

**Sustainable Vehicle
Technologies**

Market & Policy Analysis

US-China Relationship

 John Paul Helveston

 Dept. of Engineering Management and
Systems Engineering

 May 18, 2022

Hello World!



John Paul Helveston, Ph.D.

Assistant Professor, Engineering Management & Systems Engineering
Website: www.jhelvy.com

- 2010 BS in Engineering Science & Mechanics at Virginia Tech
- 2015 MS in Engineering & Public Policy at Carnegie Mellon University
- 2016 PhD in Engineering & Public Policy at Carnegie Mellon University
- 2016-2018 Postdoc at [Institute for Sustainable Energy](#), Boston University

Technology Change Lab

I study how consumers, firms, markets, and policies affect technology change to facilitate transitions to sustainable and low-carbon technologies.

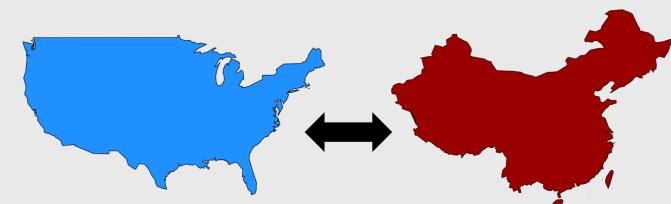
Electric & Sustainable Vehicle Technologies



Market & Policy Analysis



U.S. - China Climate Relationship



I'm interested in questions like...

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- How can we get people to buy more efficient vehicles?

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Answers depend on knowing what people want

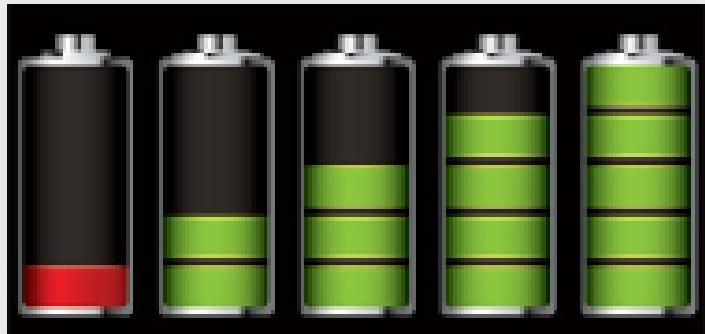
So I try to figure out what people want



Which feature do you care more about?



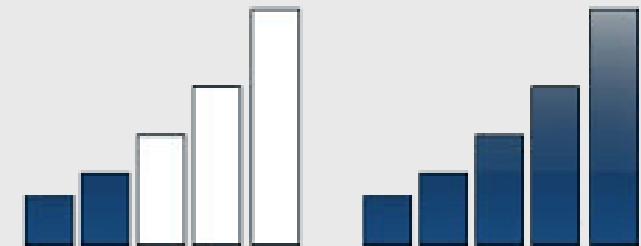
Battery Life?



Brand?

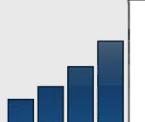
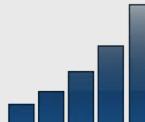
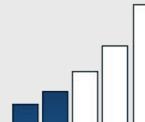


Signal quality?



Conjoint Analysis:

Use choice data to model preferences

| <u>Attribute</u> | <u>Phone 1</u> | <u>Phone 2</u> | <u>Phone 3</u> |
|------------------|--|--|---|
| Price | \$400 | \$450 | \$350 |
| Brand |  |  LG |  SAMSUNG |
| Battery Life |  |  |  |
| Signal Quality |  |  |  |

Use random utility framework to predict probability of choosing phone j

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1. $u_j = \beta_1 \text{price}_j + \beta_2 \text{brand}_j + \beta_3 \text{battery}_j + \beta_4 \text{signal}_j + \varepsilon_j$

Use random utility framework to predict probability of choosing phone j

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2. Assume $\varepsilon_j \sim \text{iid Gumbel distribution}$
3. Probability of choosing phone j : $P_j = \frac{e^{\beta' x_j}}{\sum_k^J e^{\beta' x_k}}$

Use random utility framework to predict probability of choosing phone j

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2. Assume $\varepsilon_j \sim \text{iid Gumbel distribution}$
3. Probability of choosing phone j : $P_j = \frac{e^{\beta' x_j}}{\sum_k^J e^{\beta' x_k}}$
4. Estimate $\beta_1, \beta_2, \beta_3, \beta_4$ via maximum likelihood estimation

Willingness to Pay

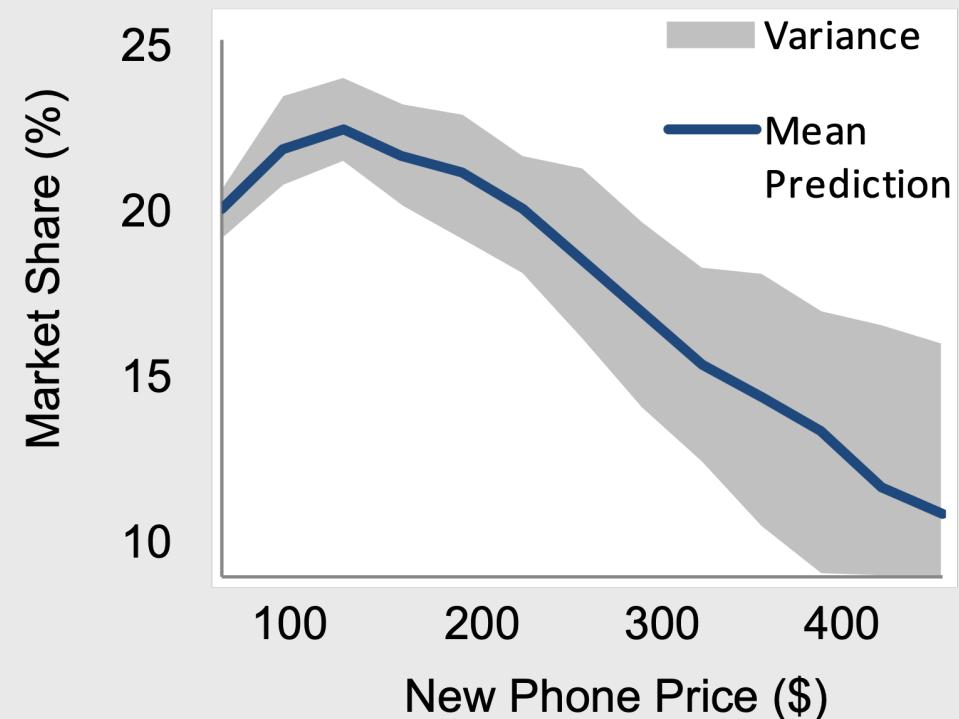
Respondents on average are
willing to pay \$XX to improve
battery life by XX%

Willingness to Pay

Respondents on average are willing to pay \$XX to improve battery life by XX%

Make predictions

$$P_j = \frac{e^{\hat{\beta}' x_j}}{\sum_k^J e^{\hat{\beta}' x_k}}$$



Choose your own adventure

Electric Vehicles

Low-carbon Fuels

Multi-modal Trips

Autonomous Vehicles

Electric Vehicle Incentives

Will subsidies drive electric vehicle adoption? Measuring consumer preferences in the U.S. and China

Helveston, John P., CMU

Yimin Liu, Ford

Elea M. Feit, Drexel U.

Erica R.H. Fuchs, CMU

Erica Klampfl, Ford

Jeremy J. Michalek, CMU

Transportation Research Part A: Policy and Practice, 73, 96–112. (2015) DOI: 10.1016/j.tra.2015.01.002

Each option will look like this:



