17th International Conference on Travel Behavior Research

July 14-18, 2024, Vienna, Austria

Spatiotemporal variation of ride-pooling potential based on observed data: A case study of New York City

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Funded by the European Union

European Research Council
Established by the European Commission

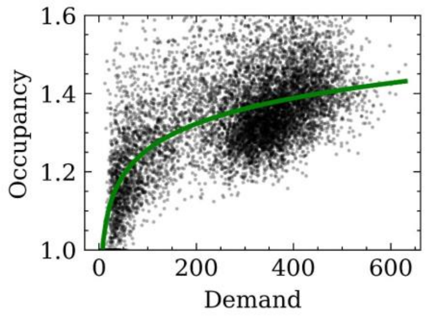
Narodowe Centrum Nauki

Uniwersytet Jagielloński w Krakowie

July 18, 2024 - Vienna, Austria

PROBLEM

Problem



The notion of critical mass well describes the general trends of ride-pooling: the average occupancy non-linearly increases with the demand.

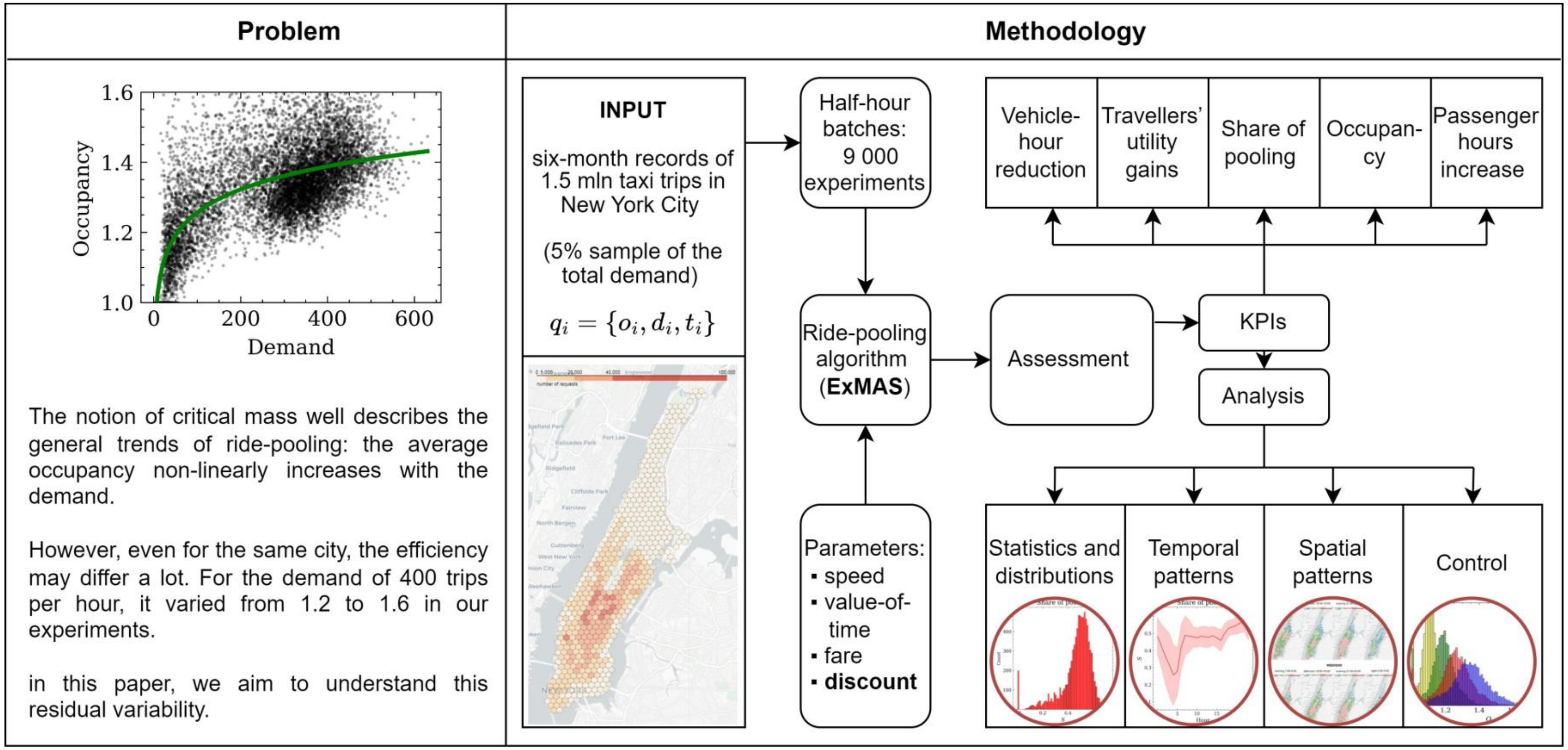
However, even for the same city, the efficiency may differ a lot. For the demand of 400 trips per hour, it varied from 1.2 to 1.6 in our experiments.

