Across Early Policy and Market Contexts Women and Men Show Similar Interest in Electric Vehicles

NCST Research Report by

Koral Buch

Kenneth S. Kurani

STEPS+ Seminar, Winter 2021

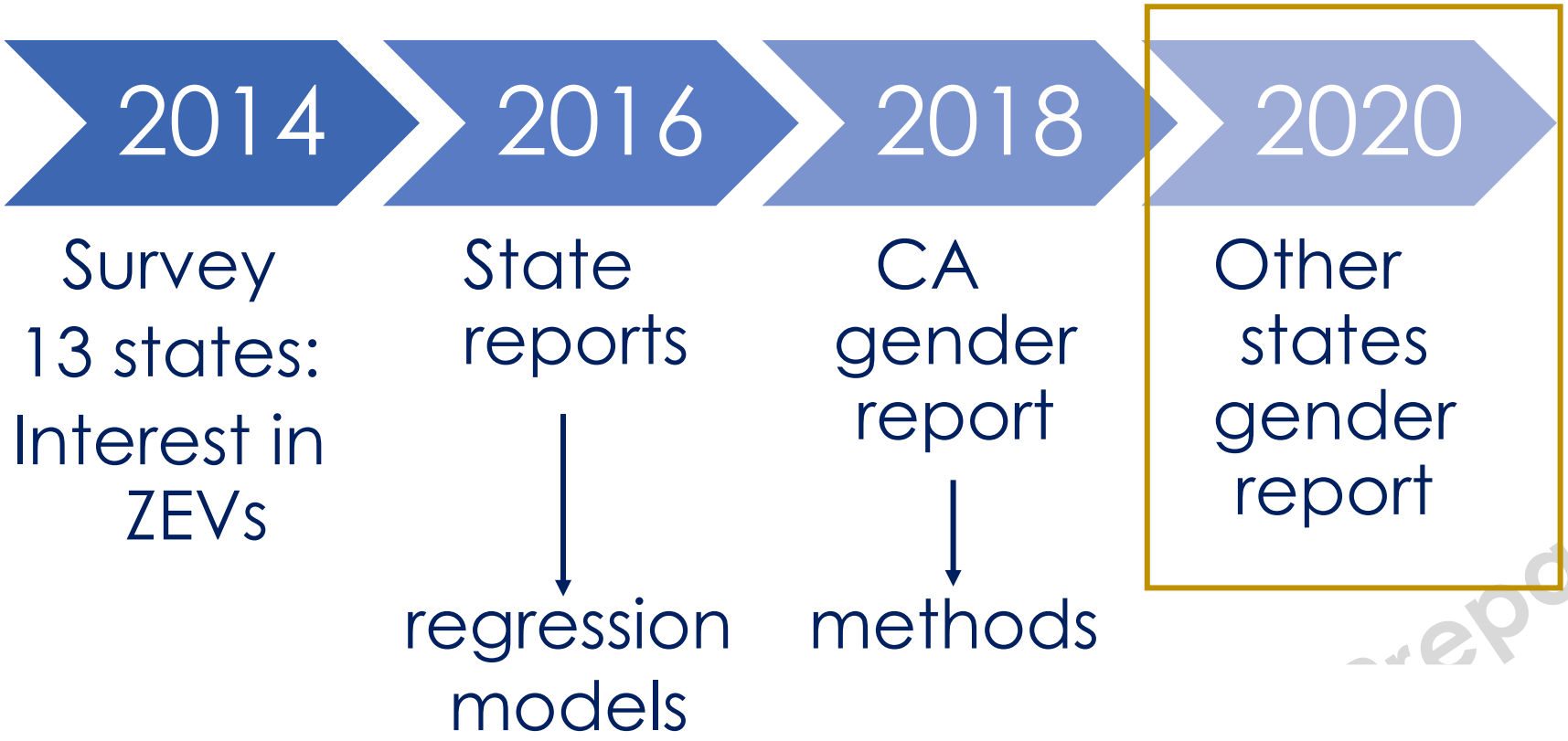
UCDAVIS

PLUG-IN HYBRID & ELECTRIC VEHICLE RESEARCH CENTER

of the Institute of Transportation Studies

