CENTER FOR TRANSPORTATION RESEARCH

19-04652 Evaluation of Ride-Sourcing Search Frictions and Driver Productivity

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WHAT STARTS HERE CHANGES THE WORLD

Introduction

Ride-sourcing companies provide pre-arranged or on-demand transportation service for compensation.

Objective

Analyze the spatial structure of ride-sourcing operational and driver performance variables to support the need for new pricing strategies.

Contributions

- Empirical evidence of spatial and temporal variation of driver productivity variables as a function of trip destination.
- Temporal and spatial evaluation of different ride-sourcing operational measures and search frictions in Austin, Texas.
- Implementation of a spatial denoising methodology to analyze high-definition spatial variables.

Methodology

Ride-Sourcing Data

Austin-based TNC (Ride Austin) trips during the period that Uber and Lyft were out of the city - from September 1, 2016, to April 13, 2017.

- Space: data is summarized over 1,305 traffic analysis zones (TAZs).
- Time: Weekday AM-peak, PM-peak, off-peak, and Weekend.

Description of variables

- Operational (based on trip origin)

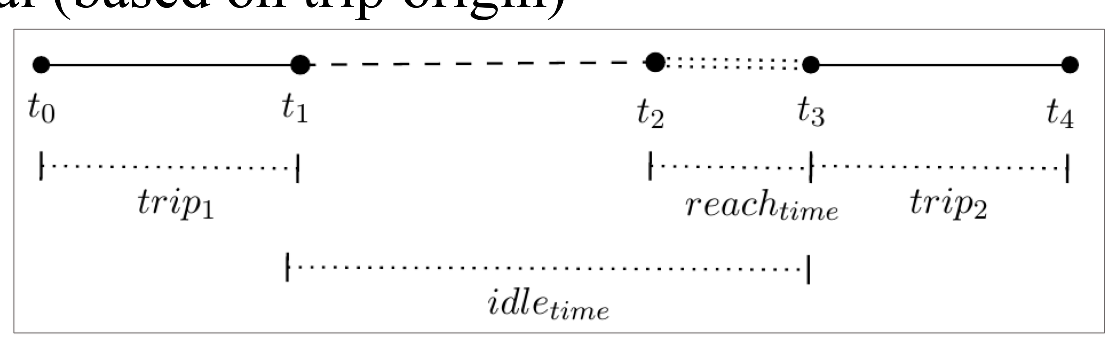


Figure: Driver time diagram

- Productivity, CBD-origin trips only (based on trip destination)

$$Prod.\boldsymbol{A} = \frac{fare_{trip1}}{t_1} \qquad Prod.\boldsymbol{B} = \frac{fare_{trip1}}{t_3} \qquad Prod.\boldsymbol{C} = \frac{fare_{trip1} + fare_{trip2}}{t_4}$$

Spatial Smoothing Approach

Analyzing operational and performance variables at a high-definition spatial level requires additional data analytics methods. We propose the use of a spatial smoothing or denoising technique that allows fine resolution analysis and compensates for the inherent sampling noise.

Smoothing

Assume that we have observations y_i, each associated with a vertex $s_i \in \mathcal{V}$ in an undirected graph $\mathcal{G} = (\mathcal{V}, \mathcal{E})$ with node set $\mathcal{V}$ and edge set $\mathcal{E}$.

