

TRANSPORT FINDINGS

The Overlooked Role of Roadworks in Micromobility's Accessibility

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Findings

Transforming cities often comes with the overlooked consequence of roadworks. Complex underground infrastructure, such as cabling, anti-flooding systems, and heating works, makes urban transformations costly and time-consuming. This trend will likely persist, making it important to understand its impact on our daily lives. For the first time, we present a comprehensive dataset on construction work in Copenhagen and analyse travel time delays in cycling trips by expanding a cycling speed model based on extensive trajectory data. Our findings reveal that construction activities can reduce average cycling speeds by 0.4 to 1 km/h on affected segments, significantly affecting mobility.

1. Questions

As cities transition to become greener and smarter, substantial changes to infrastructure are required. Often overlooked, however, is that upgrading infrastructure, including electrification, fibre networks, and district heating, has unintended impacts on accessibility and well-being. Studies suggest that roadworks influence car users' behaviour by reducing accessibility and increasing safety concerns both for them and other road users (Schwietering and Feldges 2016; Blackman, Debnath, and Haworth 2014, 2015; Walker and Calvert 2015).

In response to these issues, research has focused on mobility within work zones, considering vulnerable road users and proposing measures and technologies to improve overall safety and accessibility (Tilton 2023; Niska, Wenäll, and Karlström 2022; Attanayake et al. 2017). However, large-scale quantitative studies investigating the potential accessibility losses due to roadworks are still missing.

In this study, we integrate unique historical roadwork data for Copenhagen with micromobility speed patterns from empirical large-scale trajectory data to explore the questions below.

- How has the volume of roadworks evolved in Copenhagen from 2014 to 2023, considering different types of projects? We examine both the number of approved projects and their duration.
- How does roadwork influence travel speeds within the bicycle network? In particular, which types of roadwork have the most significant impact on cycling speeds?