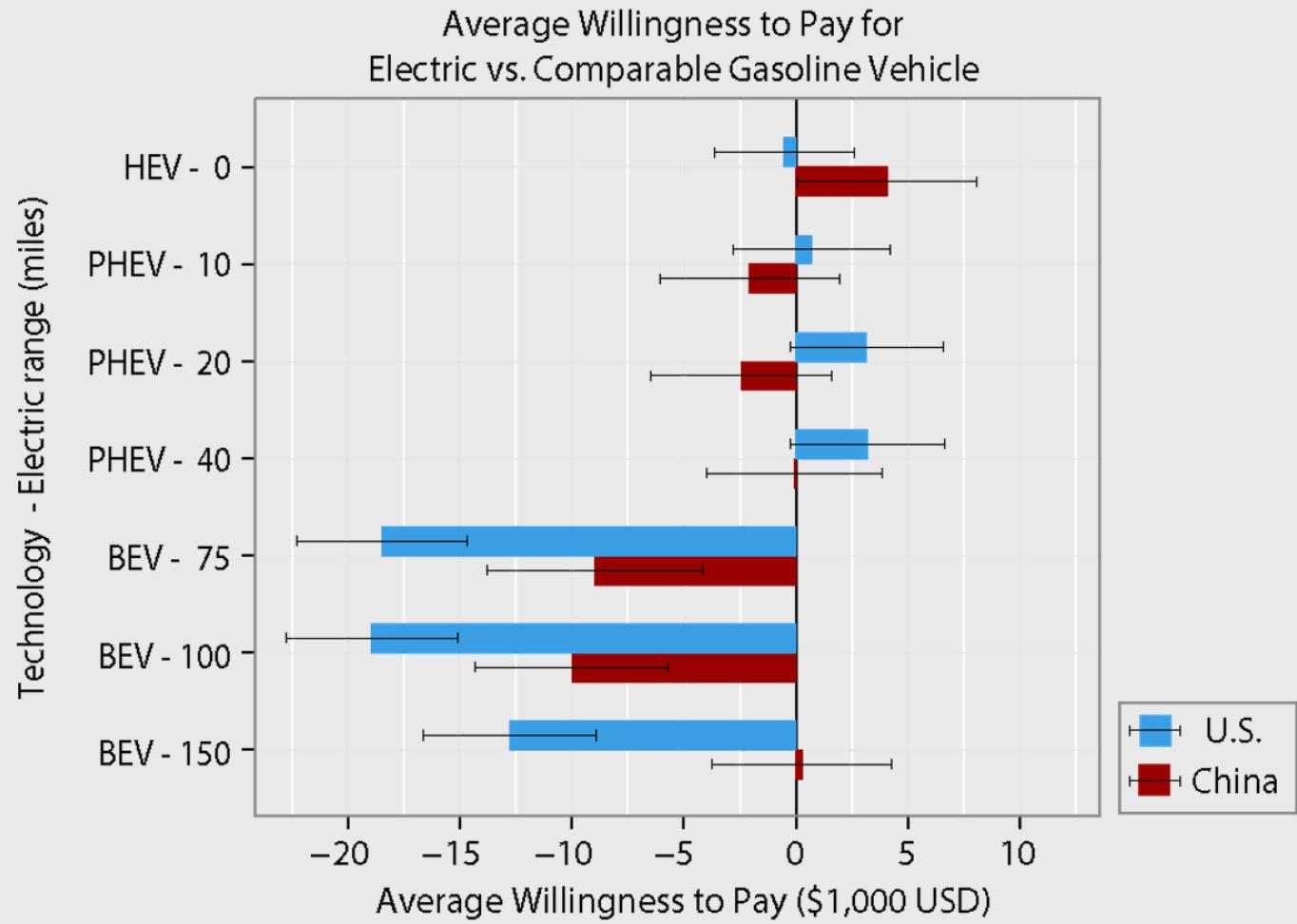
Suppose these 3 vehicles below were the only vehicles available for purchase, which would you choose?

| <u>Attribute*</u> | <u>Option 1</u> | <u>Option 2</u> | <u>Option 3</u> |
|---|--|--|--|
| Vehicle Type ⓘ | Conventional 300 mile range on 1 tank | Plug-In Hybrid & 300 mile range on 1 tank (first 40 miles electric) | Electric 75 mile range on full charge |
| Brand ⓘ | German | American | Japanese |
| Purchase Price ⓘ | \$18,000 | \$32,000 | \$24,000 |
| Fast Charging Capability ⓘ | -- | Not Available | Available |
| Operating Cost (Equivalent Gasoline Fuel Efficiency) ⓘ | 19 cents per mile (20 MPG equivalent) | 12 cents per mile (30 MPG equivalent) | 6 cents per mile (60 MPG equivalent) |
| 0 to 60 mph Acceleration Time** ⓘ | 8.5 seconds (Medium-Slow) | 8.5 seconds (Medium-Slow) | 7 seconds (Medium-Fast) |
| | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

*To view an attribute description, click on: ⓘ

**The average acceleration for cars in the U.S. is 0 to 60 mph in 7.4 seconds

Chinese car buyers
may be more
willing to adopt full
electric vehicles
than Americans.



Return to choices

Skip to end

Choice at the Pump: Measuring Preferences for Lower-Carbon Combustion Fuels?

John P. Helveston, GWU

Stephanie M. Seki, CMU

Jihoon Min, CMU

Evelyn Fairman, CMU

Arthur A. Boni, CMU

Jeremy J. Michalek, CMU

Inês M. L. Azevedo, CMU

Environmental Research Letters, 14(8)
(2019) DOI: 10.1088/1748-9326/ab2bd2

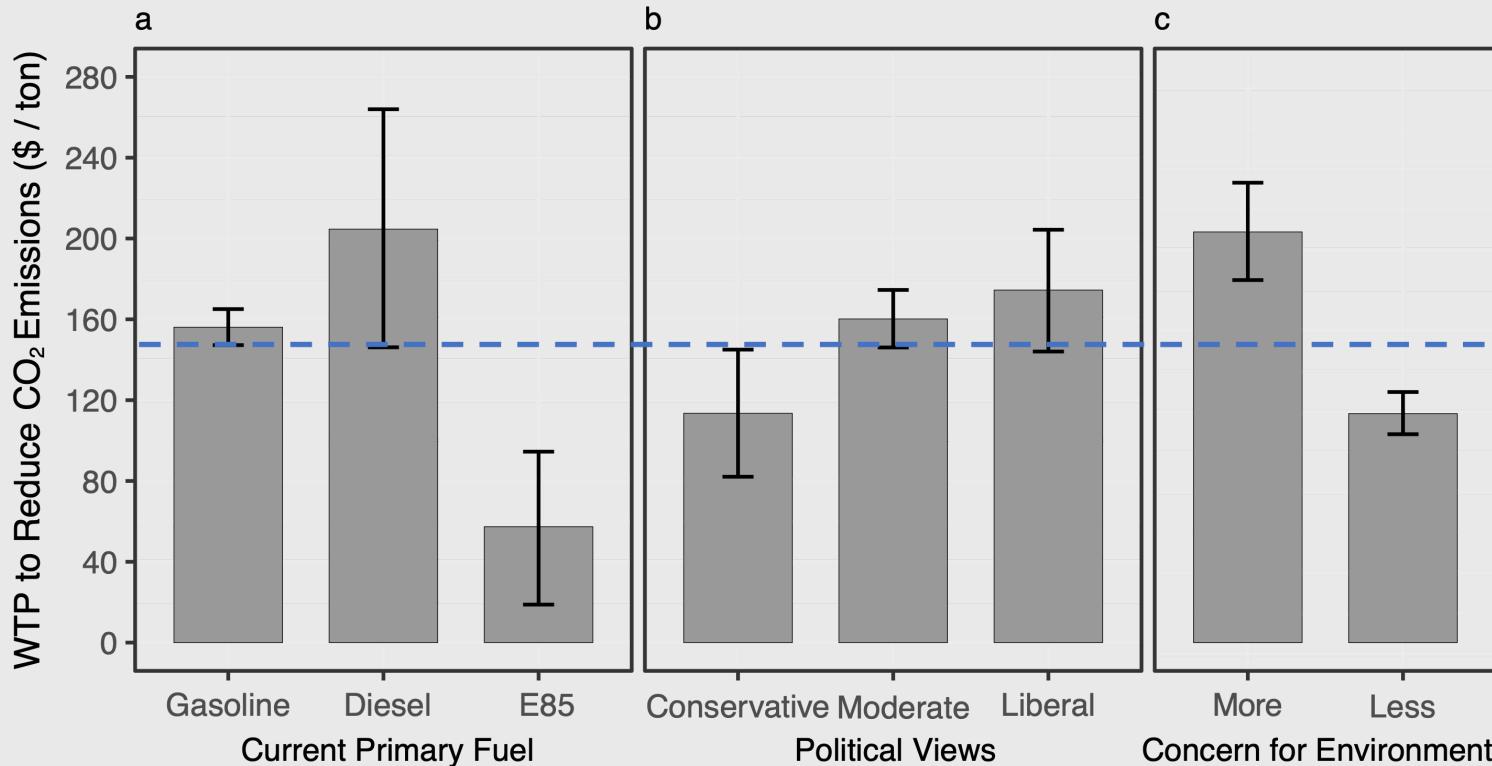
If these were your only fueling options, which fuel would you choose? (2 of 13)



Note: * Each tank allows the vehicle to travel 300 miles.

** Tailpipe emissions for light duty vehicles (in grams of CO₂ per mile)

On average, respondents WTP \$150/ton CO₂ avoided



Example:

- 26 mpg car
- 12-gallon tank
- Gas: \$3/gallon

A WTP of \$150/ton CO₂ avoided means increasing fuel price by 45%!

