Transportation Policy and Micromobility

Jacob Holifield (Cornell University)

Cornell University

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- The U.S. transportation system is dominated by cars.
  - Private vehicles account for **92%** of commutes and grocery trips and **85%** of recreational trips.
- Cars are associated with significant negative externalities.
  - Light duty vehicles cause **16%** of greenhouse gas emissions in the U.S.
  - Traffic congestion was estimated to cost **$220 billion** in 2022.

Setting and Objectives

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- **Setting:** urban planners try to maximize welfare by their choice of policies subject to a budget constraint.
    - Some policies are revenue-generating, and some policies are revenue-losing.
- **Objective:** want to use observed traffic flows, times, and prices to estimate demand for travel modes and how this demand impacts travel times, and then we want to solve the urban planner's constrained optimization problem under counterfactual bundles of policies.

Overview

1. Related literature & motivation.
2. Model.
3. Data and estimation.
4. Conclusion and expected results.

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Related literature

1. **Micromobility & public transit:** Campbell and Brakewood (2017); Ziedan et al. (2021); Chu et al. (2021)
2. **Micromobility & congestion:** Hamilton and Wichman (2018); Huang and Xu (2023); Fan and Harper (2022)
3. **Operations Research:** Liu, Siddiq, and Zhang (2022)
   - → Optimal bike lane rollout subject to congestion and budget constraints.
   - ⋆ I consider more policies, multiple cities, and model the planner's problem as a function of welfare.
4. **Transportation policy in IO:** Barwick et al. (2024); Durrmeyer and Martinez (2022); Almagro et a. (2024)
   - ⋆ I consider more policies, multiple cities, a budget constraint, and include micromobility in the inside option.

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- **Budget constraint:**
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- **Multiple cities:**
  - **The idea:** most trips are < 3 miles, can cycling be a **viable option** for replacing some of these trips in areas where public transit **is not**?

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Demand: Almagro et al. (2024)

- Almagro et al. models the process in three parts: demand, transportation technology, and the planner's problem.

- Market $m = (a, a', h)$ is the collection of people traveling from Chicago Community Area a to a' in hour h. Individual i chooses mode $j \in \mathcal{J}^i_m \cup \{0\}$ to solve:

$$\max_{j \in \mathcal{J}^i_m \cup \{0\}} \alpha_T \cdot T_{mj} + \alpha^i_p \cdot p_{mj} + \xi_{mj} + \epsilon^i_{mj},$$

  where T_{mj} and p_{mj} are travel time and price.

- Mixed logit model, we will estimate it via BLP (1995) NFXP.

Transportation technology: Almagro et al. (2024)

- Travel time for mode j in market m is:

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- A traveler follows an exogenous directed path $P_{mj} = ((a, a_1), (a_1, a_2), ..., (a_n, a'))$, and traffic on any edge $e = (a_x, a_y)$ is:

$$F_{eh} = \sum_j w_j \cdot f_{ehj}$$

  where w_j accounts for the differing impact of cars and buses on congestion, and f_{ehj} is the total number of vehicles of mode j going through e.

- Total vehicles f_{ehj} is a function of trips q for cars and fleet size k_j for transit.

Transportation technology (cont.): Almagro et al. (2024)

— Travel time over edge e, time h, and mode j is:

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- Transit users face wait time:

$$T_{mj}^{\text{wait}} = \frac{1+\omega^2}{2k_{r_m j}}$$

where ω measures variation of time between vehicles, k_j is fleet size, and r_m is an exogenous route.

Planner's problem: Almagro et al. (2024)

- The urban planner faces a constrained optimization problem of the form:

$$\max_{\mathbf{p}_G, \mathbf{k}_G} U(\mathbf{q}^*(\mathbf{p}, \mathbf{k}), T(\mathbf{q}^*(\mathbf{p}, \mathbf{k}), \mathbf{k})) - C(\mathbf{q}^*(\mathbf{p}, \mathbf{k}), \mathbf{k}) - E(\mathbf{q}^*(\mathbf{p}, \mathbf{k}), \mathbf{k})$$

$$\text{s.t.} \qquad \prod(\mathbf{q}^*(\mathbf{p}, \mathbf{k}), \mathbf{k}) + B \geqslant 0$$

where B is the municipal budget and $\mathbf{p}_G, \mathbf{k}_G$ are prices and fleet sizes within the government's control, i.e. fares, congestion prices, number of buses on a given route, etc.

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- In words, the planner wants to maximize gross utility $U(\cdot)$ less gross cost $C(\cdot)$ and environmental externalities $E(\cdot)$ subject to their revenue $\prod(\cdot)$ plus budget B being weakly positive.

Where I want to diverge from the Almagro et al. (2024) model

- There are five, maybe six, things I need to do.
  1. Include micromobility as an inside good.
     - May need to include path characteristics in the utility function.
  2. Include the planner's choice of bicycle subsidies into the model.
     - Can simply include this in $\mathbf{p}_G$ and $C(\cdot)$.
  3. Estimate for multiple cities.
     - Need to, e.g., use census tracts instead of Community Areas.

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  4. Include the planner's choice of bike lanes into the model.
     - *Where* will the planner place the bike lanes?
     - Need to change the transportation technology for on-road modes.
     - T^{vehicle}_{ehj} for cars, buses, and ride-hailing will be increasing in bike lane presence, opposite is true for bicycles.
     - Likely need to include bike line coverage by market (path), l_m, as a term in the utility function.

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5. Include the planner's choice of bike sharing into the model.
   - Need to know *where* the planner will place stations/cordon zones.
   - Increases network size, potentially reduces walking time to bike-sharing stations. May add some b_m to utility measuring bike-share availability at origin and destination census tracts.

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6 . Endogenize path selection - here, travelers do not adjust routes in counterfactuals.

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     - Cars: Smartphone data, ACS tract-level mode shares, some measure of # of commuters residing in a tract.
     - Public transit: city's transit authority
     - Ride-hailing: the company or the city.
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2. Prices:
   - Cars: some estimate of per-trip-mile cost
   - Public transit: city's transit authority, for both fares and for computing costs of increasing the fleet
   - Ride-hailing: the company or the city.
   - Bicycles: some estimate of per-trip-mile cost, and the city or some national agency for bike lane construction costs.

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    - Prices of ride-hailing: Almagro et al. use a diff-in-diff estimate of own-price elasticity to deal with this, I will have to figure out a general or case-by-case method.
    - Bike lane coverage along a route: urban planners choose bike lane provision endogenously to cycling demand. Liu, Siddiq, and Zhang (2022) use characteristics of nearby points of interest as instruments for bike lane coverage.

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  - After dealing with these, the rest proceeds as per BLP (1995).

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      a_e are edge fixed effects, from the assumption: $a_{ehj} = \log A_{ehj} = a_e + \varepsilon_{ehj}$.
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    - I.e., we regress log observed vehicle times on log observed traffic flows and edge fixed effects.
- Solve the planner's problem:
  - Compute equilibrium trips and times: $(\mathbf{q}, \mathbf{t})$ s.t. trips are determined by our demand model and travel times from our travel time model.
  - Iteratively solve approximations to the Lagrangian of the constrained maximization problem, computing a new equilibrium for each iteration.

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    - What is the optimal level of micromobility investment, does it differ substantially across cities?
    - What can we learn about the cost-effectiveness of micromobility policies relative to other transportation policies?
    - Do micromobility policies have significantly different distributional impacts relative to other transportation policies?

Thank you!