in this paper, we aim to understand this residual variability.

Shulika, O., Bujak, M., Ghasemi, F., & Kucharski, R. (2024). Spatiotemporal variability of ride-pooling potential–Half a year New York City experiment. Journal of Transport Geography, 114, 103767.

This research was funded by the National Science Centre in Poland program OPUS 19 (Grant Number 2020/37/B/HS4/01847)

PROBLEM AND IDEA



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Overview

- Here, we use 1.5 million NYC taxi trips (sampled over a six-month period) and experiment to understand how well could they be served with pooled services.
- We use a utility-driven ride-pooling algorithm and observe the pooling potential with five performance indicators: mileage reductions, travel-lers' utility gains, share of pooled rides, occupancy, and detours.
- We report distributions and temporal profiles of about 35 thousand experiments that cover weekdays, weekends, evenings, mornings, and nights.
- We report complex spatial patterns, with gains concentrated in the core of the network and costs concentrated on the peripheries. The greatest potential shifts from the North in the morning to the Central and South in the afternoon. The 32% discount seems to be sufficient to attract pooling yet dynamically adjusting it to the demand level and spatial pattern may be efficient.

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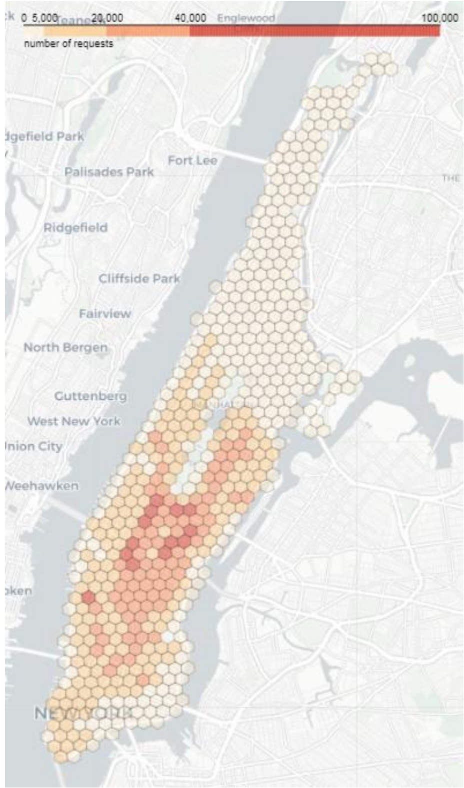
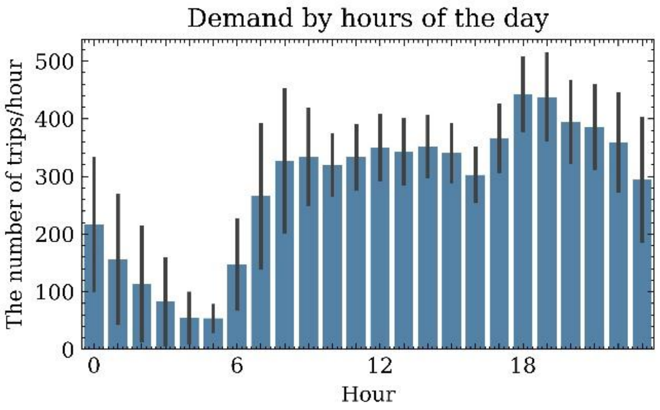
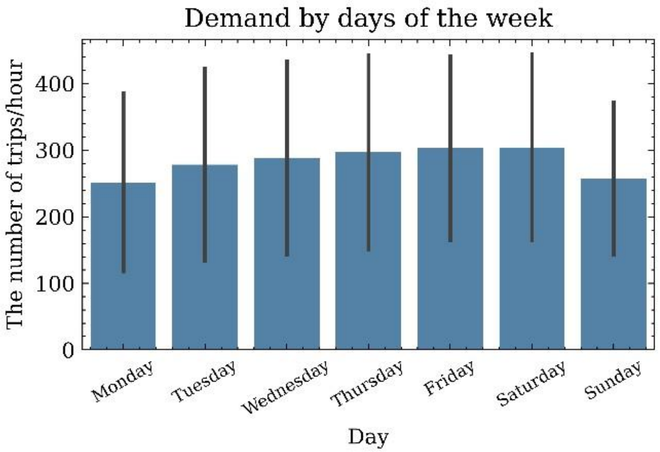
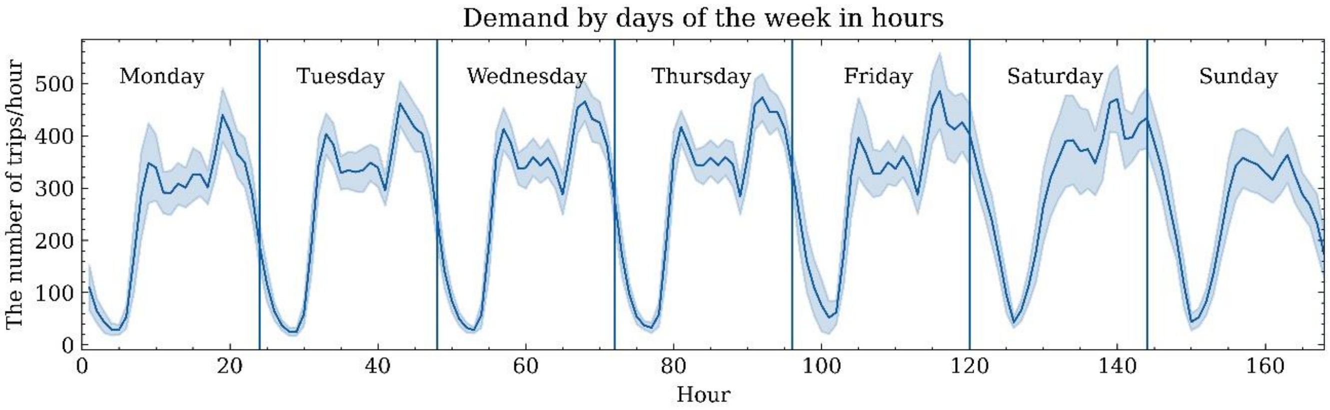
DATASET (1.5 million ride-hailing tripn in 6 months (NYC)

Spatial distribution of the trip origins









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METHOD

- We run ExMAS for each 30-minute batch of trip requests
- ith respective parameters
- We assume everyone from taxis would pool – to see what would happen
- And we report KPIs

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EXMAS algorithm (Kucharski and Cats, 2020)

Attractive shared-ride

Shared-ride is attractive if and only if detour and delay are compensated with lower fares for all sharing travellers.

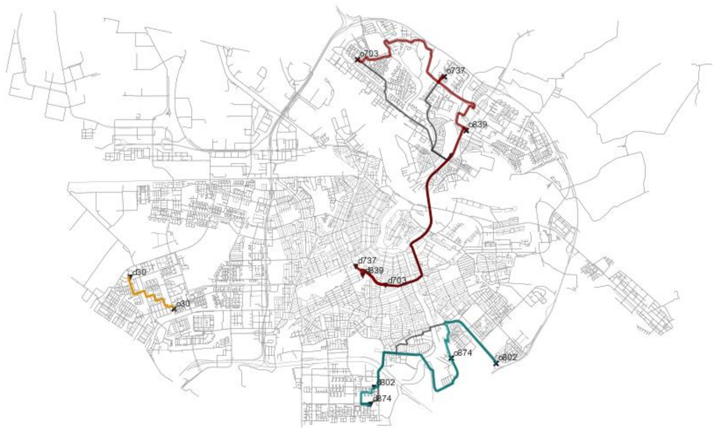
Utilities

non shared ride: $U_i^{ns} = \lambda^{ns} l_i + \beta^t t_i + \varepsilon$, where:

- λl_i distance-based fare
- β^t value-of-time
- t_i non-shared travel time
- ε random term

shared-ride: $U_{i,r}^{s} = \lambda^s l_i + \beta^t \beta^s (\hat{t}_i + |\hat{t}_i^p - t_i^p|) + \varepsilon$, where:

- β^s willingness-to-share
- $\hat{t}_i + \beta^d(\hat{t}_i^p - t_i^p)$ detoured and delayed shared time



Example of pooled trips :

a) non-shared, private ride marked yellow in the West,
b) ride shared by two travellers marked green in the South,
c) ride shared by three travellers marked brown in the North. Stars denote origins, triangle destinations, and grey bold lines traveller shortest paths, respectively

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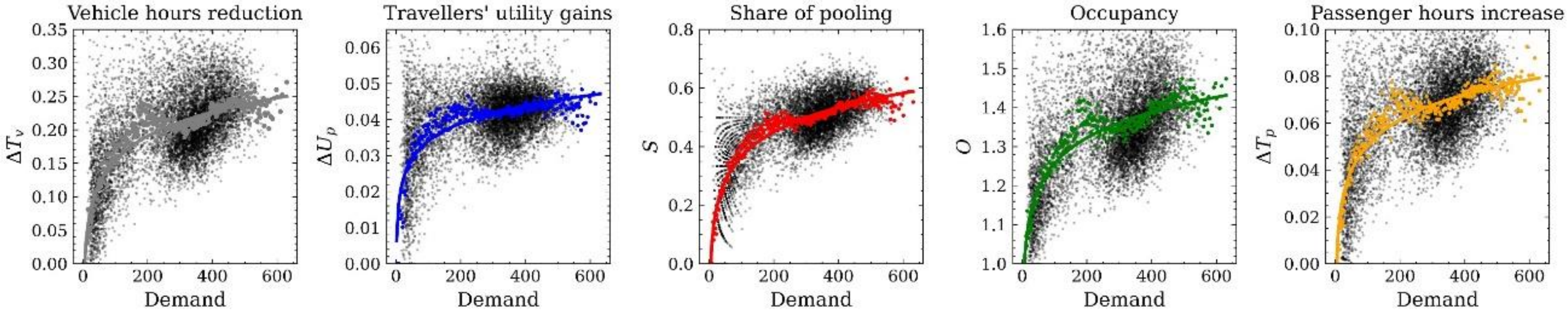
KPIs assessment

Five KPIs of ride-pooling plotted for various demand levels



Each dot represents a single batch (30-minute demand), thick dots denote average per demand level and thick line denotes a logarithmic trend-line fit.

Each performance indicator follows a similar trend: starts low, increases fast and stabilises with a flat, yet still increasing trend for high demand levels.

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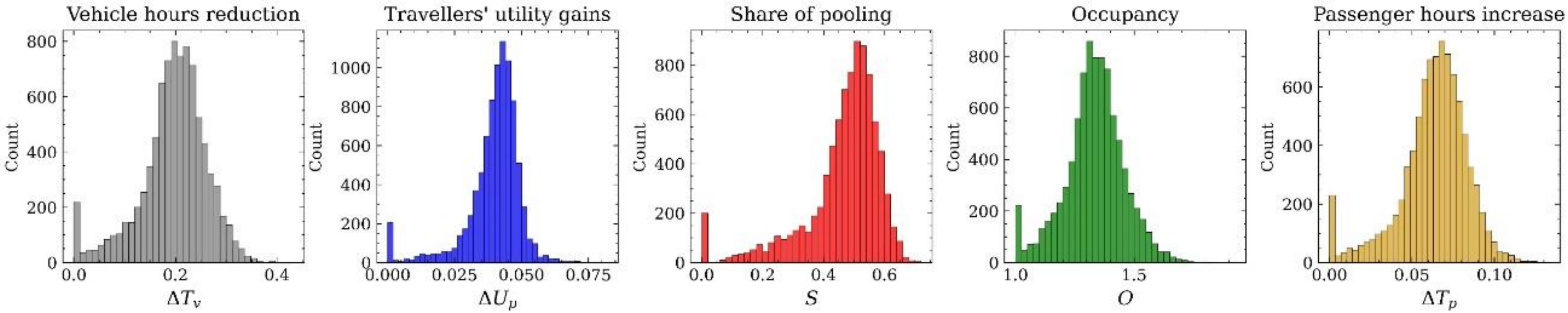
KPIs assessment

Distribution of observed KPIs of ride-pooling



Each datapoint is the result of one of about 9 thousand ride-pooling experiments on a 30-minute tripset.