Return to choices

Skip to end

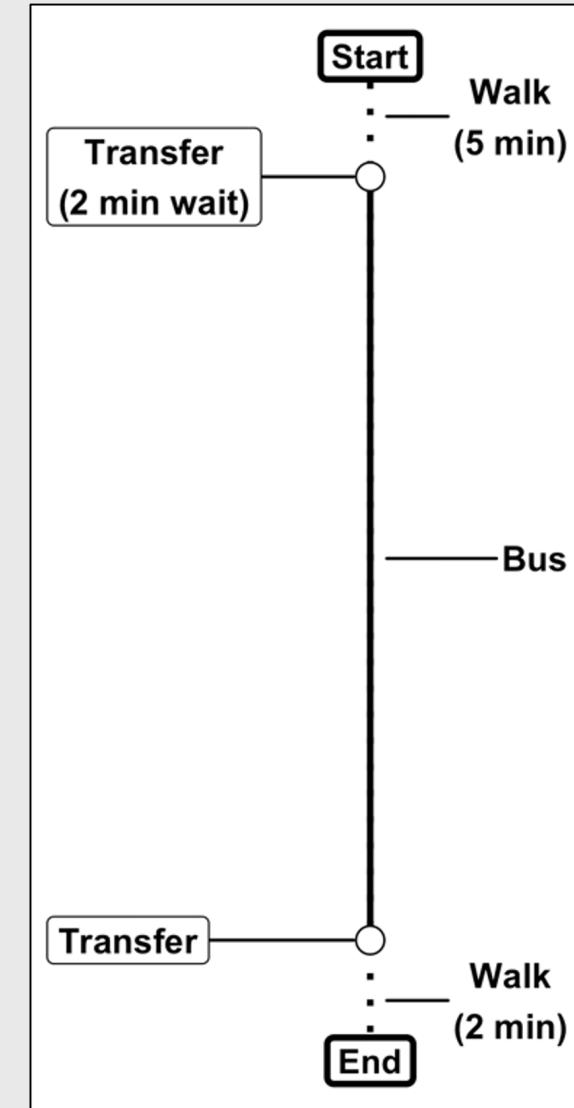
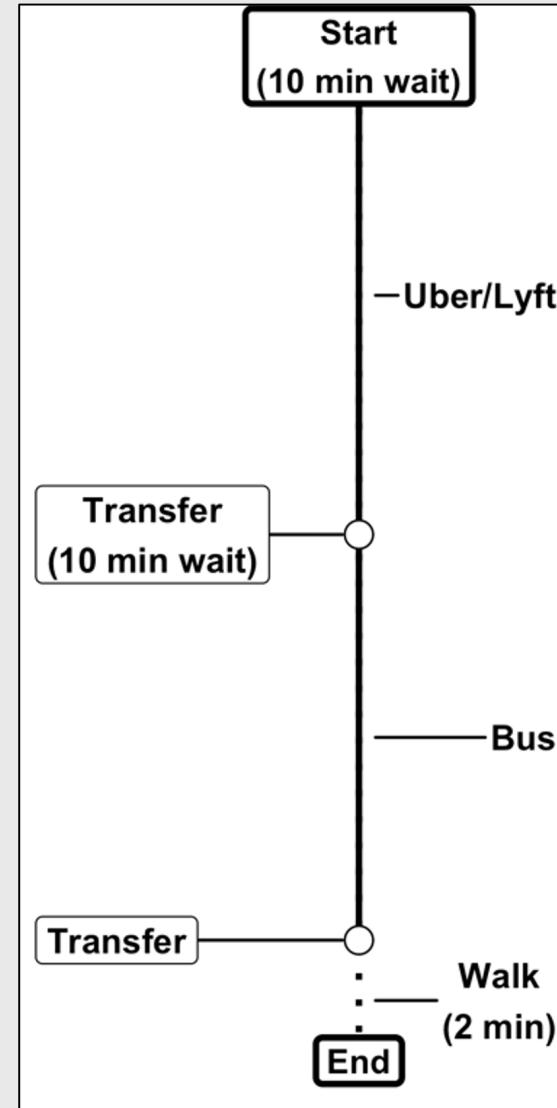
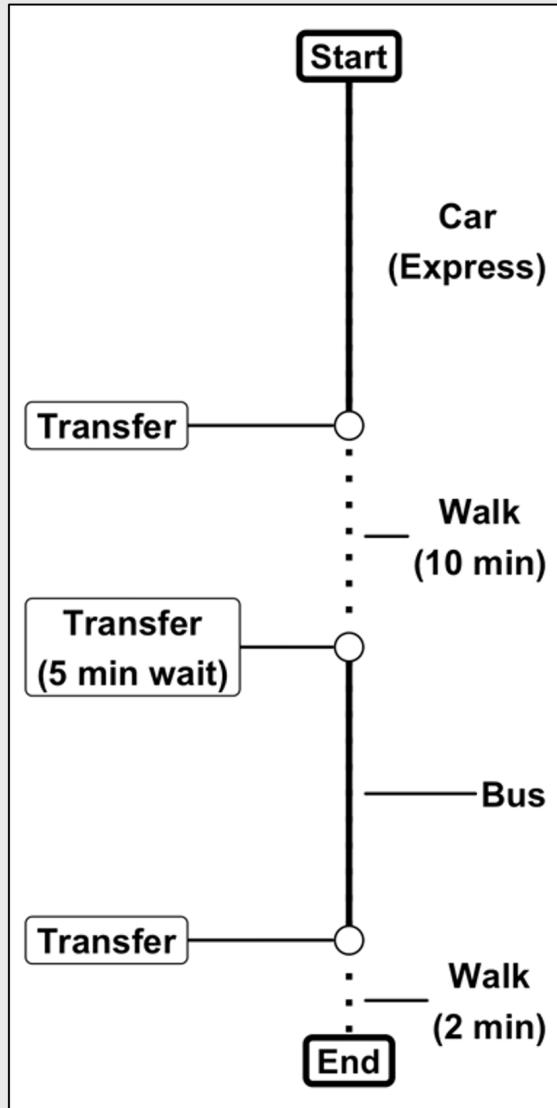
Measuring consumer preferences for multi-modal trips

John P. Helveston, Assistant Professor, EMSE

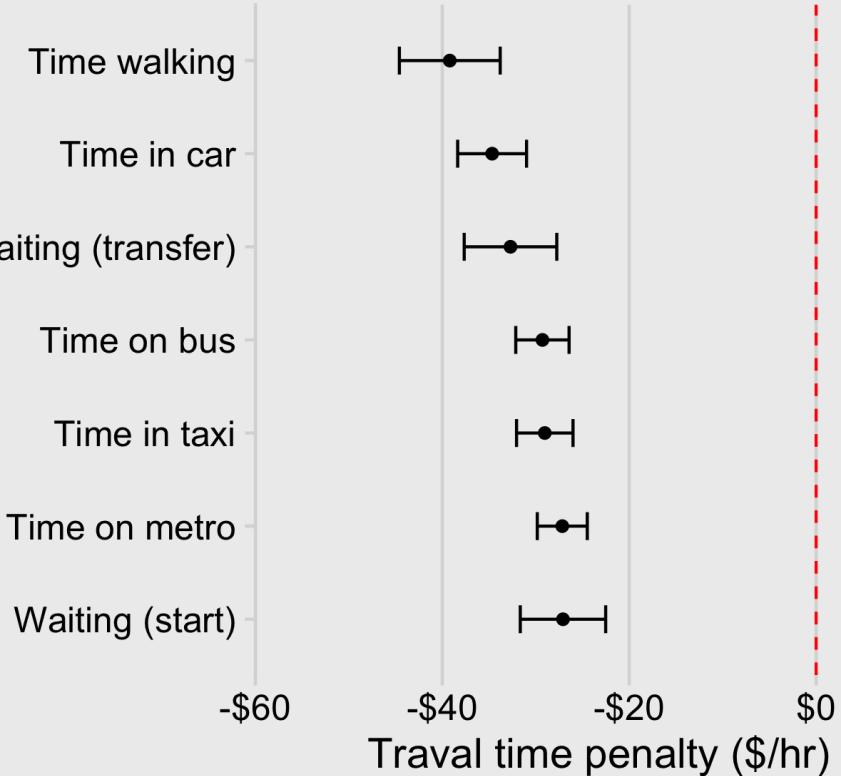
Lujin Zhao, Ph.D. Student, EMSE

Saurav Pantha, MS Alumni & Visiting Scholar, EMSE

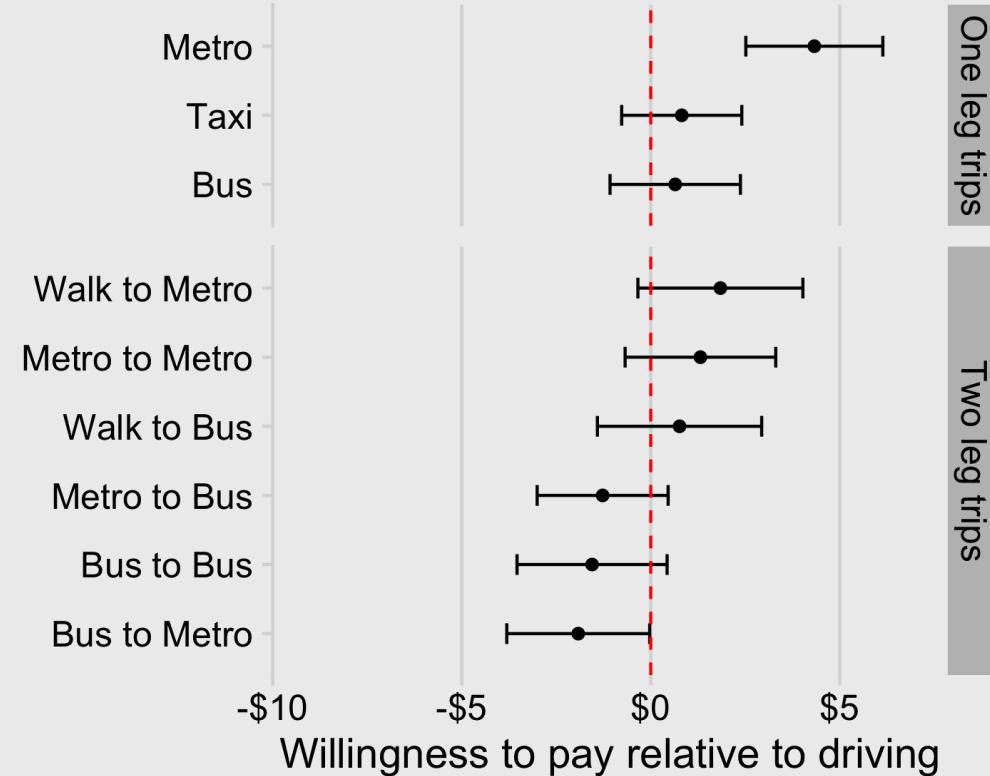
If these were your only trip options, which would you choose?



