was the strongest explanator of the e-scooter mode replacement pattern in the meta-regression. Moreover, the features of the produced outcomes, the surveys/studies listed in [Table 1](#), can also be tested in meta-regression.

Table 2. Multilevel model, explaining variation in logit-transformed proportions of the last e-scooter trips that would not have been carried out if e-scooters were not available, the induced travel due to e-scooters.

	Induced travel due to e-scooters
Intercept	-3.35 (0.11)
Logit of market share of private motorized vehicles (PMV) in commuting	0.31 (0.06)
F (test of moderators)	30.4
AIC / BIC	511 / 524
logLik	-251.3
QE (test for residual heterogeneity)	22,975
I ² (residual heterogeneity / unaccounted variability)	99.4%
Anova test of three levels vs. two levels	73.1
Single outcome variance share, sampling error (level 1)	0.7%
Within-study variance share (level 2)	43.9%
Between-study variance share (level 3)	55.4%

(All tests and all coefficients are significant at the 0.001 level; standard errors of coefficients in parentheses.)

3. Findings

Meta-regression, multilevel models

[Table 2](#) shows a parsimonious meta-regression model of induced travel due to e-scooters that resulted from testing the variables (moderators) in [Table 1](#). In the multilevel model, only one moderator showed a significant association with the logit-transformed proportion of e-scooter-induced travel demand at the 5% significant level: the case-area (logit-transformed) proportions of the commuting modes. As the proportions of PMV, PT, and AT necessarily are interrelated, it turns out that the best models include only one proportion; the best model is based on the PMV.

The multilevel meta-regression model of induced travel due to e-scooters (θ) that we estimate can be specified as the following:

$$\text{Logit}(\hat{\theta}_{ij}) = \beta_0 + \beta_1 \text{Logit}(\text{PMV}_{1,ij}) + \zeta_{(3)j} + \zeta_{(2)ij} + \varepsilon_{ij} \quad (1)$$

where the β s are the coefficients and ε_{ij} is the sampling error. The multilevel model includes a within-cluster (within-study) heterogeneity ($\zeta_{(2)ij}$, at level 2) and a between-cluster (between-study) heterogeneity ($\zeta_{(3)j}$, at level 3). The subscript ij indicates an outcome i nested in cluster j (Harrer et al. 2021). The model was estimated in R (Schwarzer et al. 2015), applying the package ‘metafor’ (Viechtbauer 2010).

[Table 2](#) shows that the variation in the logit-transformed proportions of the 192 induced e-scooter travel outcomes are fairly well explained by the variation in PMV commuting mode across outcomes and case-areas. There is a significantly positive association; the higher the (logit of the) proportion of PMV in commuting, the higher induced travel due to e-scooters. The model indicates very strong heterogeneity of the meta-data (QE, I²). It also shows that a hierarchical structure is appropriate, considering the Anova test for a

three-level (multilevel) model instead of a two-level (standard random effects) model. The shares of variance within-study and between-study are of similar order of magnitude and dominate completely the share of variance due to sampling error.

Comparisons of the multilevel meta-regression model against other meta-regression models, also including more moderators, are shown in *Supplemental Information, Section 2*. The log of the outcome area (Ln_area) is negatively associated with induced travel by e-scooter at the 10% significance level, in the multilevel model. The same association applies to the dummy variable of outcomes from three confidential e-scooter rental companies (Three_conf_comp). Other meta-regression specifications will yield somewhat stronger coefficients for these two moderators, yet we consider the multilevel model as the appropriate model for our meta data. The comparisons also include alternative multilevel models based on PT and AT in commuting, both having a negative association with induced travel due to e-scooters.

Summing-up

A new transport mode can yield induced demand (Moudon et al. 2020), indicating reductions in the generalized cost of travel for part of the inhabitants. More activities are made available for these individuals. Although the new trips are “marginal” and consumer surplus confined, the induced travel is welfare enhancing for the individuals (cf. the ‘rule of half’ in appraisal).

Using multilevel meta-regression, we have found that the proportion of induced travel, when e-scooters are made available, is expected to be higher in cities where commuting by PMV is higher ([Table 2](#)). The PMV proportion in commuting has also been found to be associated with the e-scooter mode replacement proportions; PMV is replaced to a higher extent in case-areas where PMV dominates in commuting, although e-scooters primarily replace walking and also replace PT (Badia and Jenelius 2023; Wang et al. 2023; Fearnley and Veisten 2025). Possibly, from the mode replacement pattern, we can to some extent derive that replacement instead of induced travel is predominant in the areas where AT and/or PT are extensive at the outset. Literature points to e-scooters’ lower physical exertion, compared to walking/cycling, and the door-to-door convenience of dockless e-scooters, compared to PT (e.g., Luo et al. 2021; Sanders et al. 2022; Aarhaug et al. 2023). We cannot point to other specific explanations why e-scooters induce more new trips in car-dominated areas.