A significant share of null observations (where sharing was not induced at all) was reported for all five indicators.

The remainder of the distribution follows various shapes: symmetrical (like occupancy), right-skewed (like share-of-pooling), with fat right tail (like utility gains) or thin (like share-of-pooling).

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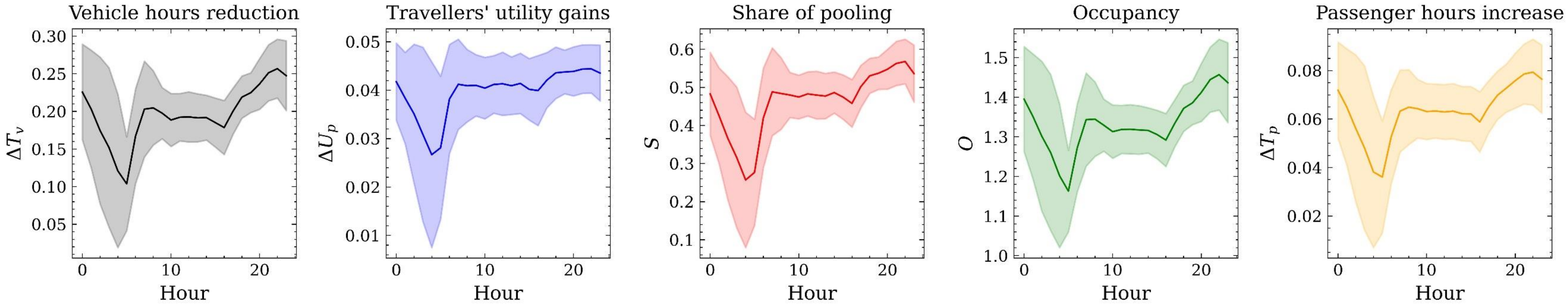
KPIs assessment

Within-day ride-pooling performance



Averages of five indicators observed throughout the day (thick lines) and their standard deviations.

Four indicators have remarkably similar profiles with low performance and high variability at night, flat plateau during the day and a peak performance in the evenings.

Only travellers' utility gains follow slightly different pattern with less significant increase in the evenings (despite high occupancy and vehicle hours reductions).

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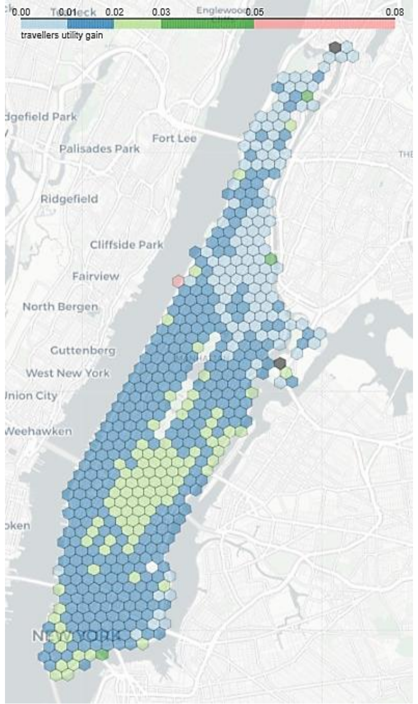
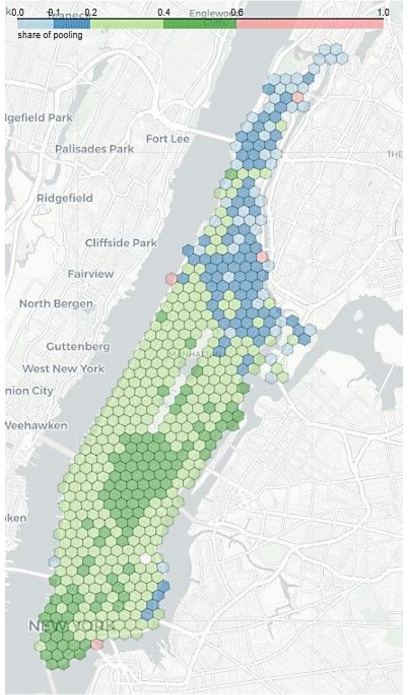
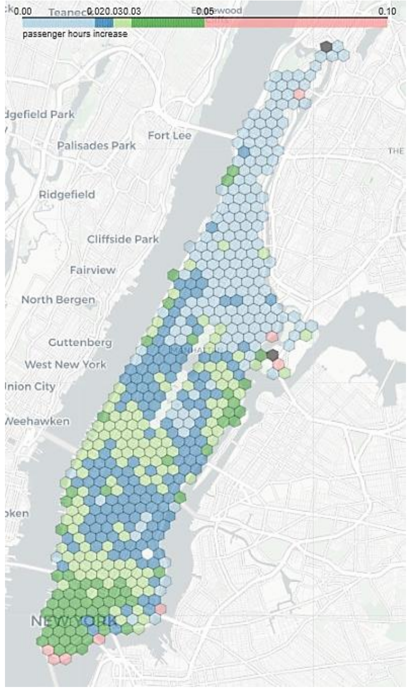
Spatial patterns of ride-pooling potential performance