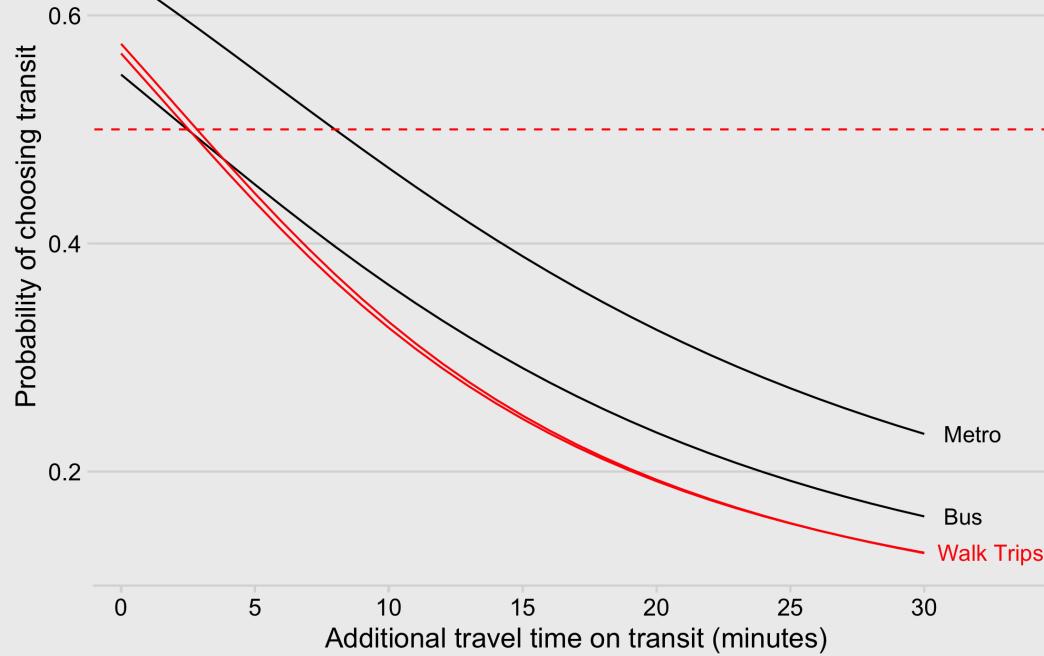
Value of time



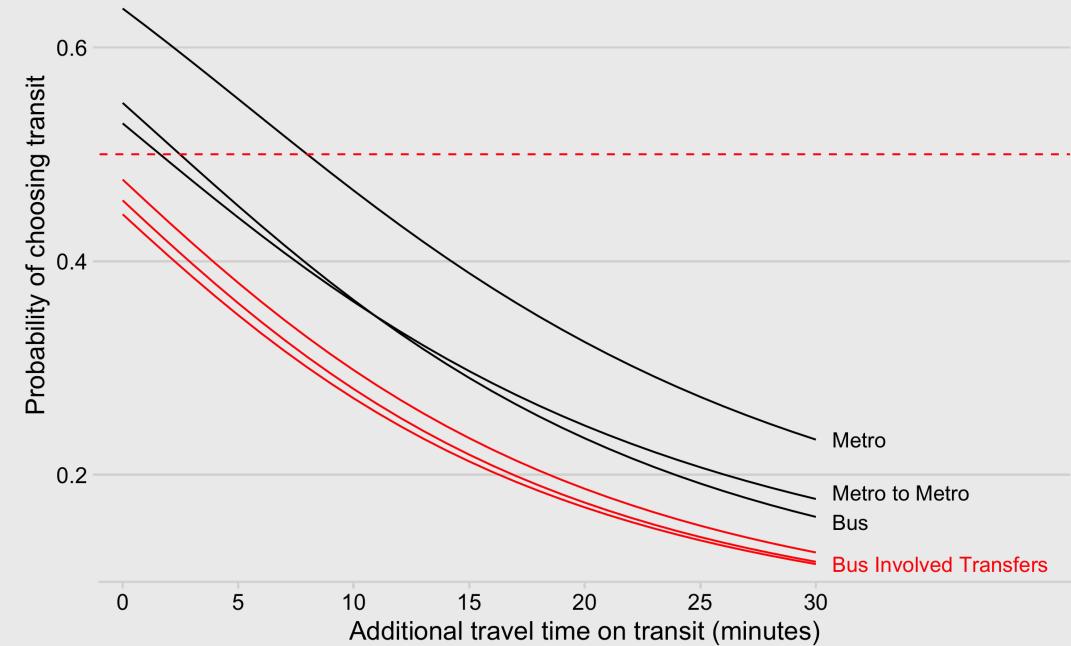
Value of mode



When will commuters choose transit over driving



When will commuters choose transit over driving



Return to choices

Skip to end

Undercutting Transit?

Exploring potential competition between autonomous vehicles and public transportation in the U.S.

John P. Helveston, Assistant Professor, EMSE

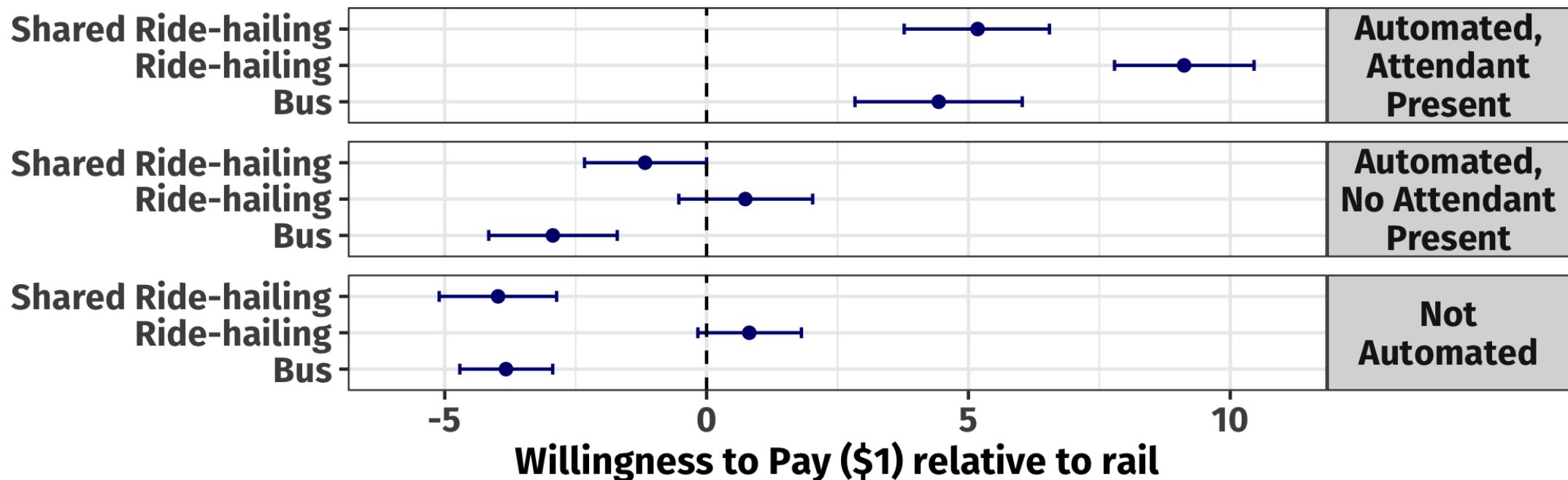
Leah Kaplan, Ph.D. Student, EMSE

Imagine you are going out for an evening leisure activity -
Which transportation option would you choose?