Prepared by Koral Buch

Project Timeline

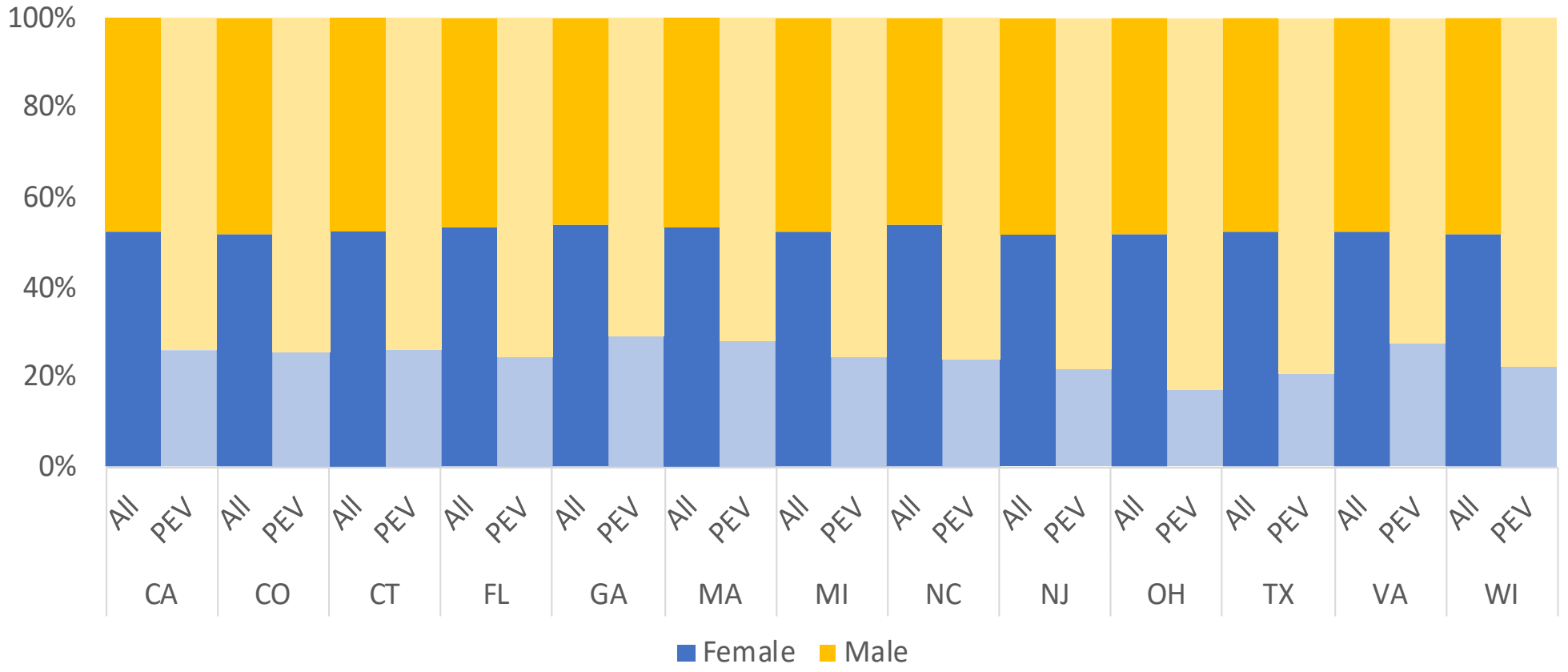


Outline

- Motivation: What is the gender split in the PEV market?
- Methods: How to analyze the differences between women and men regarding PEVs?
- Results: Do women and men differ in their interest in PEVs?

