Promoting complementarity between micromobility services and public transportation in Amsterdam

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Short summary

The emergence of shared micromobilty has been presented as a solution to the first-/last-mile problem. However, different observations show that instead of making Public Transportation more attractive, micromobility is in competition with sustainable travel alternatives. This paper presents a simulation framework based on MnMS (Multimodal network Modelling and Simulation) to evaluate the competition between shared emoped and PT in Amsterdam. Virtual stations are spread in the road network to simulate the free-floating emoped service more efficiently. The PT alternatives make use of the subway, bus, and tramway lines. Some regulations are then proposed to foster complementarity between the two modes: the reduction of the fleet size and the taxation and subsidy of trips. Taxing emoped-only trips and subsidizing combined trips by 1€ increases the share of trips using both PT and emoped from 1.6% to 7.5%.
Keywords: Multi-modal transport; Shared mobility; Traffic, network, and mobility management; Transport economics and policy; Transport network modelling.

1 Introduction

The introduction of shared micromobility in the transportation ecosystem has been presented as a tool to make the urban transportation network more sustainable. The electric, lightweight, and shared vehicles fits the needs of a significant portion of the trips in urban networks with fewer negative externalities than personal cars. Especially, the shared escooter (motorized two-wheelers where the user *stands*) services can fill the first-/last-mile gap for using Public Transportation (PT) (Yin et al., 2024) to reduce the dependence on personal cars. However, different reviews and studies (Badia & Jenelius, 2023; Weschke et al., 2022; Wang et al., 2023) point out that a significant share of escooter trips replaces active modes (walk, bike) and PT rides or is induced demand. Along with other negative externalities such as accidents and usage of road space, it leads some municipalities to rethink the place of shared escooter in the transportation network. For example, the city of Paris banned the operation of shared escooter in 2023 after a referendum (Ville de Paris, 2023).
In this paper, we investigate the promotion of complementarity between micromobility and PT for the city of Amsterdam. Under the current Dutch law, driving an escooter on public roads is illegal. Instead, the micromobility sector is present via shared emopeds (motorized two-wheelers where the user *sits*). We propose a framework to simulate the transportation network in a framework where the travelers choose between PT and emoped. We present some regulations based on an additional tax/subsidy and a cap on the fleet size to promote complementarity between emoped and PT. In the following, we present the methodology, the use-case of Amsterdam, the proposed regulations, and then discuss the results of the simulations.

2 Methodology

We simulate the competition between a shared emoped service and PT. Our simulation framework is based on the MnMS (Multimodal Networks Simulation) platform. It is developed by the LICIT-ECO7 lab to simulate a transportation network composed of different mobility services: personal car, public transportation, on-demand, and free-floating mobility services. The vehicles are moving following the trip-based Macroscopic Fundamental Diagram (MFD) (Mariotte et al., 2017; Lamotte & Geroliminis, 2018) framework.

The emoped service operates on the road network. Albeit it is free-floating, we use 200 virtual stations where users can pick up or drop off the emoped. It permits keeping the topology of the graph representing the travel alternatives fixed to decrease the computation burden. A true free-floating implementation would require to add/remove nodes and arcs each time an emoped is picked up or dropped off. The initial emoped distribution is proportional to the origin distribution of the travel demand. The PT network consists of the subway, tramway, and bus lines. All users can access both services for their travels. We only account for those two alternatives as they share the property that the user does not own the vehicle. A user can then easily use one service after the other without having the constraints of being allowed to take its bike in the subway or finding a parking spot for its personal car. We do not account for ride-hailing services as they are not as attractive in Amsterdam as in other European cities because the drivers are required to hold a taxi license to be allowed to operate. The transportation network is represented in Fig. 1.