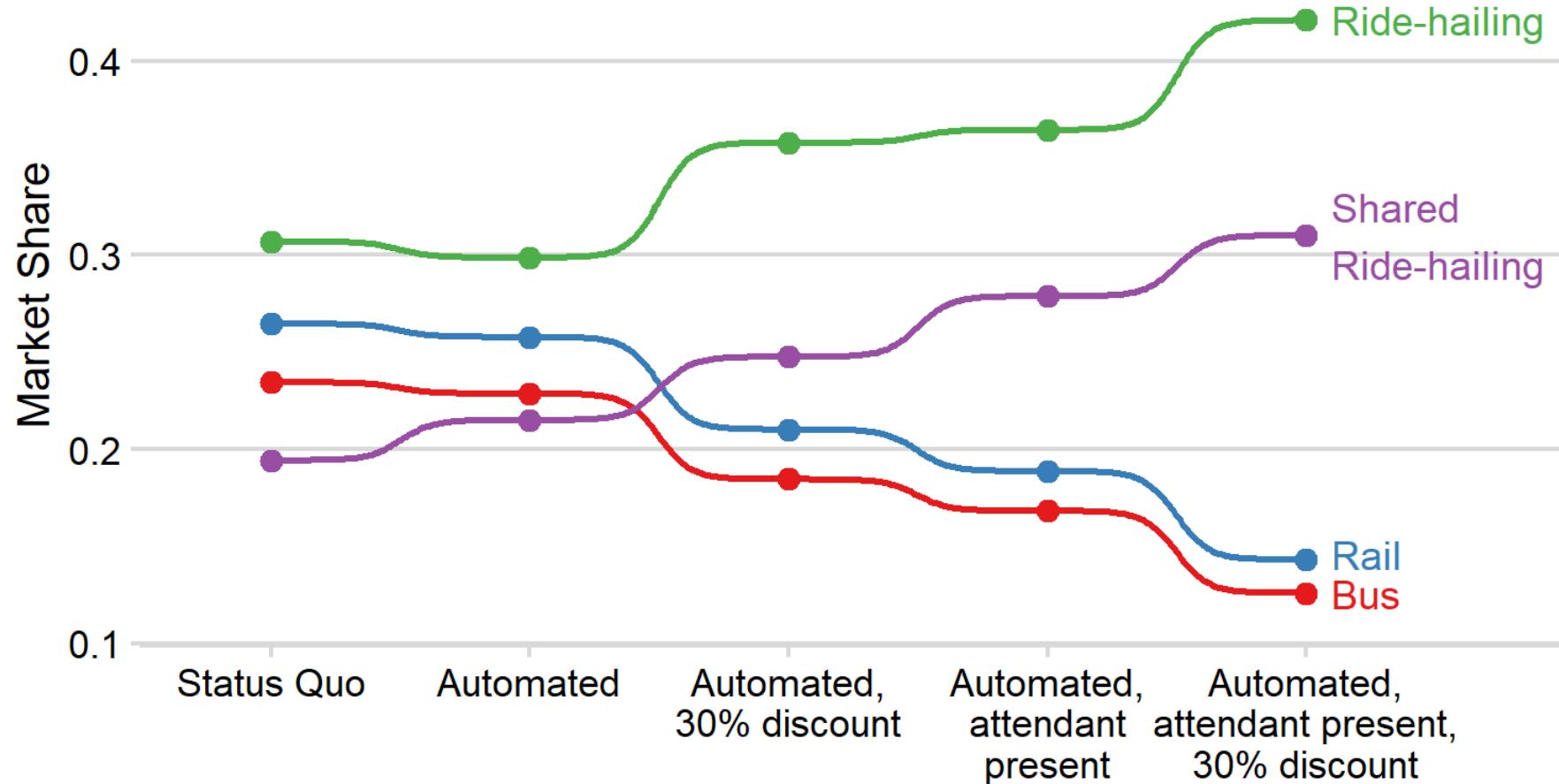
| Bus | Rail | Ride-hailing | Shared Ride-hailing |
|--|---|---|--|
| Automated, Attendant Present  | Not Automated  | Automated, No Attendant Present  | Automated, Attendant Present  |
| Price: \$1 Total Trip Time: 20 | Price: \$3 Total Trip Time: 30 | Price: \$15 Travel Time: 30 | Price: \$10 Total Trip Time: 35 |

AV preferences shift with addition of an attendant

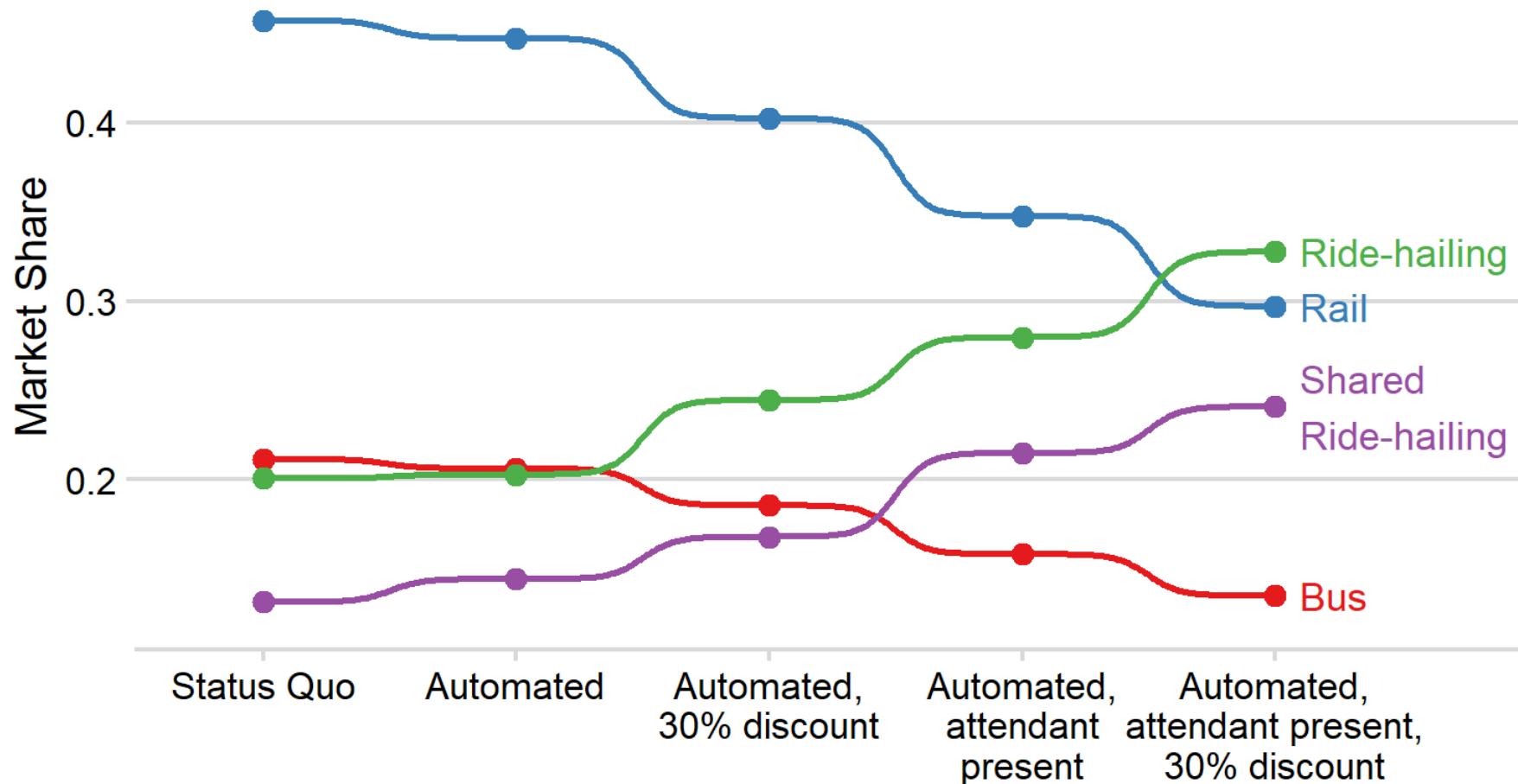
Automation alone does not drastically alter mode preferences

