Estimating the socio-environmental impacts of car substitution by bicycle and public transit using open tools

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Abstract. In metropolitan areas, car trips can be replaced by a combination of public transit and cycling for the first-and-last mile. This paper focuses on estimating the potential for cycling + PT as a substitute for car trips in the Lisbon metropolitan area and assessing its socio-environmental impacts using open data and open source tools. A decision support tool that facilitates the design and development of a metropolitan cycling network was developed (*biclaR*). A scenario of intermodality introduced, and its socio-environmental impacts were assessed using the *HEAT for Cycling* and the *HEAT as a Service* tools. Additionally, the impacts of shifting car trips to PT were estimated and monetized. The results indicate that 20% of the current trips can be made with the bicycle + PT combination. Shifting to cycling for the first-and-last mile can reduce annual CO2eq emissions from 6,000 tons/day, and the 10-year socio-environmental benefits account from €230 million. For the PT leg, the transfer from car results in the avoidance of at lest 8,500 tons of CO2eq emissions per year. The information on socio-economic benefits can support policymakers in prioritizing interventions to reduce the reliance on individual motorized transportation and effectively communicate their decisions.

Keywords: Active transport · Intermodality · First and last mile · Health economic assessment · Environmental impacts · Open data and methods

1 Introduction

In metropolitan areas, car trips can be replaced by a combination of public transit (PT) and cycling for the first-and-last mile. This approach requires interventions and programs to make bicycling more appealing, and the resulting public investments can have significant social and environmental benefits. This paper focuses on estimating the potential for cycling + PT as a substitute for car trips

in the Lisbon metropolitan area (LMA) and assessing its socio-environmental impacts using open data and open source tools.

According to the latest mobility survey conducted in 2018, the LMA registered a total of 5.3 million daily trips, with only 0.5% by bicycle. Car modal share is 58.4%, while PT accounts for 15.5%. To achieve the cycling targets set by the Portuguese national cycling strategy for 2025 and 2030 (4% and 10%, respectively), the Department of Transport introduced biclaR, a decision support tool that facilitates the design and development of a metropolitan cycling network.

This research aims to present and discuss the methods used to estimate...

Propensity to Cycle Tool

adding up an intermodality scenario to estimate cycling potential to public transit interfaces, and thus to support planning and prioritize investments in the cycling network.

2 Methods

2.1 Case Study

2.2 Modeling Origin-Destination trips

2.3 Modeling intermodality

The intermodality scenario considers trips that can combine PT and cycling for the first-and-last legs. Conservatively, we considered the sum of first-and-last legs up to 5 km. Furthermore, we restricted PT use to unimodal trips without transfers (although they can be included in future modeling). Félix, Lovelace, and Moura (2022)

Finally, we only included PT modes that can practically accommodate bicycles, such as trains, ferries, trams, and intermunicipal bus lines with bike racks (1).

To obtain reliable results, we used the OpenStreetMap road network and GTFS data. The r5r R package estimated the trip duration and distance for both the original modes and the bicycle + PT combination, while the od jittering R package estimated the OD locations based on a centroid-based OD matrix.

2.4 Assessing socio-environmental benefits

Socio-environmental impacts were assessed using the HEAT for Cycling and the HEAT as a Service tools, from the WHO. Additionally, we estimate the impacts of shifting car trips to PT for the second leg of the journey with EMEP/EEA's COPERT methodology and monetize them with the EU Guide to cost-benefit analysis.

Table 1 gives a summary of all heading levels.

