Discussion:

Bruchon, Michalek, & Azevedo.

Effects of Air Emissions Externalities on Optimal Ride-Hailing Fleet Electrification and Operations

Don MacKenzie

University of Washington

Is policy intervention justified, on externality-correcting grounds, to increase electrification of ridehailing fleets?

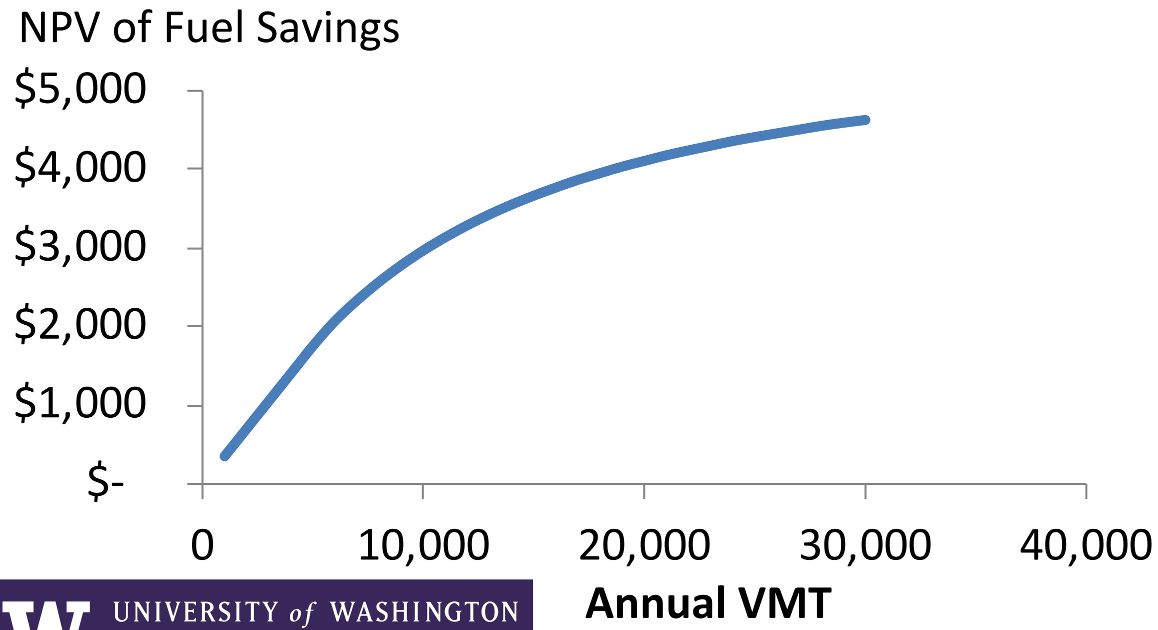
https://electrek.co/2019/11/15/lyft-200-electric-cars-drivers-denver/

https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/About_Us/Organization/Divisions/Policy_and_Planning/PPD_Work/PPD_Work_Products_(2014_forward)/Electrifying%20the%20Ride%20Sourcing%20Sector.pdf

Opportunities and risks of EVs in ridehailing service are ambiguous

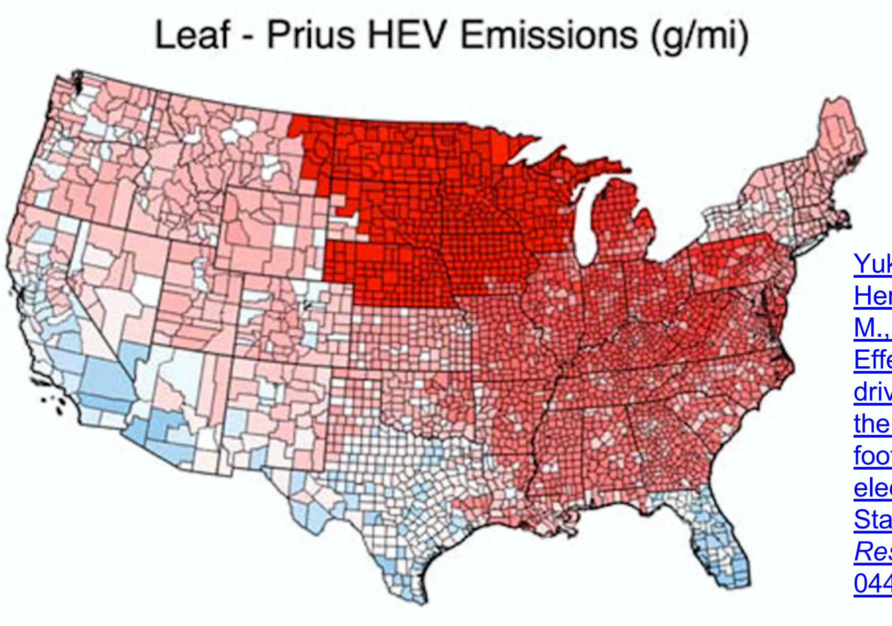
Opportunities

- Financially attractive in high-mileage applications
- Can reduce GHGs and criteria pollutant exposure