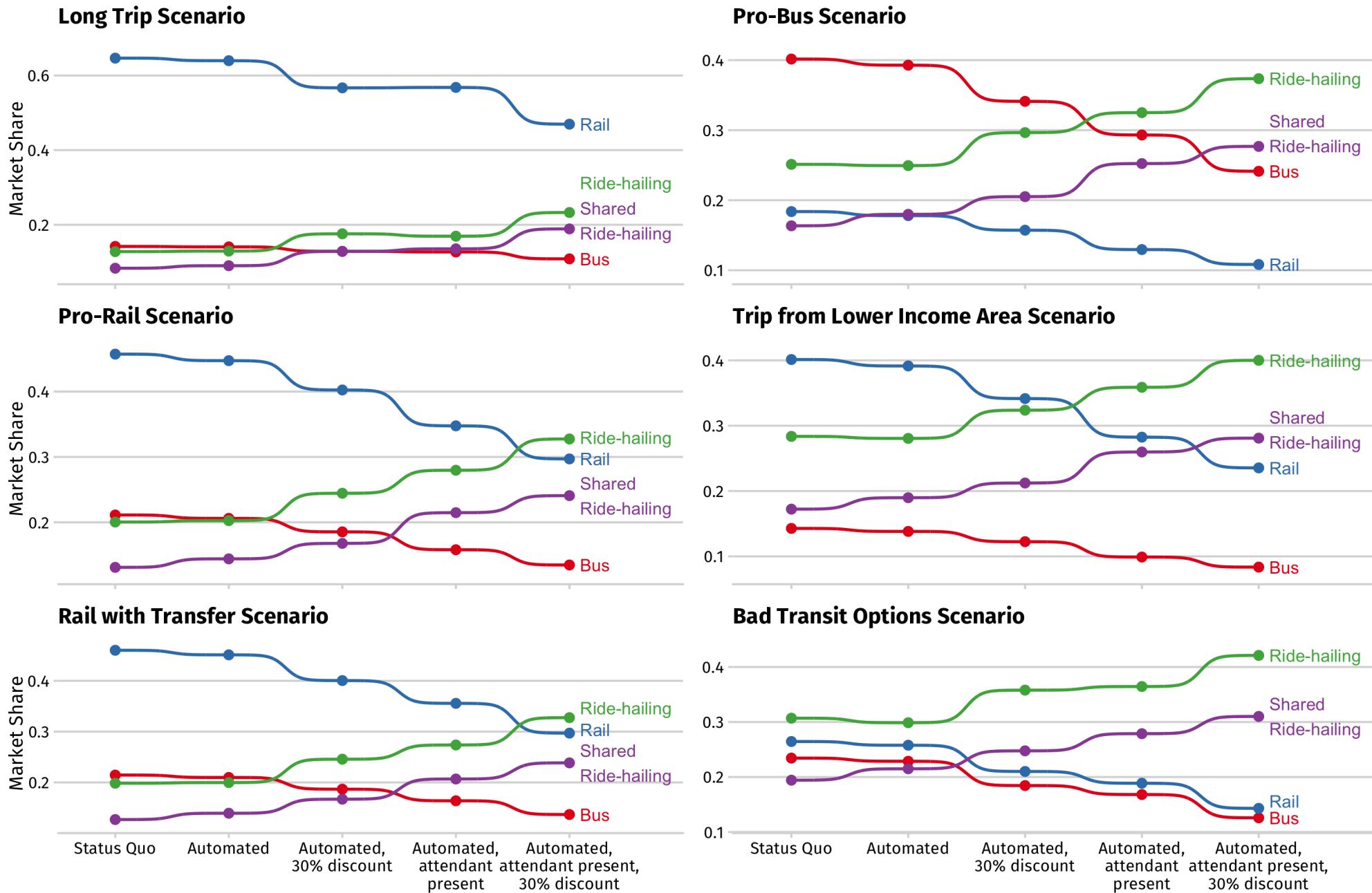


Bad Transit Options Scenario



Pro-Rail Scenario





Return to choices

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Designing more efficient & equitable EV incentives

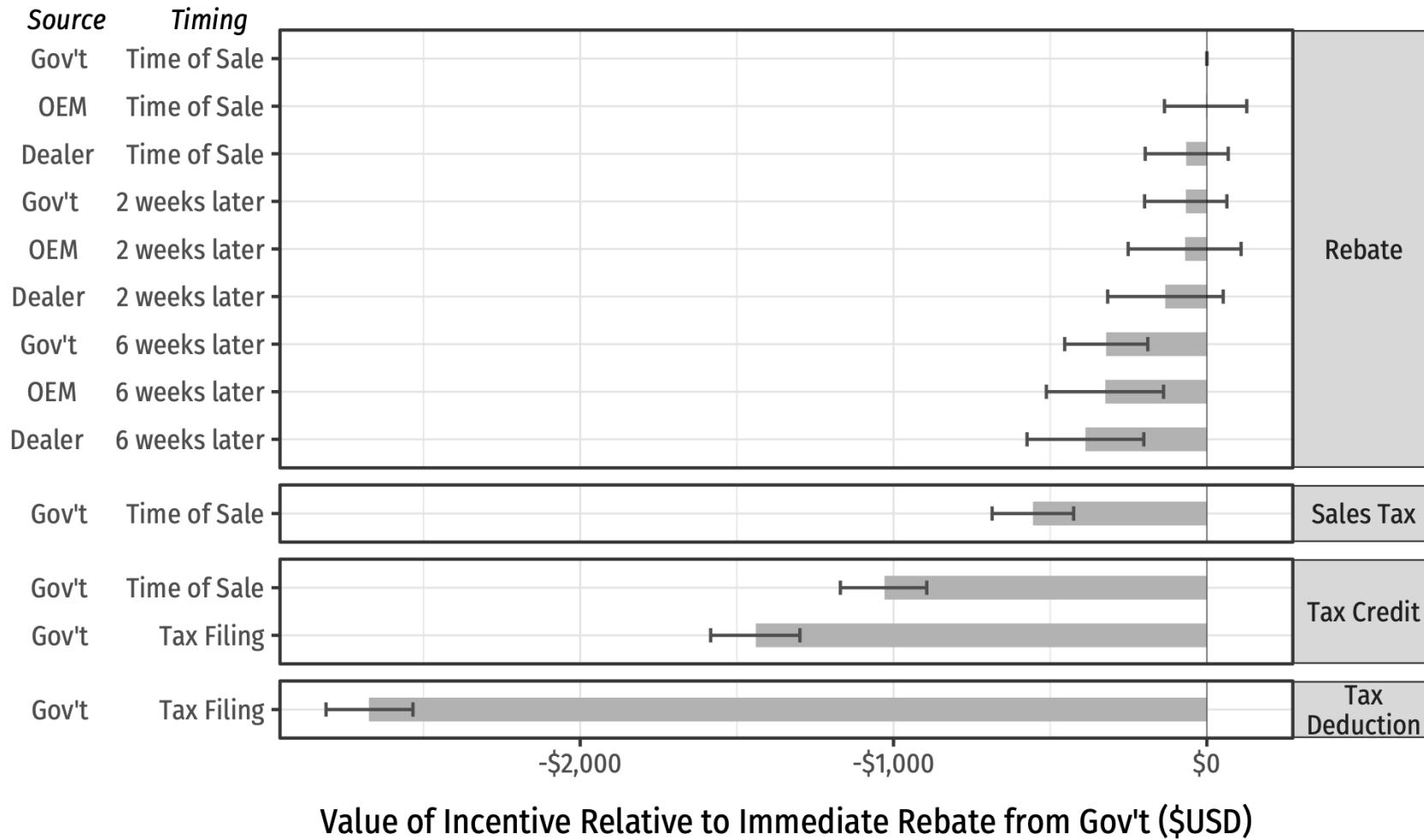
John P. Helveston, Assistant Professor, EMSE

Laura Roberson, Ph.D. Student, EMSE

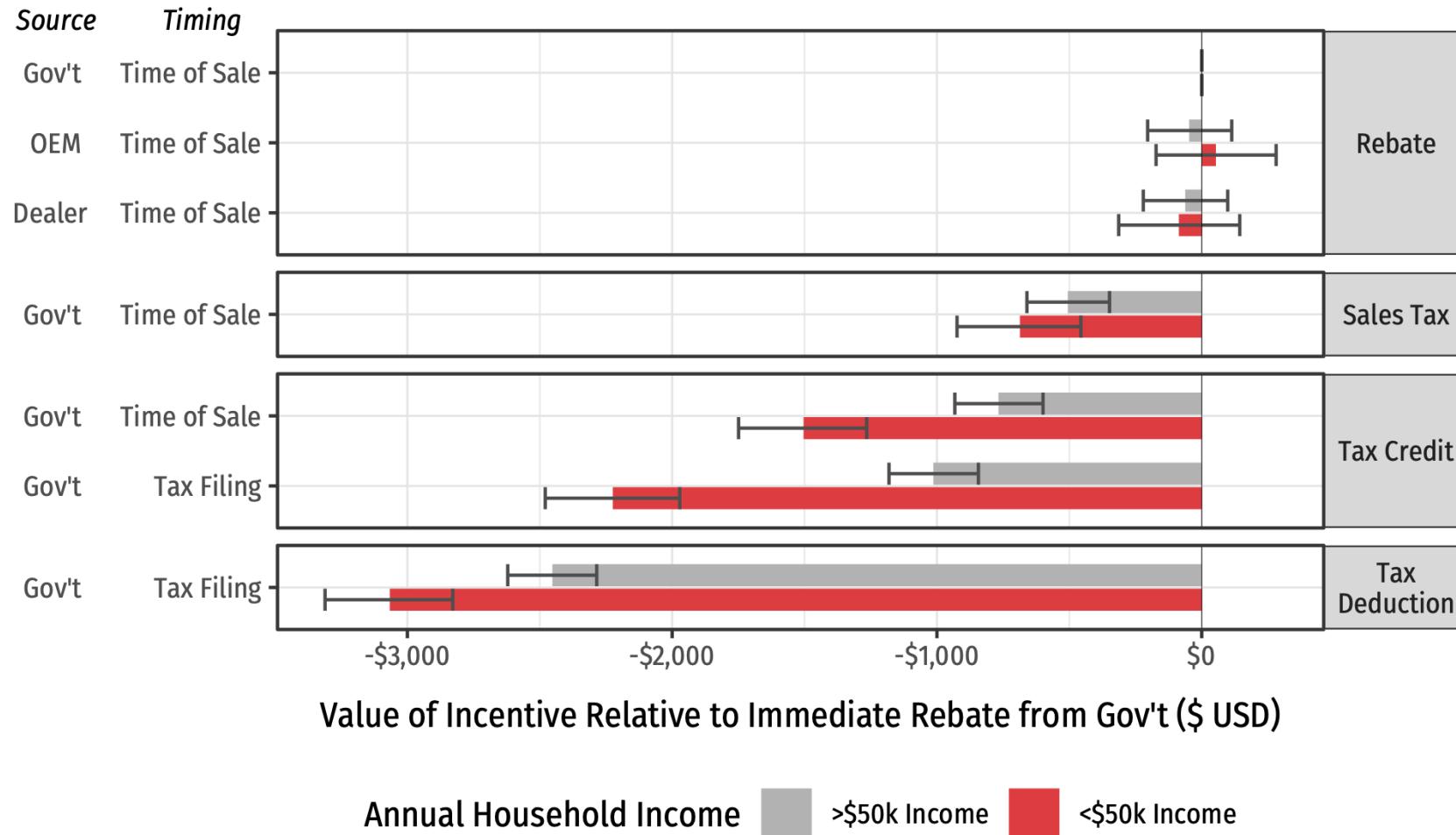
Which incentive option would you prefer?