In our meta-analysis we tested a large set of potential explanatory variables, or moderators ([Table 1](#)), finding only weak associations except for the mode share in commuting. We have pointed to the literature on the relationship between mode shares and case area characteristics (e.g., Ewing and Cervero

2010; Credit and O'Driscoll 2024). Other characteristics than those tested might explain more of the variation in the induced travel due to e-scooters, e.g., the road infrastructure (bike lanes), rental e-scooter fleet characteristics, or other factors. More studies and outcomes from other continents than Europe might also yield new insights. We leave these issues for future meta-analyses.

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REFERENCES

- Aarhaug, J., N. Fearnley, and E. Johnsson. 2023. "E-Scooters and Public Transport – Complement or Competition?" *Research in Transportation Economics* 98. <https://doi.org/10.1016/j.retrec.2023.101279>.
- Badia, H., and E. Jenelius. 2023. "Shared E-Scooter Micromobility: Review of Use Patterns, Perceptions and Environmental Impacts." *Transport Reviews* 43 (5): 811–37. <https://doi.org/10.1080/01441647.2023.2171500>.
- Borenstein, L., V. Hedges, J. P. T. Higgins, and H. R. Rothstein. 2009. *Introduction to Meta-Analysis*. John Wiley & Sons, Ltd. <https://doi.org/10.1002/9780470743386>.
- Cao, Z., X. Zhang, K. Chua, H. Yu, and J. Zhao. 2021. "E-Scooter Sharing to Serve Short-Distance Transit Trips: A Singapore Case." *Transportation Research Part A: Policy and Practice* 147: 177–96. <https://doi.org/10.1016/j.tra.2021.03.004>.
- Cervero, R. 1996. "Mixed Land-Uses and Commuting: Evidence from the American Housing Survey." *Transportation Research Part A: Policy and Practice* 30 (5): 361–77. [https://doi.org/10.1016/0965-8564\(95\)00033-X](https://doi.org/10.1016/0965-8564(95)00033-X).
- Conwell, L. J., F. Eckert, and A. M. Mobarak. 2023. *More Roads or Public Transit? Insights from Measuring City-Center Accessibility*. NBER Working Paper Nos. 30877, National Bureau of Economic Research, Cambridge, MA. <https://doi.org/10.3386/w30877>.
- Credit, K., and C. O'Driscoll. 2024. "Assessing Modal Tradeoffs and Associated Built Environment Characteristics Using a Cost-Distance Framework." *Journal of Transport Geography* 117: 103870. <https://doi.org/10.1016/j.jtrangeo.2024.103870>.
- Ewing, R., and R. Cervero. 2010. "Travel and the Built Environment." *Journal of the American Planning Association* 76 (3): 265–94. <https://doi.org/10.1080/01944361003766766>.
- Fearnley, N., and K. Veisten. 2025. "What Proportions of Different Transport Modes Do E-Scooters Replace? A Meta-Analysis." *Journal of Cycling and Micromobility Research* 5: 100082. <https://doi.org/10.1016/j.jcmr.2025.100082>.
- Harrer, M., P. Cuijpers, T. Furukawa, and D. Ebert. 2021. *Doing Meta-Analysis with R: A Hands-On Guide*. Chapman & Hall. <https://doi.org/10.1201/9781003107347>.
- Luo, H., Z. Zhang, K. Gkritza, and H. Cai. 2021. "Are Shared Electric Scooters Competing with Buses? A Case Study in Indianapolis." *Transportation Research Part D: Transport and Environment* 97: 102877. <https://doi.org/10.1016/j.trd.2021.102877>.
- Moudon, A. V., X. J. Ban, M. Lowry, et al. 2020. *The Impact of Shared Mobility Options on Travel Demand*. Report. University of Washington. https://depts.washington.edu/trac/bulkdisk/pdf/Moudon_Shared_Mobility_Travel_Demand.pdf<https://digital.lib.washington.edu/server/api/core/bitstreams/ad54a2cc-a86c-4bf3-b10f-74c7e9517fa1/content>.
- Sanders, R. L., V. da Silva Brum Bastos, and T. A. Nelson. 2022. "Insights from a Pilot Investigating the Impacts of Shared E-Scooter Use on Physical Activity Using a Single-Case Design Methodology." *Journal of Transport & Health* 25: 101379. <https://doi.org/10.1016/j.jth.2022.101379>.
- Schwarzer, G., J. R. Carpenter, and G. Rücker. 2015. *Meta-Analysis with R*. Springer Cham. <https://doi.org/10.1007/978-3-319-21416-0>.
- Viechtbauer, W. 2010. "Conducting Meta-Analyses in R with the Metafor Package." *Journal of Statistical Software* 36 (3): 1–48. <https://doi.org/10.18637/jss.v036.i03>.

Wang, K., X. Qian, D. T. Fitch, Y. Lee, J. Malik, and G. Circella. 2023. “What Travel Modes Do Shared E-Scooters Displace? A Review of Recent Research Findings.” *Transport Reviews* 43 (1): 5–31. <https://doi.org/10.1080/01441647.2021.2015639>.

SUPPLEMENTARY MATERIALS

Supplemental information

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