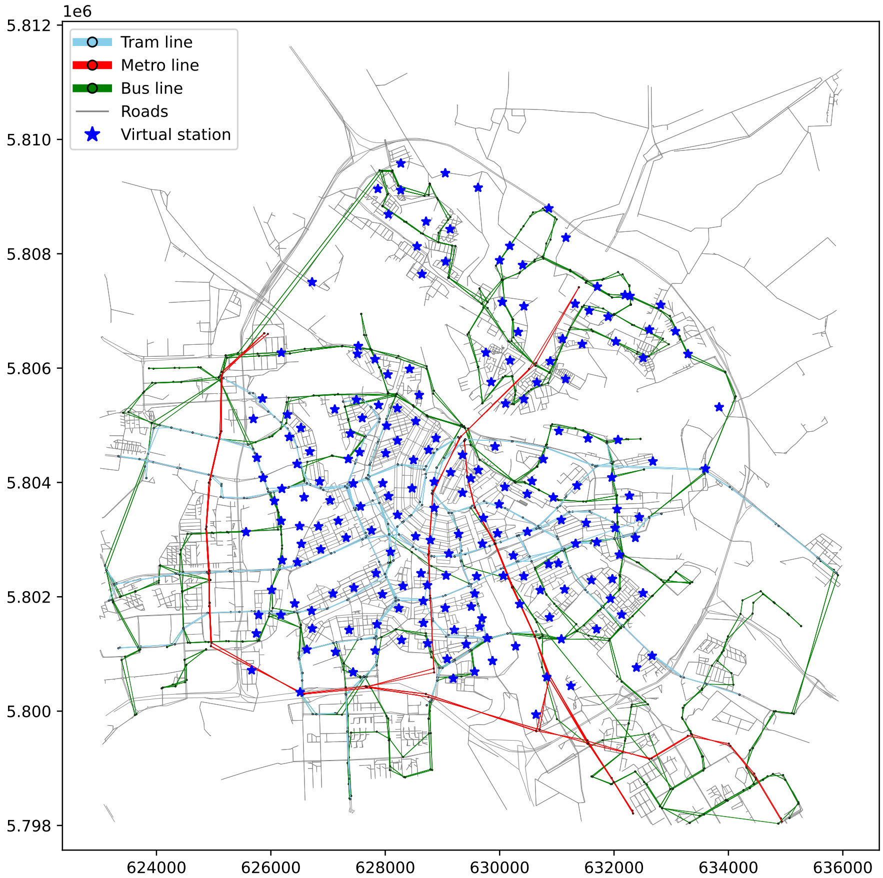

Figure 1: Amsterdam road network with PT lines and virtual emoped stations.

The travel cost C_p of path p is decomposed over the different modes (PT or emoped) $m \in M_p$ used in the path p:

$$C_p = \sum_{m \in M_p} (\alpha + f_m) T_m^p + F_m^0. \tag{1}$$

α is the Value of Time (VoT) (money per time), f_m the time-based service fee (money per time), T_m^p the travel time of the leg using mode m, and F_m^0 the fixed service fee (money). For each traveler, MnMS computes three paths: the shortest only with emoped, the shortest only with PT, and the shortest combining emoped and PT. The user is then assigned to the shortest of these three paths, i.e., each user chooses the travel alternative following the lowest monetary cost.
We propose two simple regulations, easy both for implementation on a Mobility-as-a-Service (MaaS) platform and for the users to understand:

- a reduction of the fleet size,
- a tax if the trip only uses the emoped and/or a subsidy if the trip combines emoped and PT.

For the simulation, we use the following numerical value: the VoT α is 20 €/h; the fleet size is 600 emopeds; the time-based fee f_{emoped} for emoped service is 0.33€/min with a base fee F^0_{emoped} of 1€. The PT service fee is only a based fee F^0_{PT} of 1€, as we assume the travelers are regular commuters and have a monthly/yearly subscription. The average speeds of buses, tramways, subways, and emoped are set to 5.5m/s, 8.3m/s, 13m/s, and 7m/s respectively. We generate 4301 travelers based on the demand of Winter et al. (2021) between 7:00 and 9:00 inside the ring road. We use this scenario to investigate the effects of a fleet size reduction and the effects of taxing emoped-only trips and subsidizing combined trips.