| Sales Tax Exemption | Tax Credit | Tax Deduction | Rebate from Dealer |
|---------------------------------|---------------------------------|--|--|
| Amount: \$1,900 | Amount: \$2,500 | Amount: \$2,000 | Amount: \$2,000 |
| Time Frame: Time of Sale | Time Frame: Time of Sale | Time Frame: At Tax Filing (approx. April 2022) | Time Frame: Time of Sale From: Dealer |

Immediate rebate is **\$1,400** more valuable than tax credit



Immediate rebate even more preferred for **low-income households**



Return to choices

Skip to end

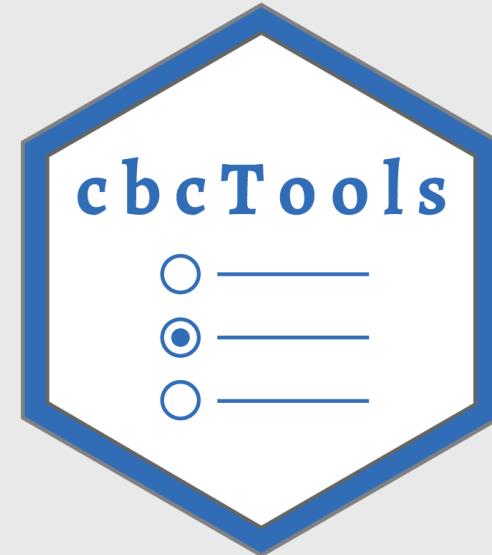
logitr



Fast estimation of multinomial and mixed logit models in R with “Preference” space or “Willingness-to-pay” space utility parameterizations.

<https://jhelvy.github.io/logitr/>

cbcTools



Tools for designing choice based conjoint (cbc) survey experiments and conduction power analyses.

<https://jhelvy.github.io/cbcTools/>

Analyzing historical vehicle listings data



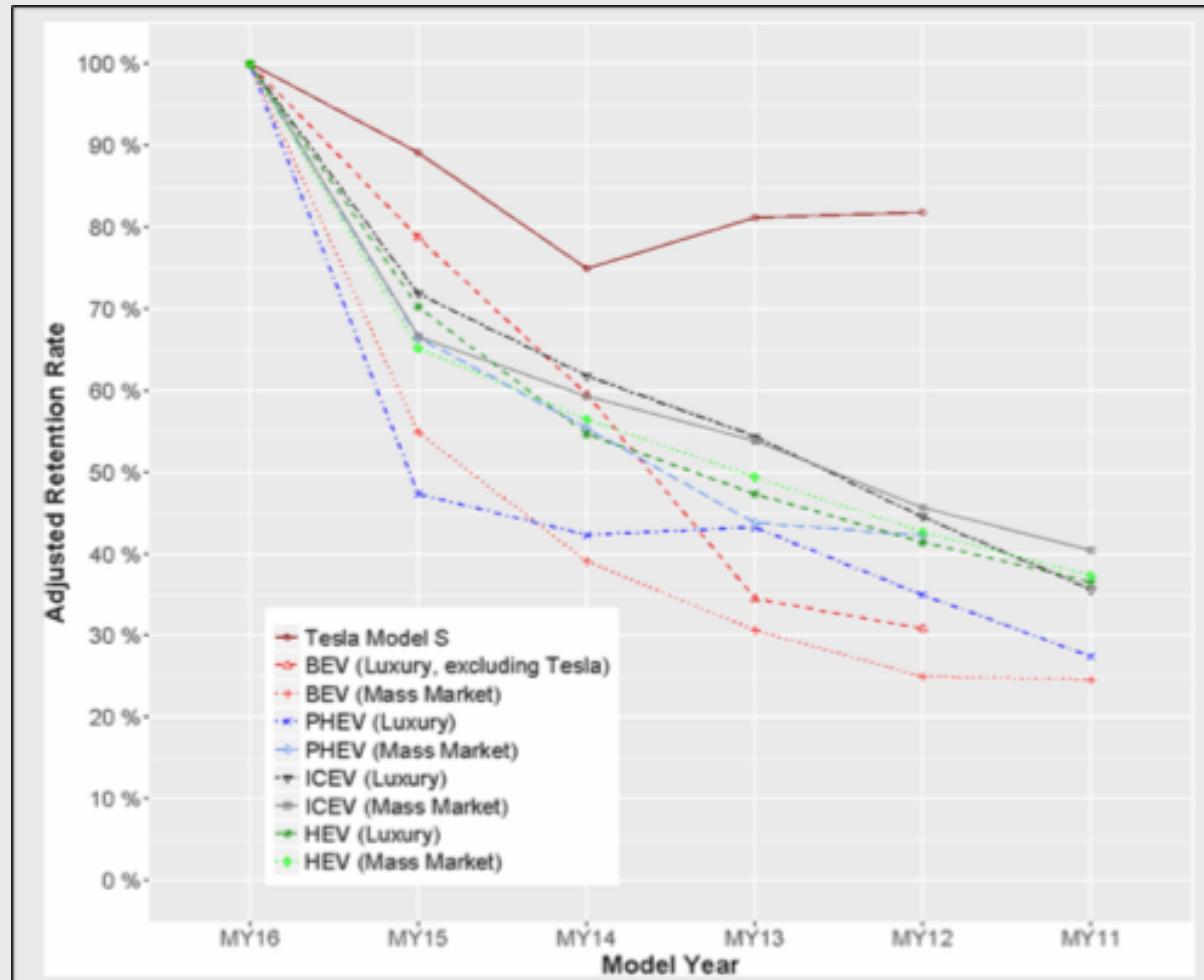
- New and used cars from 2015-2019
- ~55,000 dealerships

| Powertrain | Listings |
|------------------------|------------|
| Gasoline | 22,769,637 |
| Hybrid | 749,460 |
| Battery Electric (BEV) | 87,852 |
| Plug-In Hybrid (PHEV) | 112,222 |