Risks

- Charging downtime
- Environmental impacts depend on time & location of charging; lifecycle impacts



Yuksel, T., Tamayao, M. A. M., Hendrickson, C., Azevedo, I. M., & Michalek, J. J. (2016). Effect of regional grid mix, driving patterns and climate on the comparative carbon footprint of gasoline and plug-in electric vehicles in the United States. *Environmental Research Letters*, *11*(4), 044007.

Analysis uses RideAustin data

Sample 5,000 RideAustin Trips

↓

Reduce to 25 O/D locations via cluster analysis

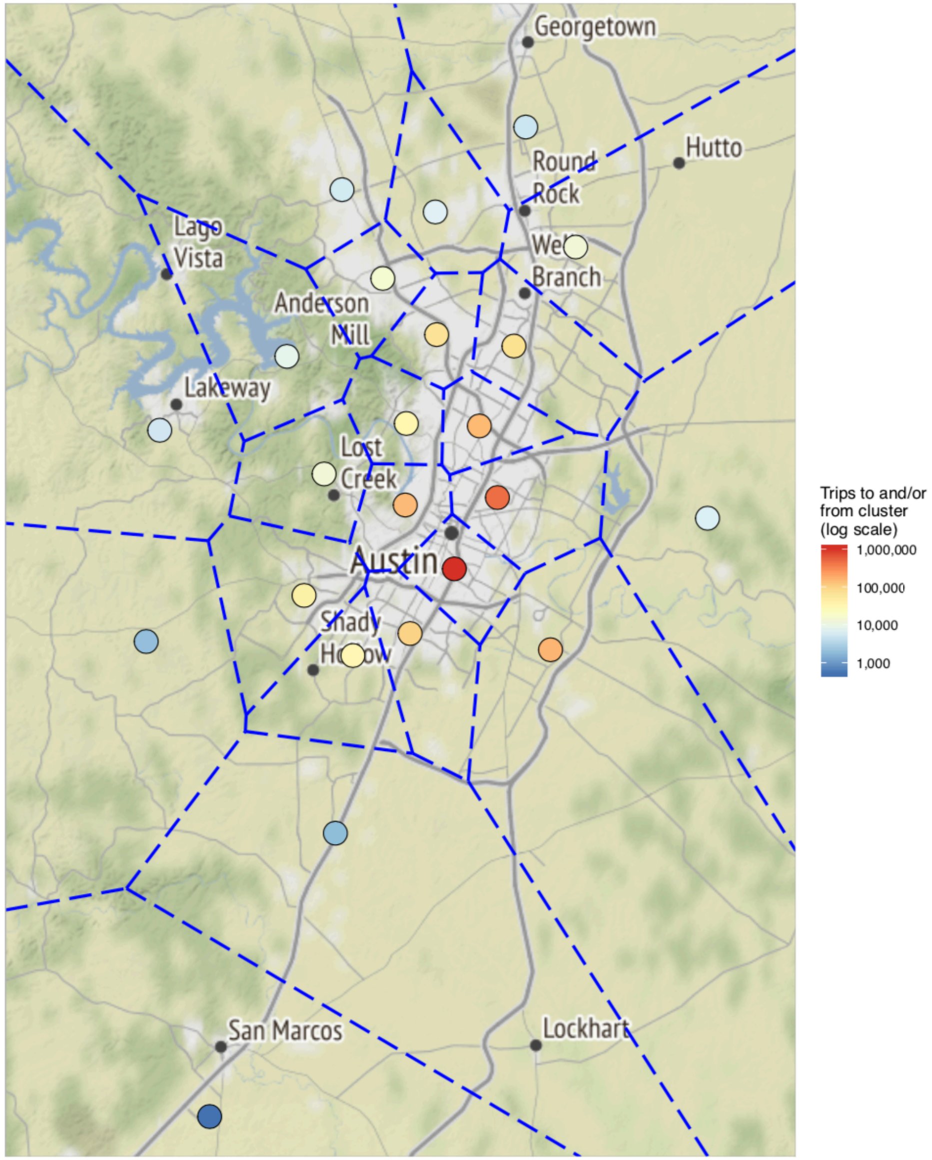
↓

Minimize private or social costs by varying mix & routing

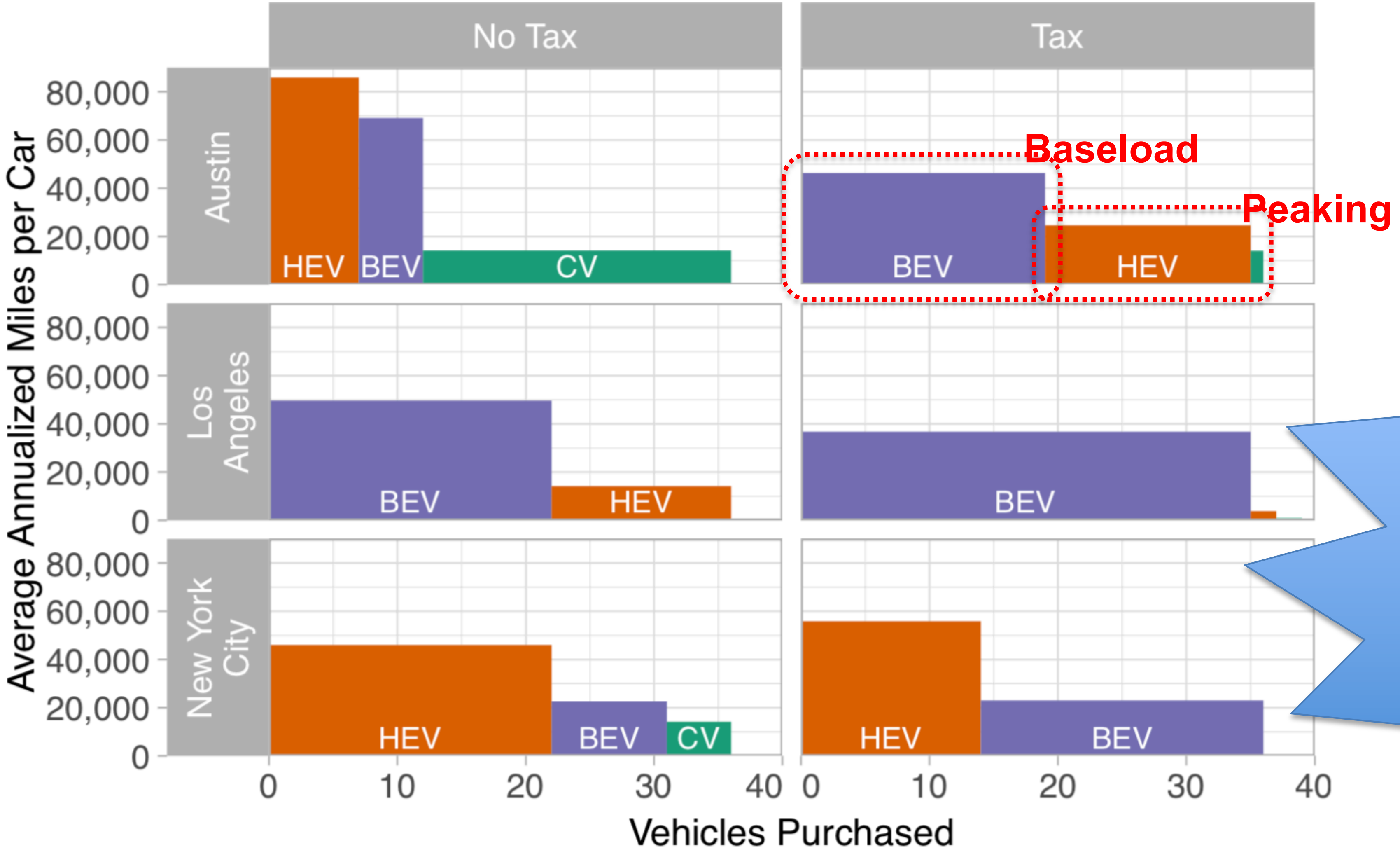
↓

Reapply for LA & NYC using local damage costs & energy prices

Geographic clusters and their trip volumes



Key finding: Pigouvian taxation shifts fleet & VMT toward HEVs & BEVs

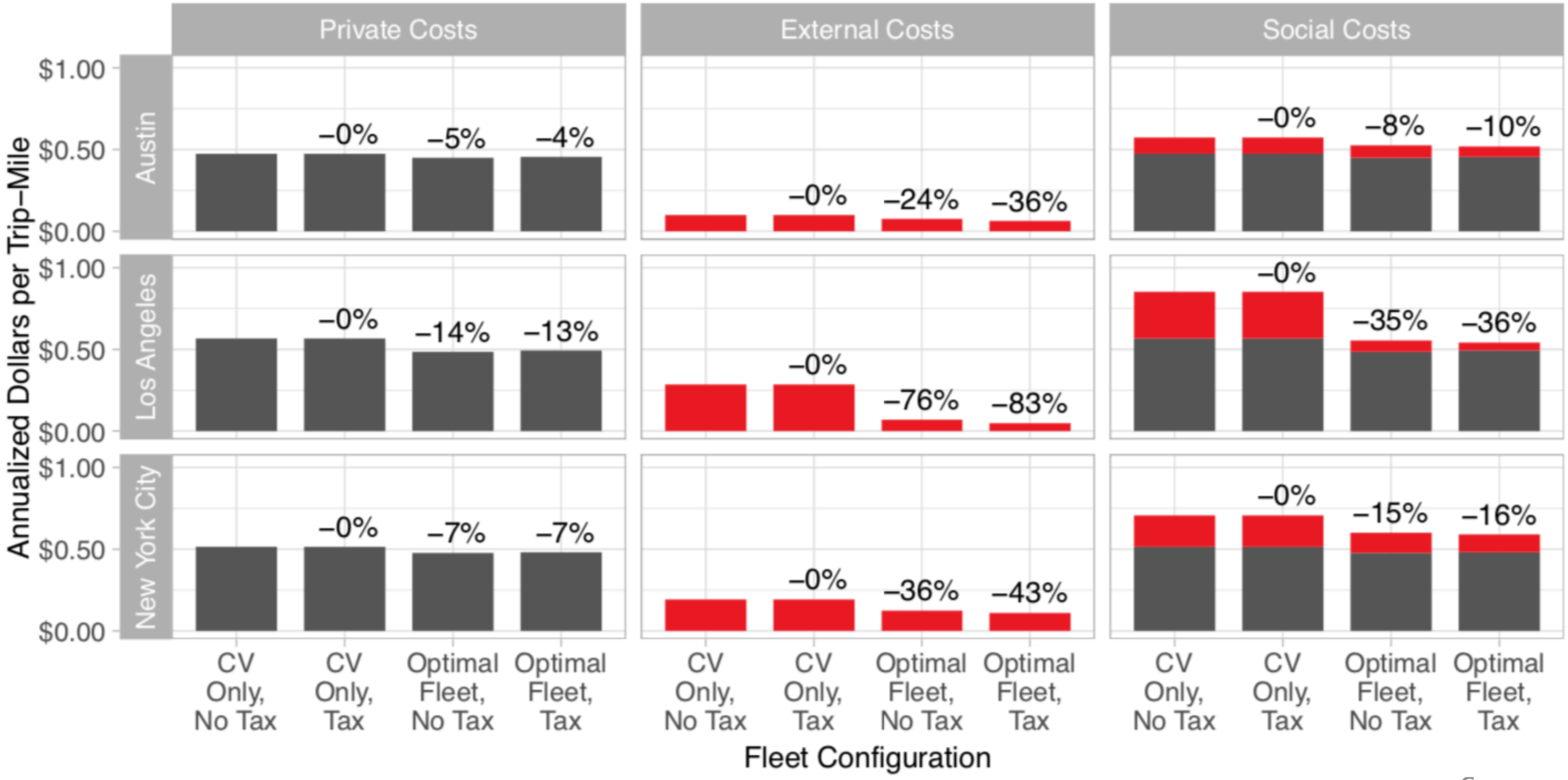


Surprise:
sometimes BEVs provide baseload & HEVs peaking, others vice versa

One difference of interpretation

Authors: *“Our results consistently suggest that internalizing air emissions externalities results in a greater degree of electrification (shift from CV to HEV and BEVs and shift from HEV to BEV) as well as operational changes that together reduce air emissions external costs (by 12% to 31% in the base case and 2% to 81% across sensitivity cases, depending on the city)”*

What I see:
Most of the reduction in external costs appears to come from optimizing a mixed fleet, even without Pigouvian taxation.