$$y_i = x_i + \varepsilon_i, \; i = 1, \dots, n$$

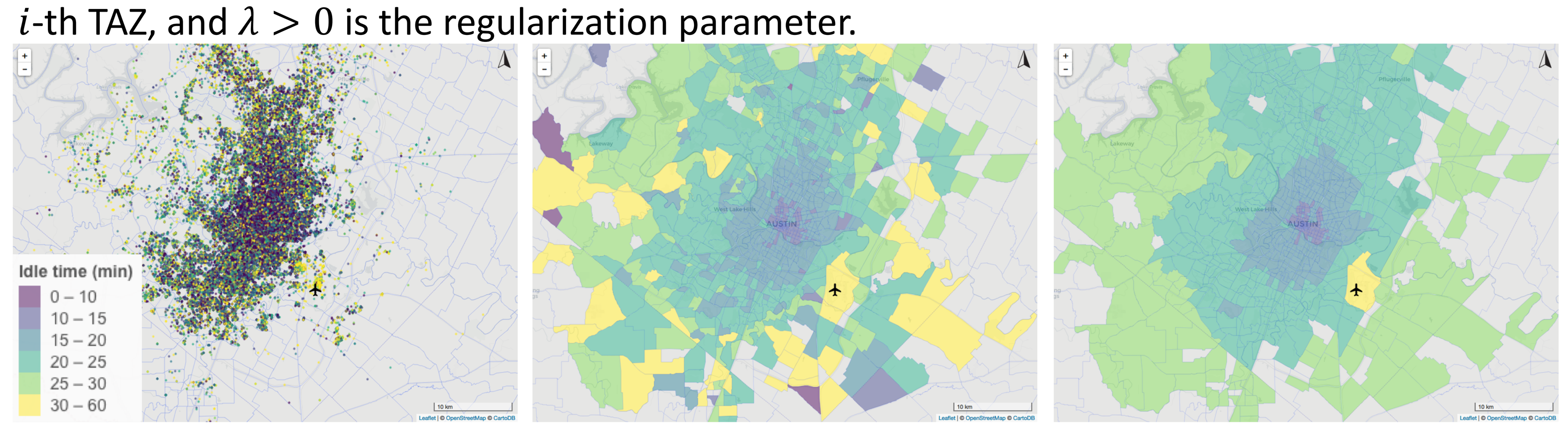
where, x_i is the "true" denoised signal and ε_i is mean-zero error. ***Goal***: find x.

Graph-Fused Lasso (GFL)

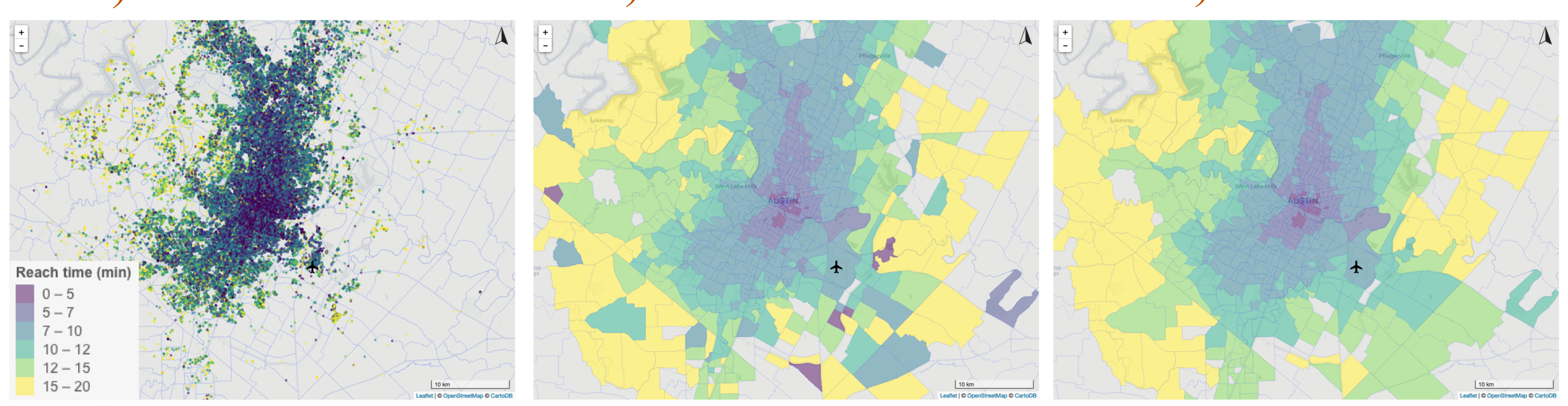
One way to estimate x is by using the GFL, defined by a convex optimization problem that penalizes the first differences of the signal across edges.

$$min_{x \in \mathbb{R}^n} \sum_{i=1}^{n} \frac{\eta_i}{2} (y_i - x_i)^2 + \lambda \sum_{(r,s) \in \mathcal{E}} |x_r - x_s|$$

Where, r is the start node and s is the end node, η_i is the count of trips observed within the i-th TAZ, and $\lambda > 0$ is the regularization parameter.