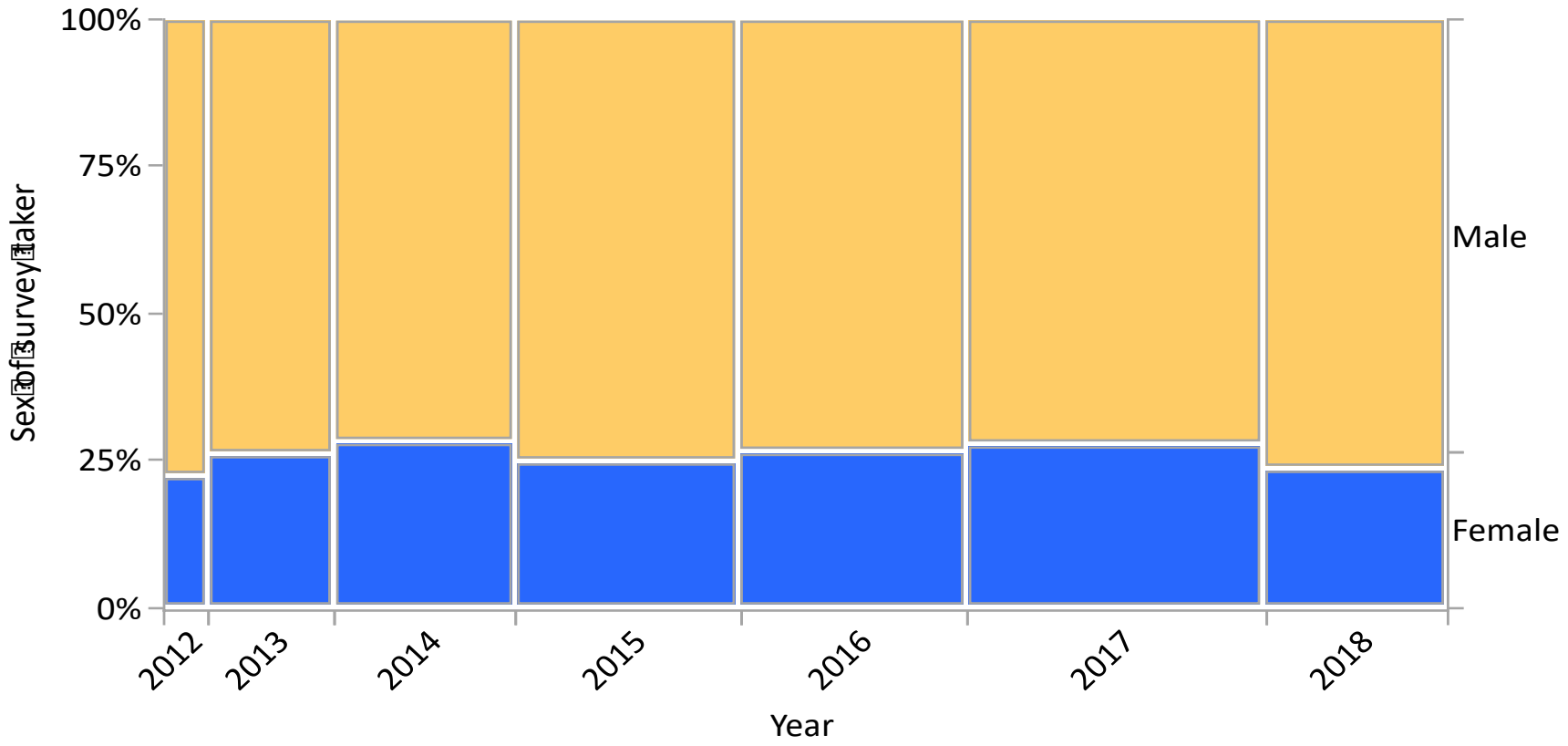
Motivation

New registered vehicles in 2017 and early-2018 in selected states



Motivation

California registered PEV by gender



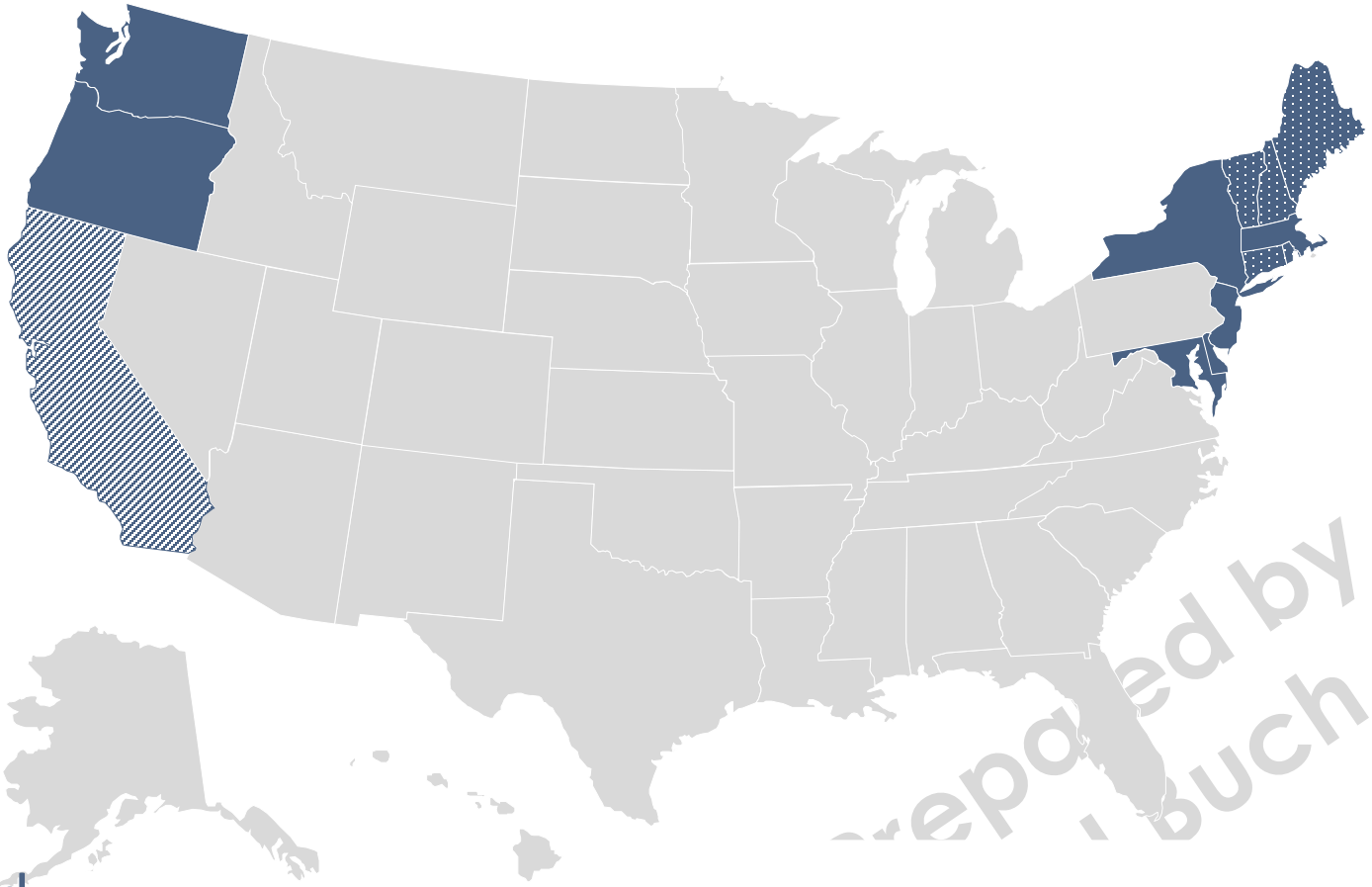
Lee, J.H. et al., 2019, Who is buying electric vehicles in California? Characterising early adopter heterogeneity and forecasting market diffusion

Outline

- Motivation: What is the gender split in the PEV market?
- Methods: How to analyze the differences between women and men regarding PEVs?
- Results: Do women and men differ in their interest in PEVs?