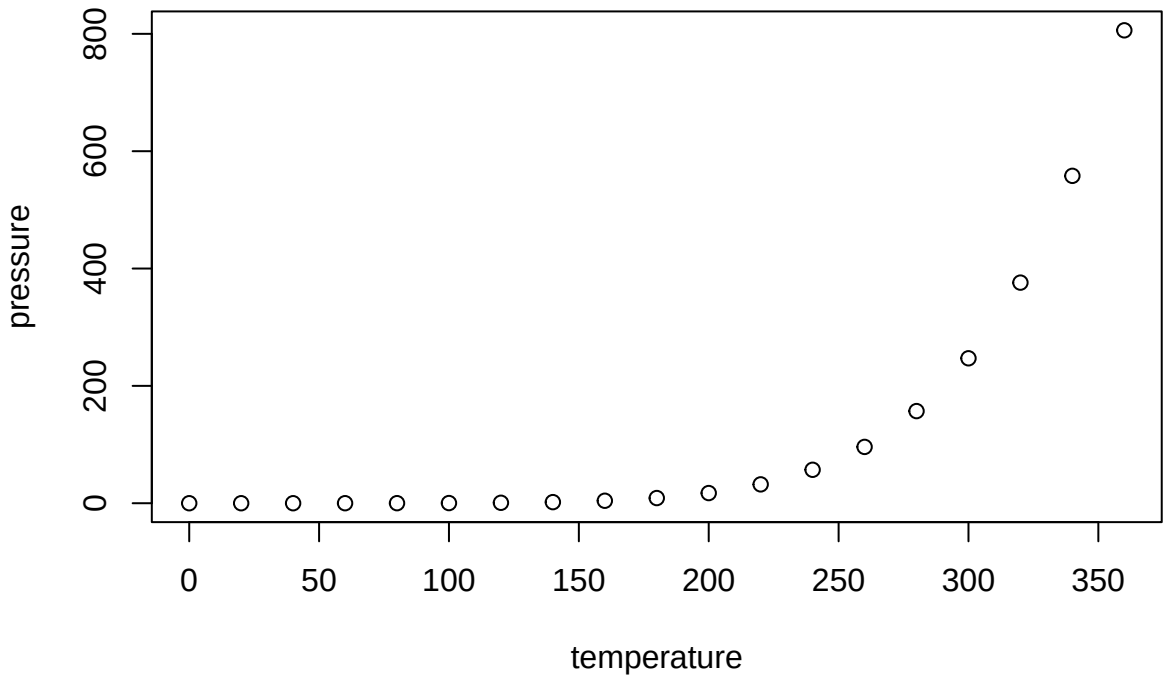

Fig. 1. Interfaces and lines considered, by transport mode, in the Lisbon metropolitan area

Table 1. Table captions should be placed above the tables.

temperature	pressure
0	0.0002
20	0.0012
40	0.0060
60	0.0300
80	0.0900
100	0.2700

3 Results and Discussion

The results indicate that 20% of the current trips can be made with the bicycle + PT combination, with an additional 12% of PT trips being potentially replaced. Shifting to cycling for the first-and-last mile can reduce annual CO2eq emissions by 6,000 to 15,000 tons/day, and the 10-year socio-environmental benefits account for €230 to €590 million, depending on the cycling targets. For the PT leg, the transfer from car results in the avoidance of 8,500 to 20,800 tons of CO2eq emissions per year, or €1.4 to €3.5 million over 10 years, with trains offering the greatest potential for substitution (88%).

Map result (2).

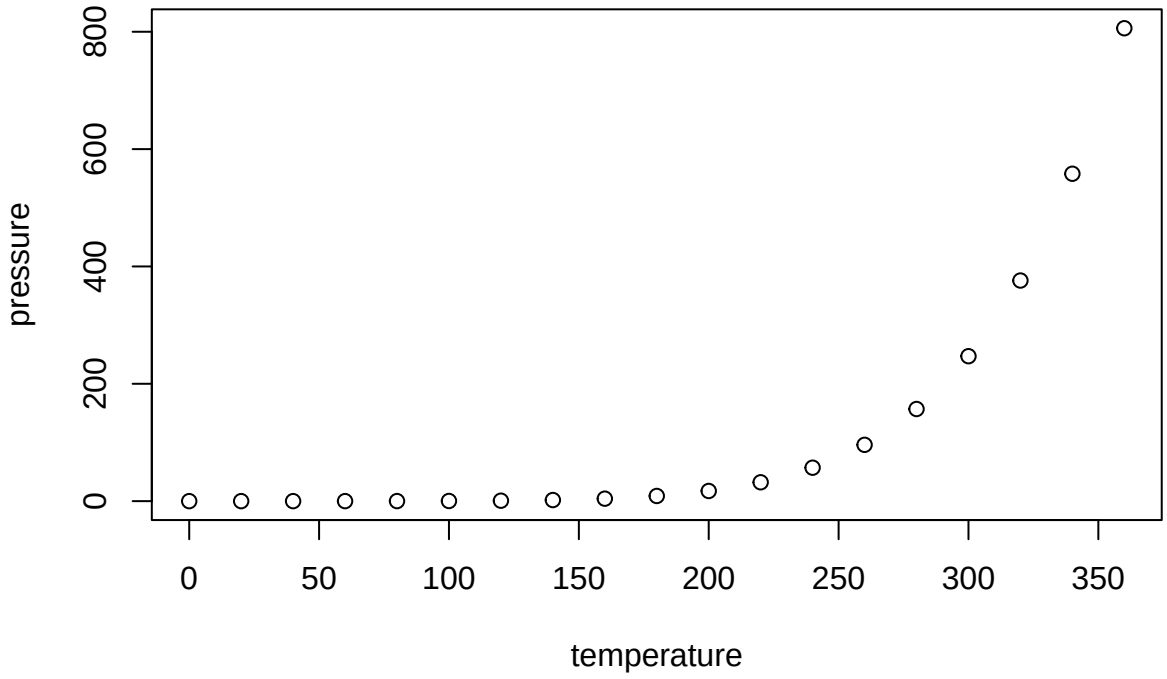

Fig. 2. Bike routes with highest potential to serve as first and last mile when replacing cycling and PT from car trips (screenshot of the interactive online tool).

4 Conclusion

By making the research process publicly accessible in a code repository, this study enables the replication of similar estimates for socio-environmental impacts resulting from a modal shift from cars to bicycles + PT in other metropolitan areas. The provided information on socio-economic benefits can support policy-makers in prioritizing interventions to reduce the reliance on individual motorized transportation and effectively communicate their decisions.

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Thomas Götshi - HAAS.

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