Supplementary Information for the Study: The Overlooked Role of Roadworks in Micromobility's Accessibility

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In this file, we provide additional details to supplement the study: *"The Overlooked Role of Roadworks in Micromobility's Accessibility."* It offers a thorough explanation of our methodological decisions and model specifications in addition to a comprehensive presentation of the data used in the study.

Data

The speed calculation utilizes large-scale trajectory data, which includes GNSS coordinates collected via a smartphone app connected to a bicycle airbag helmet (Hovding). The GNSS data frequency is 1-2 Hz. While the data covers the Copenhagen metropolitan area, only the Municipality data was used to align with the roadworks data in a spatial context.

To calculate the in-motion speed at the segment level for each trip, we first, exclude all geolocation points with speeds below 5 km/h, as this indicates walking speed or stops, such as those caused by traffic lights (Rupi et al., 2020). Then, for each trip (k), we calculate the average speed for cyclists on each segment (l) as shown in Equation (1) (Argyros et al., 2024). This was further used as the target variable of our model.

$$S_{k,l} = \frac{\sum_{i=1}^{p} distance_i}{\sum_{i=1}^{p} time_i}, \forall k, l \tag{1}$$

Further, given the geocoding accuracy and the spatial extent of the roadworks, a 20-meter buffer around the roadworks was chosen. GPS devices generally have an average accuracy of 10 meters from the road centreline (Desai et al., 2021), making this buffer a reasonable and effective measure for filtering affected links. After linking the roadwork projects to their respective segments, we created a binary variable to identify trip segments affected by roadworks. This variable indicates whether a trip/user is passing through a segment where roadworks are in progress. We used the project start and end dates provided in the data, along with the timestamps of each trip, to match the two datasets accurately.

Model

For modelling the average cycling speed for a trip on a segment we used a mixed exponential model with random effects as presented in the Method section of the study. In detail, the variables used and their associated coefficients are presented below (Table 1). The log-transformation of variables has been applied to improve the log-likelihood of the model (Argyros et al., 2024).

- DCI is a roughness index representing the surface quality of a segment (Argyros et al., 2024; Bíl et al., 2015).
- Elevation represents the steepness of a segment and is measured in meters. Very steep segments have a slope greater than 35 m/km, while steep segments have a slope between 10 and 35 m/km.
- Infrastructure contains categorical variables related to the type of bicycle infrastructure in a segment (Łukawska et al., 2023).
- Trip characteristics are categorical variables that describe the length of the trip.
- Seasonal and time are categorical variables about the season of the year and whether the trip is on a weekend, during peak traffic hours, or at night.

Table 1. (continue) The model variables omitted from Table 1 of the study are presented here.