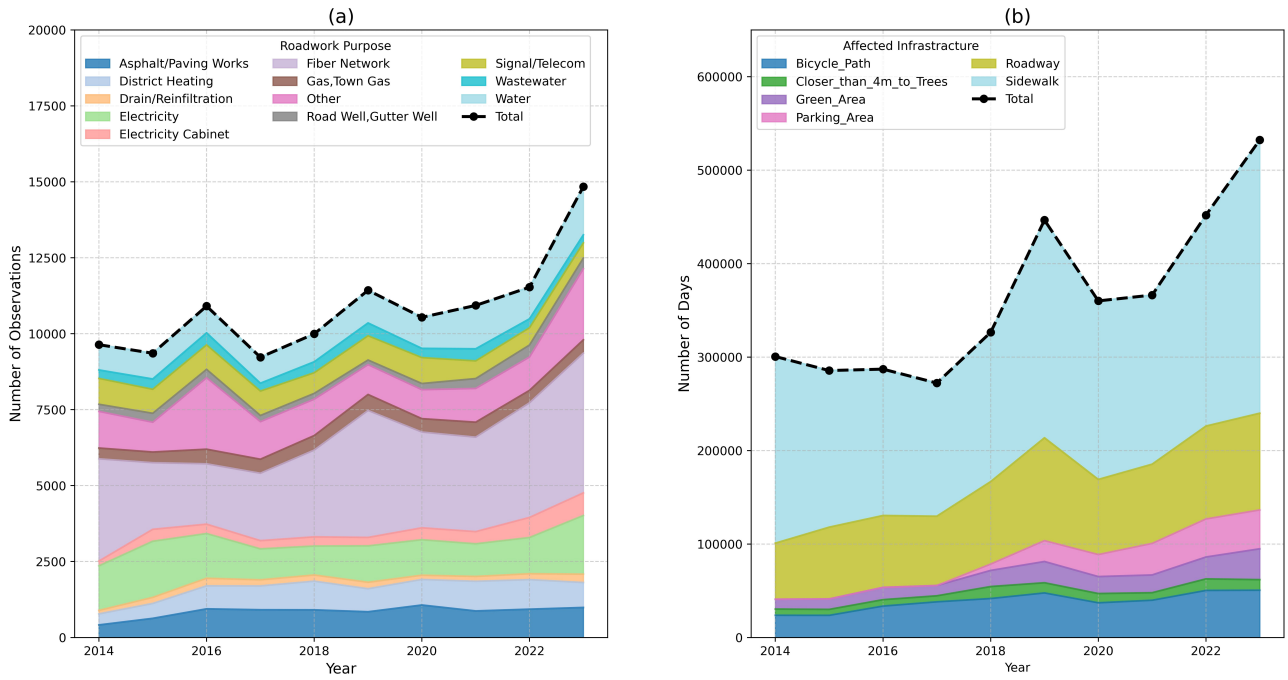


Fig. 1. Roadworks development in Copenhagen Municipality between 2014-2023. The number of projects across different roadwork purposes (a) and the number of days that each type of infrastructure is affected (b) per year are presented.

- From a broader perspective, what accessibility and welfare benefits could be achieved by halving the duration of roadworks, focusing on bicycle traffic?

Overall, we aim to uncover the impacts of roadworks on micromobility users and assess the extent of these effects. By doing so, we aim to initiate a discussion on the need for better planning and consideration for road users during roadwork periods.

2. Methods

[Figure 1a](#) illustrates the increase in approved roadworks in Copenhagen from 2014 to 2023 based on data provided by the Municipality. We observe a 50% rise in the number of roadwork projects, accompanied by a growth in the construction time (i.e. project duration in days) across all infrastructure types ([Figure 1b](#)). Notably, roadwork on bike lanes has more than doubled during this period. Lastly, as illustrated in [Figure 2](#) the main clusters of roadworks are concentrated towards the city's centre.

The roadwork data was geocoded as either a point or line object. To integrate this data with the detailed bicycle network of Copenhagen, developed in (Łukawska et al. 2023), we created a 20-meter buffer around the roadwork locations and identified the affected road links by selecting those intersecting with the area.