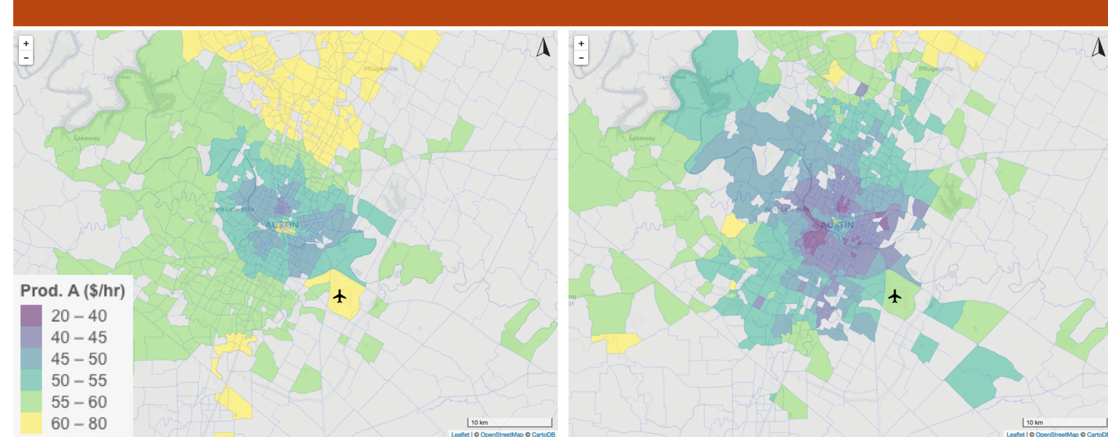


a) Idle time data b) Non-smoothed c) Smoothed

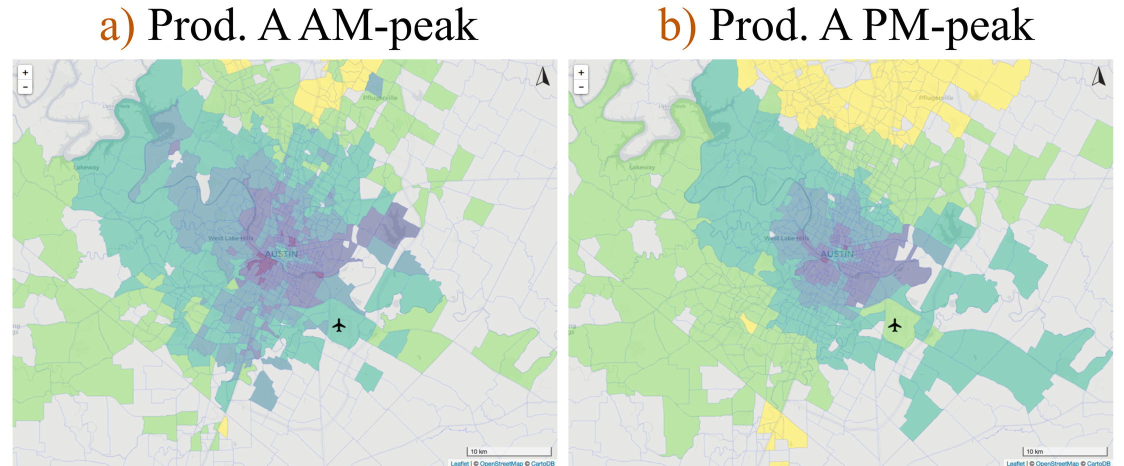


a) Reach time data b) Non-smoothed c) Smoothed

Results



a) Prod. A AM-peak b) Prod. A PM-peak

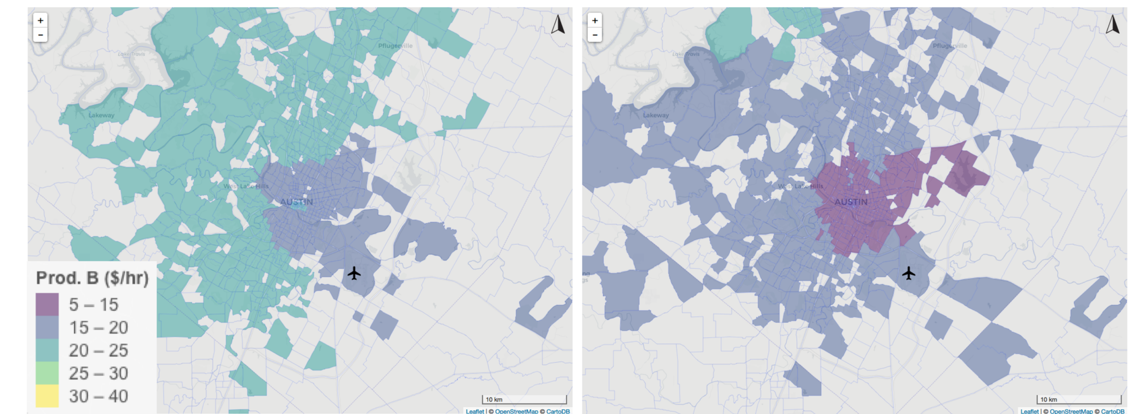