	Model I		Model II		Model III		Model IV	
	Coef.	Std.Err.	Coef.	Std.Err.	Coef.	Std.Err.	Coef.	Std.Err.
Road Roughness Indicator								
ln(DCI)	0.032	0.001	0.035	0.001	0.035	0.001	0.034	0.001
Elevation								
ln(Very steep uphill)	-0.159	0.002	-0.159	0.002	-0.155	0.002	-0.157	0.002
ln(Steep uphill)	-0.022	0.000	-0.022	0.000	-0.022	0.000	-0.022	0.000
Flat	-	-	-	-	-	-	-	-
ln(Steep downhill)	0.012	0.000	0.012	0.000	0.012	0.000	0.012	0.000
ln(Very steep downhill)	0.040	0.002	0.042	0.002	0.044	0.002	0.042	0.002
Infrastructure								
ln(Length (in m))	0.070	0.000	0.070	0.000	0.071	0.000	0.071	0.000
Cycleway	-	-	-	-	-	-	-	-
Footways	-0.077	0.001	-0.078	0.001	-0.076	0.001	-0.077	0.001
Living streets	-0.136	0.002	-0.134	0.002	-0.130	0.002	-0.133	0.002
Shared paths	-0.053	0.001	-0.053	0.001	-0.053	0.001	-0.053	0.001
Pedestrian zones	-0.190	0.002	-0.190	0.002	-0.189	0.002	-0.189	0.002
Res. roads w/o bike infra.	-0.067	0.001	-0.064	0.001	-0.064	0.001	-0.064	0.001
Res. roads w/ painted bike l.	-0.003	0.001	-0.001	0.001	0.004	0.001	0.002	0.001
Res. roads w/ protected bike l.	0.018	0.001	0.020	0.001	0.021	0.001	0.020	0.001
Med. roads w/o bike infra.	-0.023	0.001	-0.021	0.001	-0.019	0.001	-0.020	0.001
Med. roads w/ painted bike l.	0.033	0.001	0.038	0.001	0.039	0.001	0.039	0.001
Med. roads w/ protected bike l.	0.069	0.000	0.071	0.000	0.071	0.000	0.072	0.000
Large roads w/o bike infra.	0.032	0.001	0.033	0.001	0.033	0.001	0.033	0.001
Large roads w/ painted bike l.	0.002	0.001	0.004	0.001	0.006	0.001	0.004	0.001
Large roads w/ protected bike l.	0.074	0.000	0.076	0.000	0.077	0.000	0.076	0.000
Traffic Light at segment start	-0.077	0.000	-0.076	0.000	-0.076	0.000	-0.077	0.000
Traffic Light at segment end	-0.146	0.000	-0.146	0.000	-0.146	0.000	-0.146	0.000
Roundabouts	-0.112	0.002	-0.114	0.002	-0.113	0.002	-0.114	0.002
Trip Caracteristics								
Short size trips (less than 1 km)	-0.088	0.001	-0.088	0.001	-0.088	0.001	-0.088	0.001
Short-medium trips (1-5 km)	-	-	-	-	-	-	-	-
Medium size trips (5-10 km)	0.031	0.000	0.031	0.000	0.031	0.000	0.031	0.000
Long size trips (above 10 km)	0.048	0.001	0.048	0.001	0.047	0.001	0.048	0.001
Seasonal and Time								
Weekend	-0.025	0.000	-0.025	0.000	-0.025	0.000	-0.025	0.000
On peak period	0.014	0.000	0.014	0.000	0.014	0.000	0.014	0.000
During night	-0.013	0.001	-0.013	0.001	-0.013	0.001	-0.013	0.001
Is spring	-0.001	0.000	-0.001	0.000	-0.001	0.000	-0.001	0.000
Is winter	-0.024	0.000	-0.024	0.000	-0.024	0.000	-0.024	0.000
Weather								
ln(Wind speed (in km/h))	-0.017	0.000	-0.017	0.000	-0.017	0.000	-0.017	0.000
Temperature below 0 °C	-0.035	0.001	-0.035	0.001	-0.035	0.001	-0.035	0.001
Temperature 0-10 °C	-	-	-	-	-	-	-	-
Temperature 10-20 °C	-0.010	0.000	-0.011	0.000	-0.010	0.000	-0.010	0.000
Temperature above 20 °C	-0.005	0.000	-0.005	0.000	-0.005	0.000	-0.005	0.000
Land Usage								
High-rise urban areas	-	-	-	-	-	-	-	-
Green areas	0.013	0.000	0.012	0.000	0.012	0.000	0.012	0.000
Industrial areas	-0.013	0.000	-0.013	0.000	-0.013	0.000	-0.013	0.000
Low-rise urban areas	0.010	0.000	0.010	0.000	0.009	0.000	0.010	0.000
No. Observations								7477385
No. Unique Links								17287
Log-Likelihood		-1422190		-1420393		-1419124		-1420547
R-squared		0.228		0.228		0.229		0.228

- Weather variables describe wind speed and temperature during the trip.
- Land usage contains categorical variables indicating the surrounding land uses of a road segment.

Regarding the roadworks variables, the models use different categories provided in the dataset, as explained in the study.

- Model 1 accounts for whether the cyclist's speed is affected by any type of roadwork that happens on a segment.
- Model 2 includes categorical variables related to the type of road infrastructure affected by the project.
- Model 3 uses categorical variables based on the type of affected infrastructure, such as electricity works, gas works, wastewater, etc.
- Model 4 includes variables related to the type of work performed during the process, such as drilling, excavation, or pulling existing pipes.

These distinctions help to better understand the impact of different types of roadworks on micromobility accessibility.

References

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