3 Results and discussion

The first regulation is reducing the number of emoped in the city to prevent a large mode shift from PT to emoped. The mean travel time, travel distance, total distance traveled by emoped, along with the mode shares are presented in Table 1 for different fleet sizes.

Table 1: Travel times, distances, and mode shares for different fleet sizes.

Fleet size	0	50	150	300	600
Mean travel time (min)	22.8	22.2	21.8	21.5	21.3
Mean travel distance (km)	3.39	3.29	3.30	3.32	3.33
Total emoped distance (km)	0	128	376	560	703
Emoped only (%)	0	1.5	5.2	7.5	9.6
PT only (%)	100	98.3	94.3	91.6	88.9
Combined (%)	0	0.2	0.5	0.9	1.6

The introduction of emoped service reduces the mean travel time by 7%. Without regulation, a fleet size of 600 leads to a mode share of almost 10%. The share of combined trips is less than 2%. As expected, the reduction of the fleet size leads to the reduction of the share of emoped-only trips and the total distance driven by emoped. However, the share of combined trips becomes negligible with less than 1% for a fleet smaller than 300 emopeds. Reducing the fleet size reduces the share of emoped-only trips, but it does not achieve the goal of promoting combined trips, as it makes it more difficult for users to find an available emoped at a convenient location for first-/last-mile trips.

We thus propose a second approach, where the regulator adds a tax on emoped-only trips and/or gives a subsidy for combined trips. We test the effect of 0.5€, 1€ taxes, a 1€ subsidy, and the combination of a 1€ subsidy and a 1€ tax. Note that the subsidy is equal to the PT fee and that a higher subsidy may lead some users to use PT solely for the subsidy. The mean travel time, travel distance, total distance traveled by emoped, along with the mode shares are presented in Table 2 for different taxes and subsidies and the reference fleet size of 600.

Table 2: Travel times, distances, and mode shares for different taxes/subventions for a fleet size of 600 emopeds.

Regulation	No tax	Tax 0.5€	Tax 1€	Sub 1€	Sub+Tax 1€
Mean travel time (min)	21.3	21.8	22.1	21.4	22.1
Mean travel distance (km)	3.33	3.33	3.34	3.31	3.31
Total emoped distance (km)	703	439	274	678	333
Emoped only (%)	9.6	5.4	2.8	7.7	1.3
PT only (%)	88.9	93.0	95.4	86.2	91.3
Combined (%)	1.6	1.6	1.8	6.1	7.5

Applying the taxation permits to reduce the share of emoped only trips, from about 10% to 3%. The share of combined trips increases very little and stays below 2%. The subsidy manages to get the share of combined trips to 6%. The 'carrot and stick' approach tax plus subsidy permits to reach a share of combined trips of almost 8% while reducing the emoped-only trips to about 1%. However, the tax and subsidy require external funding as there are more subsidized trips are subsidized than taxed ones. The total emoped distance is reduced by more than half while the variation in mean travel time or travel distance is less than 5%.

4 Conclusions

This paper presents a methodology to assess the competition between a micromobility service and Public Transportation (PT) and then evaluate the effect of different regulation strategies to foster complementarity: fleet size reduction and taxing/subsidizing trips. We used a case study based on the network and demand of Amsterdam. We proposed adding an extra cost on trips using only an emoped to foster the use of emoped as a first-/last-mile complement to PT.
The fleet size reduction is not adequate to reduce the share of trips only using emoped while increasing the share of combined trips. Policies based on tax and subsidies seem more appropriate to reduce competition and increase complementarity between PT and the shared emoped service. In future works, we will use data provided by an emoped service provider to calibrate the model. Also, to extend the simulation to a full day, we will implement emoped relocation strategies.

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