Utility Gains



Share of pooling



PassHours

Travellers' utility gains **(a)** are pronounced in the central part of the network, but the greatest share of pooling **(b)** is also observed in the southernmost part (Wall Street), here, however, the increase in passenger hours is the greatest and decreases toward the north **(c)**.

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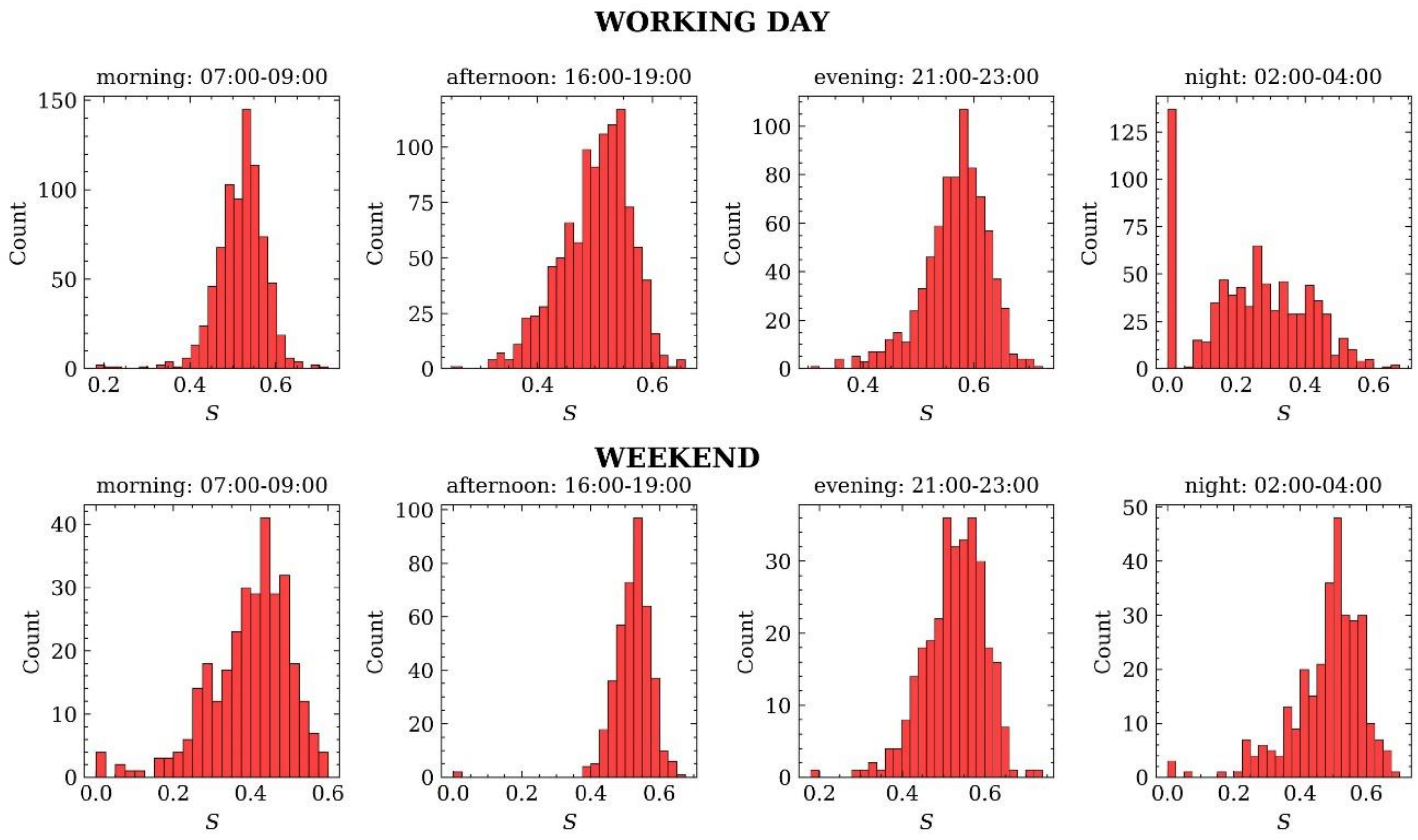
Distribution of the share of pooled rides the working days (top) and weekends (bottom) for four periods of the day (columns)