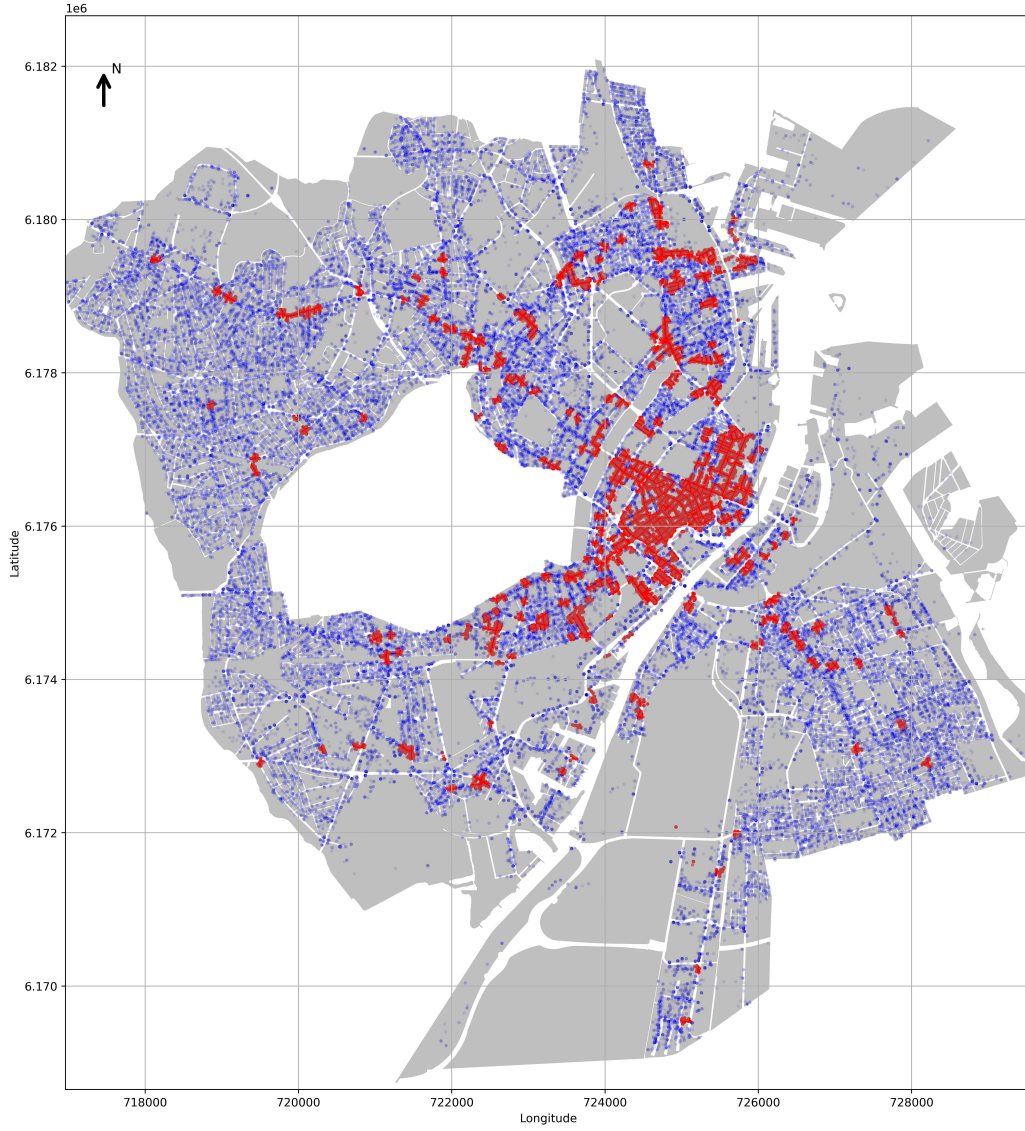


Fig. 2. The spatial distribution of roadworks in Copenhagen between 2014-2023. Clusters with large roadwork concentration (red) are based on the density-based spatial clustering of applications with noise (DBSCAN) algorithm (Ester et al. 1996).

We extended a cycling speed model developed in (Argyros et al. 2024) to incorporate roadwork data. The cycling speed is defined as the average speed of a traveller on a road segment. It is calculated based on empirical large-scale trajectory data from bicycle airbags (June 2020 - June 2021) in Copenhagen. By identifying cyclists travelling through areas affected while roadworks were underway, we were able to identify the trip segments which were impacted. Approximately 60% of trips were influenced by roadwork.

A mixed exponential model with random effects (γ_v) for different users (v) was used, (Equation 1) with the average cycling speed (S_v) on a segment (l) being the target variable and X represents the explanatory variables used in the model (see supplementary information for a detailed description) (Lindstrom and Bates 1988). We focused on roadworks impacting bike paths, sidewalks, and roadways, and excluded those affecting only green or parking

areas. Furthermore, we tested various variable combinations to examine how different roadwork projects impacted cycling speeds based on their associated categories (e.g. type of infrastructure, equipment).

$$S_{v,l} = \exp(\beta_0 + \gamma_v + \beta X + \epsilon), \forall v, l \quad (1)$$

Finally, to evaluate the overall impact of roadworks on accessibility, we estimated the travel time and welfare gains over a year, assuming that the duration of the roadworks was halved. The purpose is to understand the socioeconomic value of a measure to reduce the roadwork impact. We approximate this scenario by randomly reducing the number of affected observations by 50%. Subsequently, the total link travel time (in both cases) was scaled based on the average annual cycling flow data from the COMPASS transport model for Copenhagen (Paag, Kjems, and Hansen 2019). Lastly, the travel time reduction can be translated into welfare gains by using the value of travel time (VTT) prices for Denmark defined as 112 DKK per hour for 2024 (Pilegaard et al. 2006).

3. Findings

As presented in [Table 1](#), we observed a significant reduction in average cycling speed due to roadworks. The average link cycling speed from Model 1 was approximately 16 km/h for our sample. Therefore, as the coefficient for the variable indicating roadwork presence was -0.024, it suggests that roadworks caused a speed reduction of 0.4 km/h.