Some limitations of the current model

“operator has perfect knowledge of exogenous demand and total control over fleet acquisition and routing”

Demand is satisfied, but it is unclear how timing of trips is considered.

There does not seem to be a cost for waiting time, and I don’t see how waiting time is measured.

$$\underset{\mathcal{X}}{\text{minimize}} \sum_{k\in\mathcal{K}} \kappa_k + \sum_{(i,j)\in\mathcal{A}} c_{k,i,j} a_{k,i,j} + \sum_{k\in\mathcal{K}} \sum_{t\in\mathcal{T}_+} c_t \Delta q_{k,t}^{\text{CHG}} + \tau \left[\sum_{k\in\mathcal{K}} \delta_k + \sum_{(i,j)\in\mathcal{A}} d_{k,i,j} a_{k,i,j} + \sum_{k\in\mathcal{K}} \sum_{t\in\mathcal{T}_+} d_t \Delta q_{k,t}^{\text{CHG}} \right] \quad \text{Minimize private and external car, fuel, and electricity costs} \quad (1a)$$

subject to

$$\sum_{i\in\mathcal{V}} a_{k,i,j} = \sum_{i\in\mathcal{V}} a_{k,j,i} \quad \forall k\in\mathcal{K}, j\in\mathcal{V}\backslash\{r,s\} \quad \text{Flow is preserved across nodes except source and sink} \quad (1b)$$

$$\sum_{k\in\mathcal{K}} a_{k,i,j} = n_{i,j} \quad \forall (i,j)\in\{\mathcal{A}: n_{i,j} > 0\} \quad \text{Demand is satisfied} \quad (1c)$$

$$\sum_{j\in\mathcal{V}\backslash r} a_{k,r,j} = n_k \quad \forall k\in\mathcal{K} \quad \text{Dispatched cars are purchased} \quad (1d)$$

$$\kappa_k \geq \alpha_{\omega,k}^{\text{COSTS}} n_k + \beta_{\omega,k}^{\text{COSTS}} \sum_{(i,j)\in\mathcal{A}} m_{i,j} a_{k,i,j} \quad \forall k\in\mathcal{K}, \omega\in\Omega_k \quad \text{Per-vehicle private capital costs vary with usage} \quad (1e)$$

$$\delta_k \geq \alpha_{\omega,k}^{\text{DAMAGES}} n_k + \beta_{\omega,k}^{\text{DAMAGES}} \sum_{(i,j)\in\mathcal{A}} m_{i,j} a_{k,i,j} \quad \forall k\in\mathcal{K}, \omega\in\Omega_k \quad \text{Per-vehicle manufacturing external costs vary with usage} \quad (1f)$$

$$q_{k,t+1} \leq q_{k,t} + \sum_{(i,j)\in\{\mathcal{A}: t_i = t\}} a_{k,i,j} \Delta q_{k,i,j}^{\text{MAX}} \quad \forall k\in\mathcal{K}_{\text{B}}, t\in\mathcal{T}_{\text{Q}} \quad \text{BEV charge level is tracked (times with a charger starting timeslot)} \quad (1g)$$

Conclusions

“This suggests a potential role for policy because when emissions externalities are unpriced, firms have incentives to lower private cost in ways that increase air emissions, implement a lower degree of electrification, and charge BEVs when the grid is less clean than socially optimal…. Pigovian taxes offer efficiency and flexibility, but in the absence of such an option, other policies that encourage similar outcomes, such as policies encouraging increased electrification, could potentially improve economic efficiency.”

- Much of the benefit comes simply from optimizing the fleet powertrain mix. There are further benefits from the Pigouvian tax, but most of it is realized simply by getting the vehicles into the fleet.
- Without getting the vehicles into the fleet, a Pigouvian tax doesn’t seem to help.
- Fleets should already be choosing an optimized fleet based on private cost minimization, but they are not, which highlights the difference between a centrally managed fleet and today’s TNC ecosystem.

Some future opportunities in this area

- How does a competitive market for supplying rides affect the gap between market and socially optimal outcomes?
  - Especially when we consider waiting times
- Make demand endogenous, depending on price and waiting time
- Incorporate costs of charging stations!
- Permit drivers to swap BEVs and continue driving