In the afternoons, evenings, and nights of the weekend half of the trips can be attractively shared, yet for the weekend mornings in many cases less than 40% of trips are shared, in the nights of the working days often times no trips are pooled at all.

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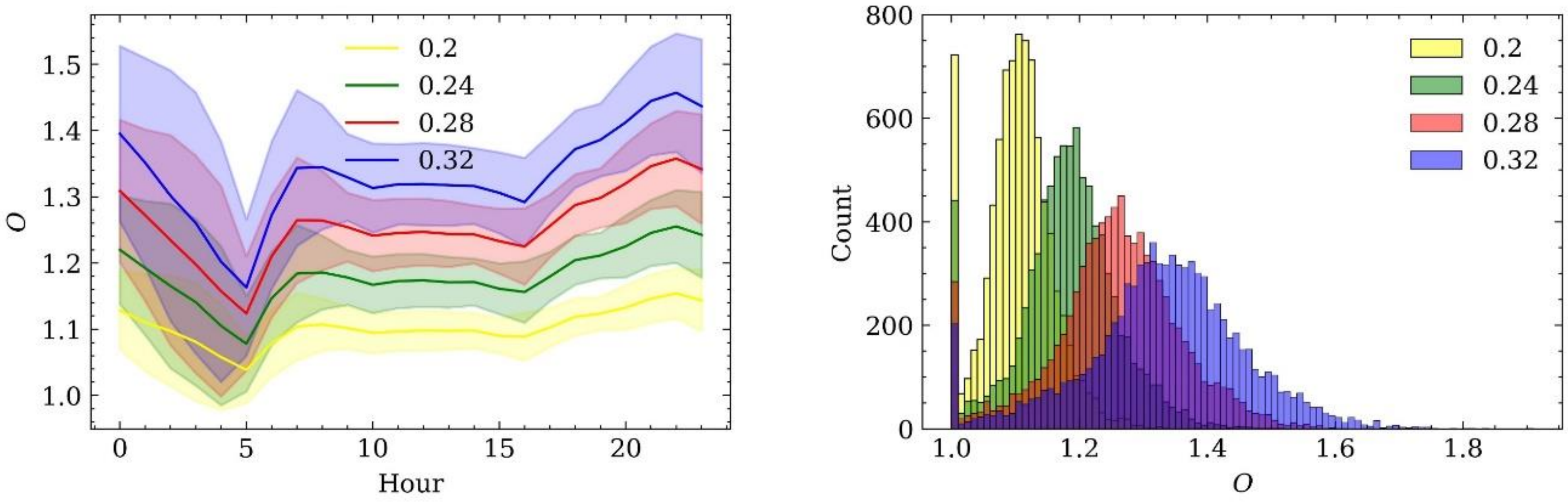
Controlling the ride-pooling performance with the ride-polling discount



Average occupancy (central ride-pooling efficiency indicator) increases with the discounts offered, both within the day (left) and in total (right).

The within-day profile has the same shape yet is magnified. The share of solo rides (bars at occupancy of 1 on the right panel) substantially decreases with increasing discount and the occupancy shifts to the right.

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Summary

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Questions

Discussion

Thank you!

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Tomorrow in Vienna

🚀 Central European Excellence in Transportation Research Association **CEETRA** 🚀

2nd meeting

Acknowledgement: This research was also supported by the European Union within the Horizon Europe Framework Programme, ERC Starting Grant COeXISTENCE no. 101075838.

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