c) Prod. A off-peak d) Prod. A weekend

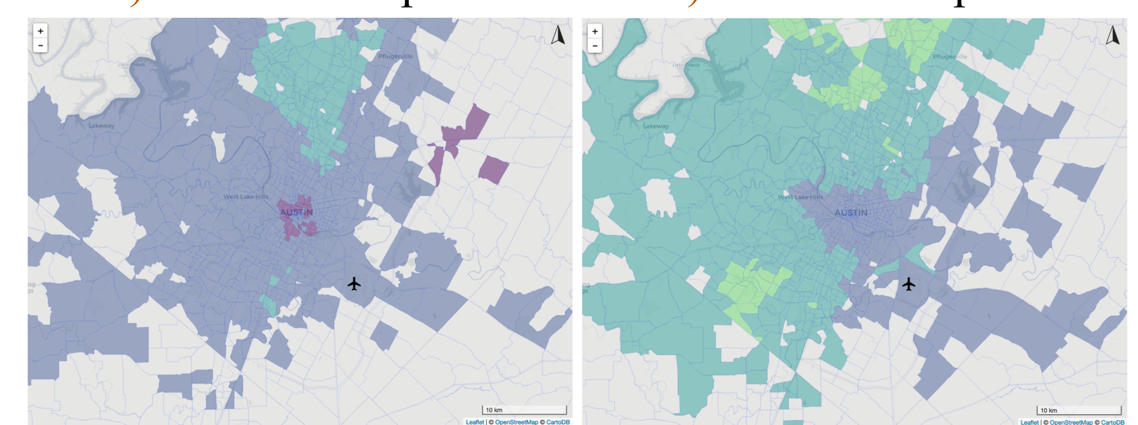
Productivity A

- Driver productivity for a single journey
- Donut-like effect
- Comparable between trips of fewer than 0.8 kilometers and longer than twenty-five kilometers