Estimating residual value of EVs

John P. Helveston,
Assistant Professor,
EMSE

Laura Roberson, Ph.D.
Student, EMSE

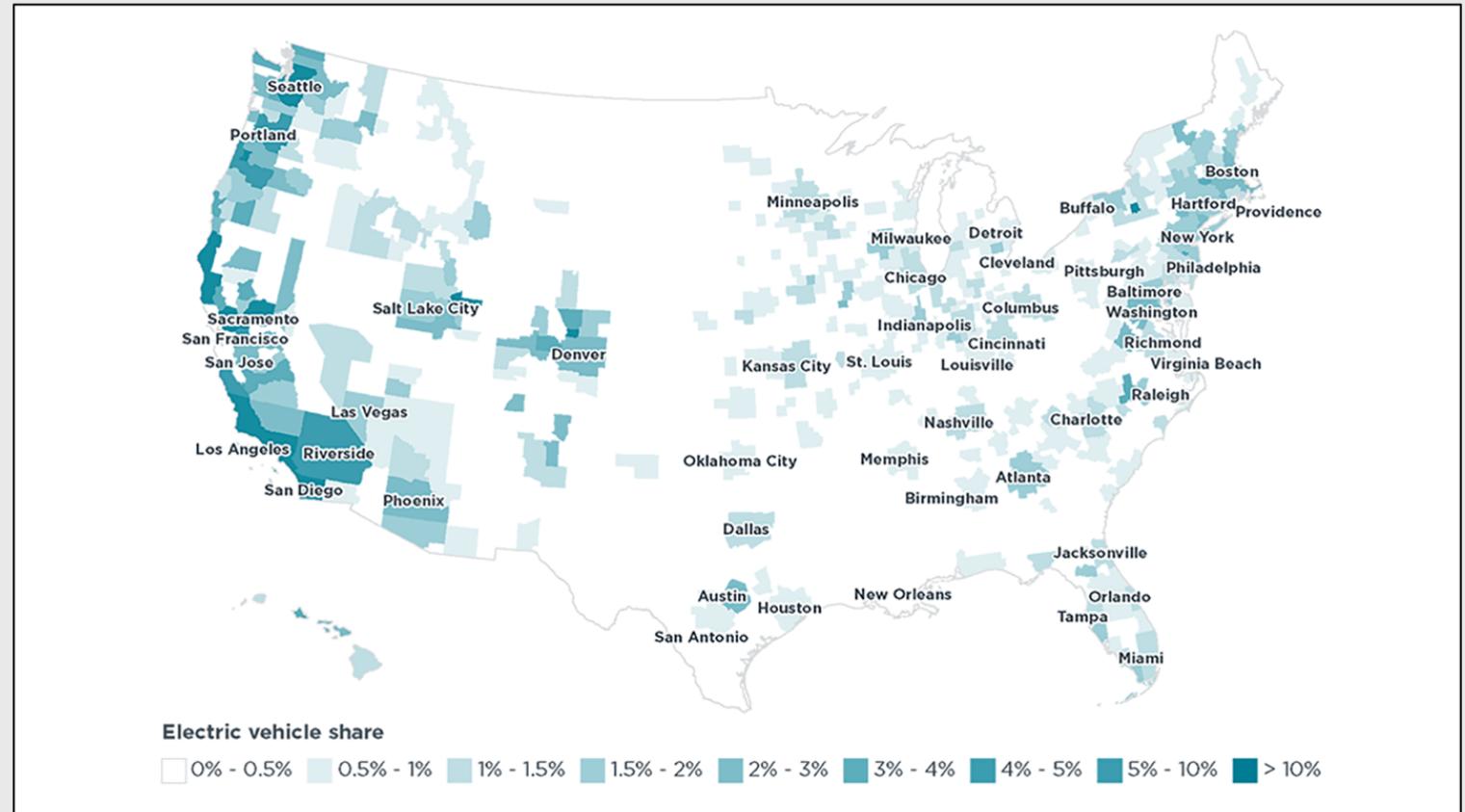


Where are the EVs?

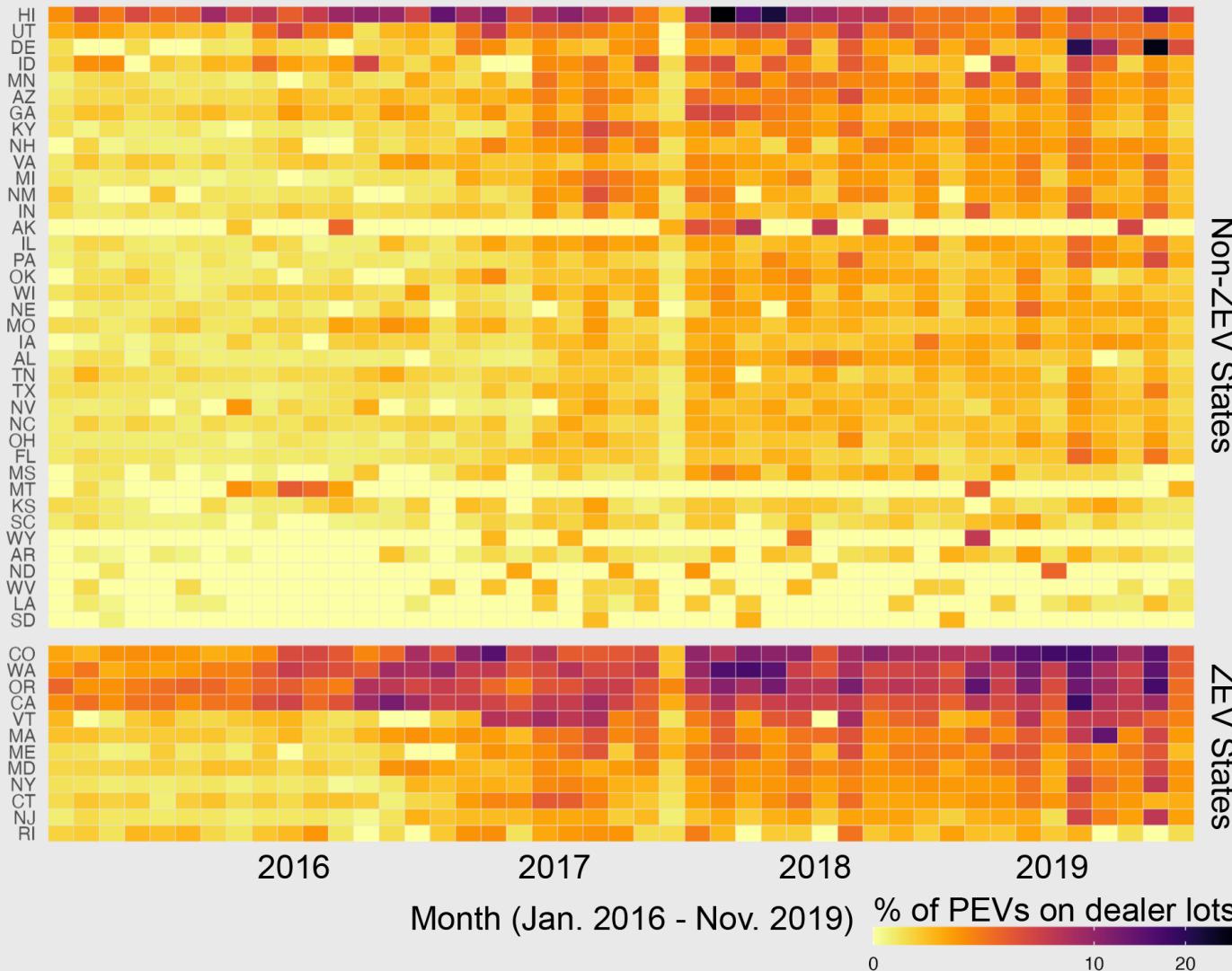
John P. Helveston,
Assistant Professor,
EMSE

Kazi Asifa,
Undergraduate Student,
EMSE

2019 study by Sierra
Club found that 74% of
dealerships are not
selling EVs

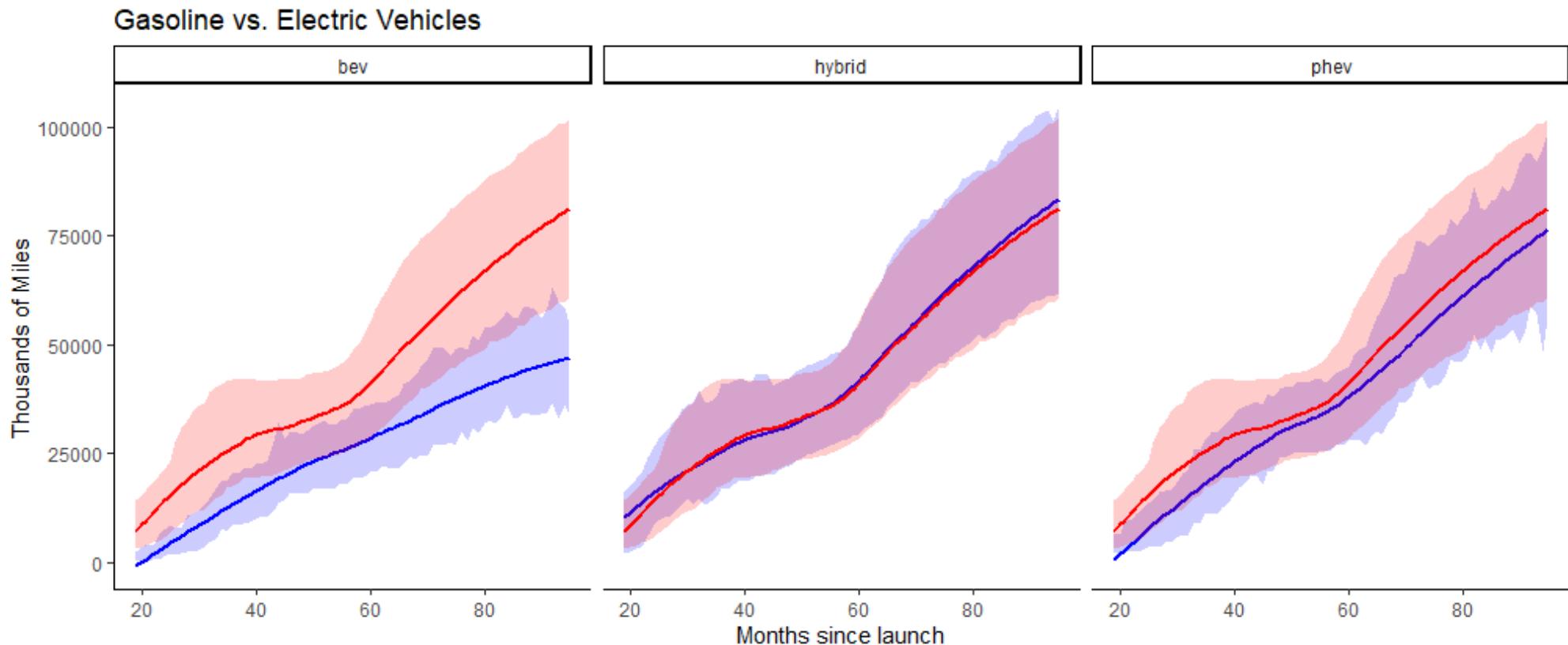


EVs are disproportionately supplied to ZEV states



Do EV owners drive as much as gasoline car owners?

John P. Helveston, Assistant Professor, EMSE
Eliese Ottinger, Undergraduate Student, EMSE



Thanks!

Slides: <https://github.com/jhelvy/research>

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