Moreover, as found in Model 2, the location of roadworks has varying impacts on cycling speed. For instance, the speed reduction is more pronounced when sidewalks or roadways are affected, likely due to increased interactions between cyclists with pedestrians or cars respectively. Similarly, the roadwork purpose is important as found in Model 3. Roadworks related to road drainage and wastewater have a larger impact on cycling speed than those for district heating and fibre networks, indicating that the interventions in the latter cases are probably smaller. Additionally, as found in Model 4, larger effects are observed with methods such as ramming and cracking, suggesting that the excavation method could also influence the magnitude of the effect.

Therefore, it is important to consider countermeasures to facilitate micromobility traffic on segments undergoing specific roadworks. Halving the duration of roadwork projects could yield substantial benefits for society, including travel time savings of approximately 32,573 hours (0.083% of the total travel time), translating to an estimated welfare gain of 3.6 million DKK per year for the considered network.

Table 1. Cycling speed model. Estimated coefficients for variables related to roadworks in the network. The model also controlled for variables related to weather, elevation, infrastructure type, surface condition and trip characteristics. See supplementary information for more details.

	Model I		Model II		Model III		Model IV	
	Coef.	Std.Err.	Coef.	Std.Err.	Coef.	Std.Err.	Coef.	Std.Err.
Intercept	2.629	0.002	2.632	0.002	2.630	0.002	2.630	0.002
User Var	0.016	0.001	0.016	0.001	0.016	0.001	0.016	0.001
Construction Works								
Roadworks	-0.024	0.000	-	-	-	-	-	-
Roadway	-	-	-0.015	0.000	-	-	-	-
Bicycle Path	-	-	-0.005	0.000	-	-	-	-
Sidewalk	-	-	-0.014	0.000	-	-	-	-
Asphalt/Paving Works	-	-	-	-	-0.011	0.000	-	-
District Heating	-	-	-	-	-0.006	0.001	-	-
Drain/Reinfiltration	-	-	-	-	-0.064	0.001	-	-
Electricity	-	-	-	-	-0.027	0.000	-	-
Electricity Cabinet	-	-	-	-	-0.012	0.001	-	-
Fiber Network	-	-	-	-	-0.008	0.000	-	-
Gas,Town Gas	-	-	-	-	-0.028	0.001	-	-
Other	-	-	-	-	-0.020	0.000	-	-
Road Well,Gutter Well	-	-	-	-	-0.020	0.001	-	-
Signal/Telecom	-	-	-	-	-0.025	0.001	-	-
Wastewater	-	-	-	-	-0.028	0.001	-	-
Water	-	-	-	-	-0.005	0.001	-	-
Cracking	-	-	-	-	-	-	-0.066	0.002
Cross Excavation	-	-	-	-	-	-	-0.014	0.002
Directional Drilling	-	-	-	-	-	-	-0.003	0.001
Drilling	-	-	-	-	-	-	-0.022	0.003
Excavation	-	-	-	-	-	-	-0.017	0.000
Length Excavation	-	-	-	-	-	-	-0.018	0.001
Other	-	-	-	-	-	-	-0.021	0.000
Fixing Existing Pipe	-	-	-	-	-	-	-0.009	0.001
Relining	-	-	-	-	-	-	-0.039	0.002

Soil Displacement	-	-	-	-	-	-	-0.037	0.002
Splice Hole	-	-	-	-	-	-	-0.010	0.000
Surface Works	-	-	-	-	-	-	-0.004	0.001
Test Hole	-	-	-	-	-	-	-0.020	0.001
No. Observations								7477385
No. Unique Links								17287
Log-Likelihood	-1422190		-1420393		-1419124		-1420547	
R-squared	0.228		0.228		0.229		0.228	

However, the type of countermeasures and their long-term impact should be carefully considered, as roadworks provide long-term benefits to accessibility and society. Reducing roadworks by not executing projects could negatively affect overall welfare.

Additionally, roadworks are associated with various negative impacts not addressed in this study, such as increased accident risk, revenue losses for nearby shops, reduced well-being and livability for residents, visual discomfort, and elevated noise levels. This underscores the need for further research into the broader implications of roadworks.

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SUPPLEMENTARY MATERIALS

Supplementary Information

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