$$Prod.\boldsymbol{A} = \frac{fare_{trip1}}{t_1}$$



a) Prod. B AM-peak b) Prod. B PM-peak



c) Prod. B off-peak d) Prod. B weekend

Productivity B

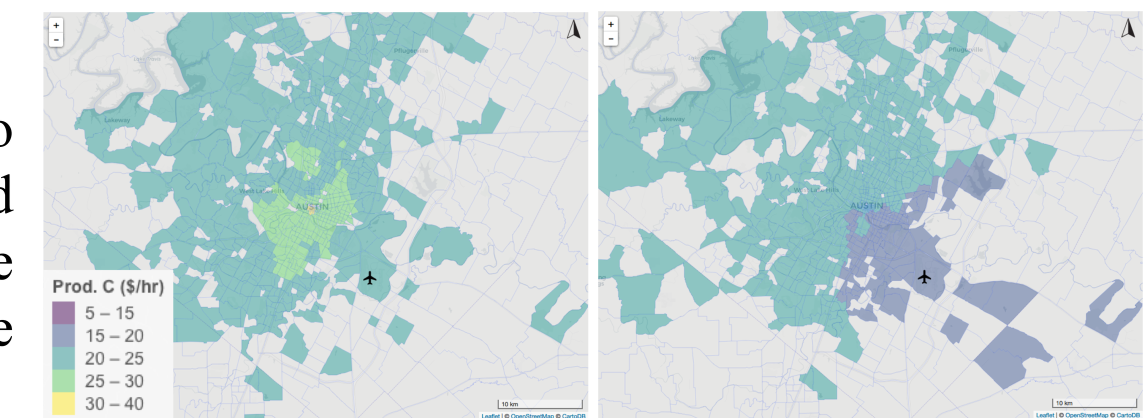
- Capture the effect of the ending-zone idle time
- The spatial contrast is lesser than observed in Prod. A
- The time effect is significant

$$Prod.\boldsymbol{B} = \frac{fare_{trip1}}{t_3}$$

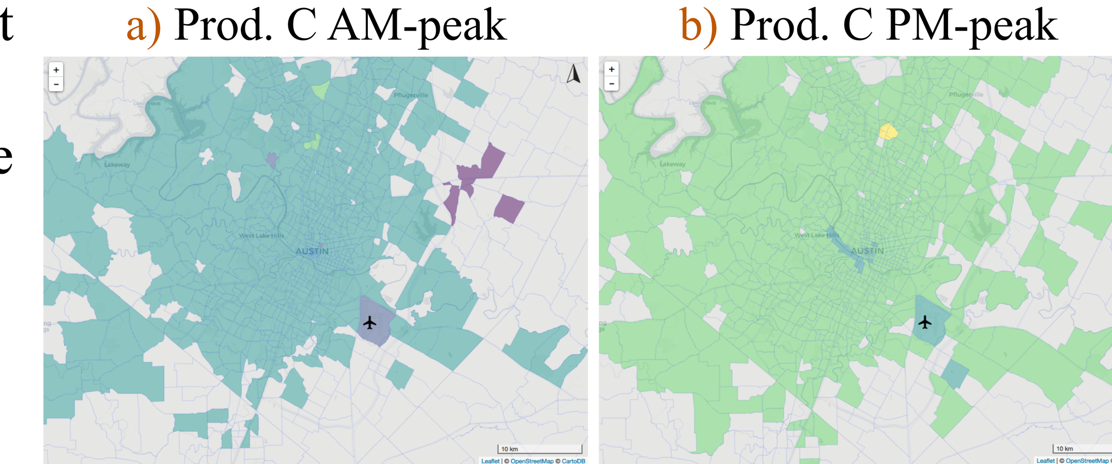
Productivity C

- Productivity of two consecutive trips and takes into account the ending-zone idle time between them
- Lower spatial impact compared to Prod. B
- Weekend trips are more favorable for drivers

$$Prod.\boldsymbol{C} = \frac{fare_{trip1} + fare_{trip2}}{t_4}$$



a) Prod. C AM-peak b) Prod. C PM-peak



c) Prod. C off-peak d) Prod. C weekend

Conclusions

Primary findings of this research suggest that there are differences in space and time that can affect ride-sourcing search frictions and driver productivity. Providing spatio-temporal pricing strategies could be one way to balance driver equity across the network.

- **Driver and operator point of view**
  More efficient driver supply method.
- **Planners and engineer's perspective**
  Understand the characteristics of the ride-sourcing service in Austin.
- **Pricing strategies and policies**
  Warranty fair conditions in driver compensation.