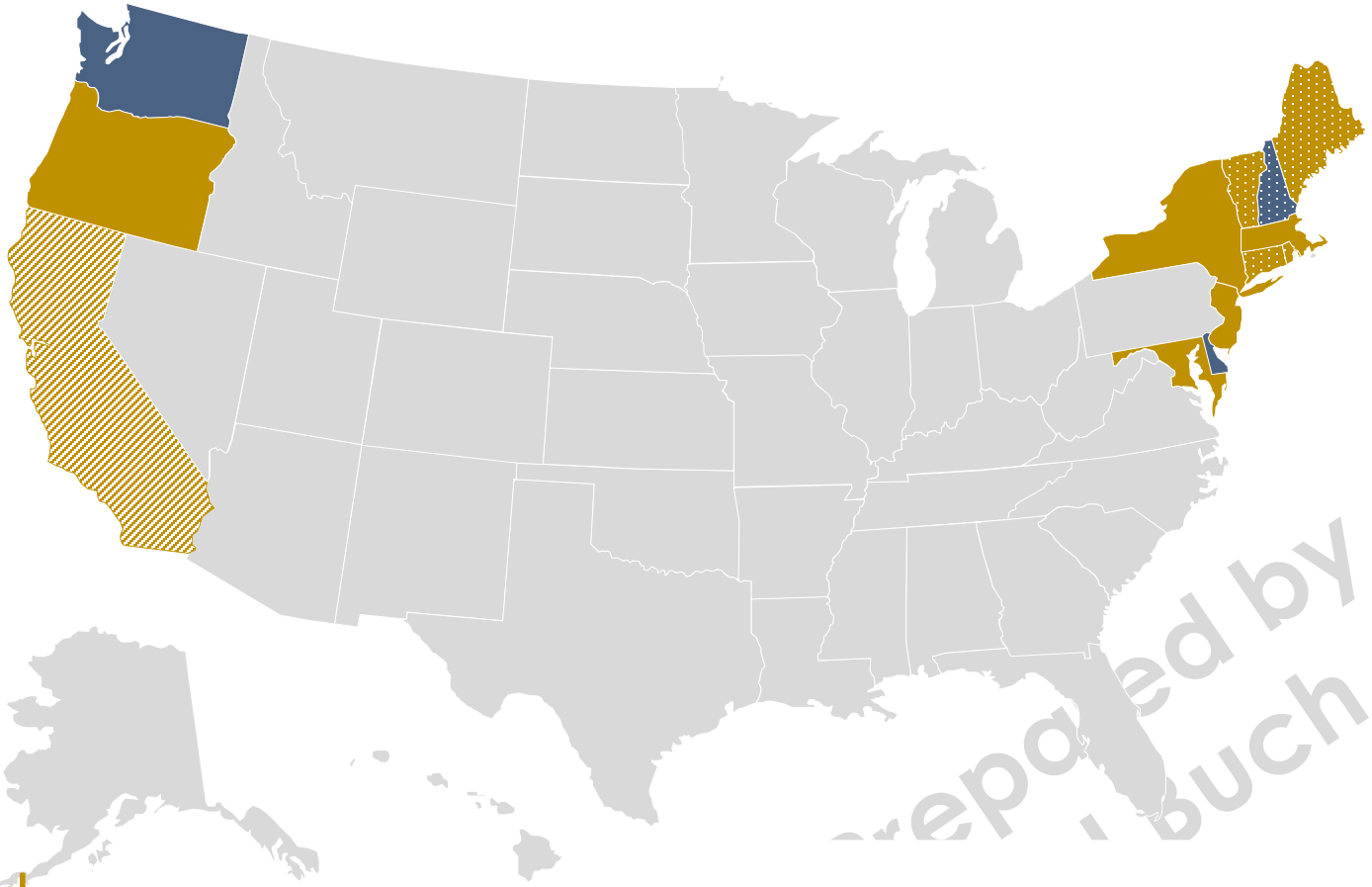
Analysis Scope

- California (CA)
- Oregon (OR)
- Washington (WA)
- Delaware (DE)
- Maryland (MD)
- Massachusetts (MA)
- New Jersey (NJ)
- New York (NY)
- NESCAUM (Connecticut, Maine, New Hampshire, Rhode Island, Vermont + MA, NJ, NY)



Policy Context: ZEV Mandate (1990)

- California (CA)
- Oregon (OR)
- Washington (WA)
- Delaware (DE)
- Maryland (MD)
- Massachusetts (MA)
- New Jersey (NJ)
- New York (NY)
- NESCAUM (Connecticut, Maine, New Hampshire, Rhode Island, Vermont + MA, NJ, NY)



Policy Context: Other

- **CA:** HOV lane exemption, The Clean Vehicle Rebate Project
- **OR:** Residential Energy Tax Credits (for infrastructure)
- **WA:** Motor vehicle sales and use tax exemption
- **DE:** Low Emission Vehicle Program
- **MD:** HOV lane exemption, PEV tax credit
- **MA:** Massachusetts Offers Rebates for Electric Vehicles (MOR-EV)
- **NJ:** Vehicle Toll Incentive
- **NY:** HOV lane exemption, E-ZPass discount
- **Vermont (NESCAUM):** Drive Electric Vermont purchase incentive
- And more…

Data

- On-line survey
- December 2014 - January 2015
- New-car buying households

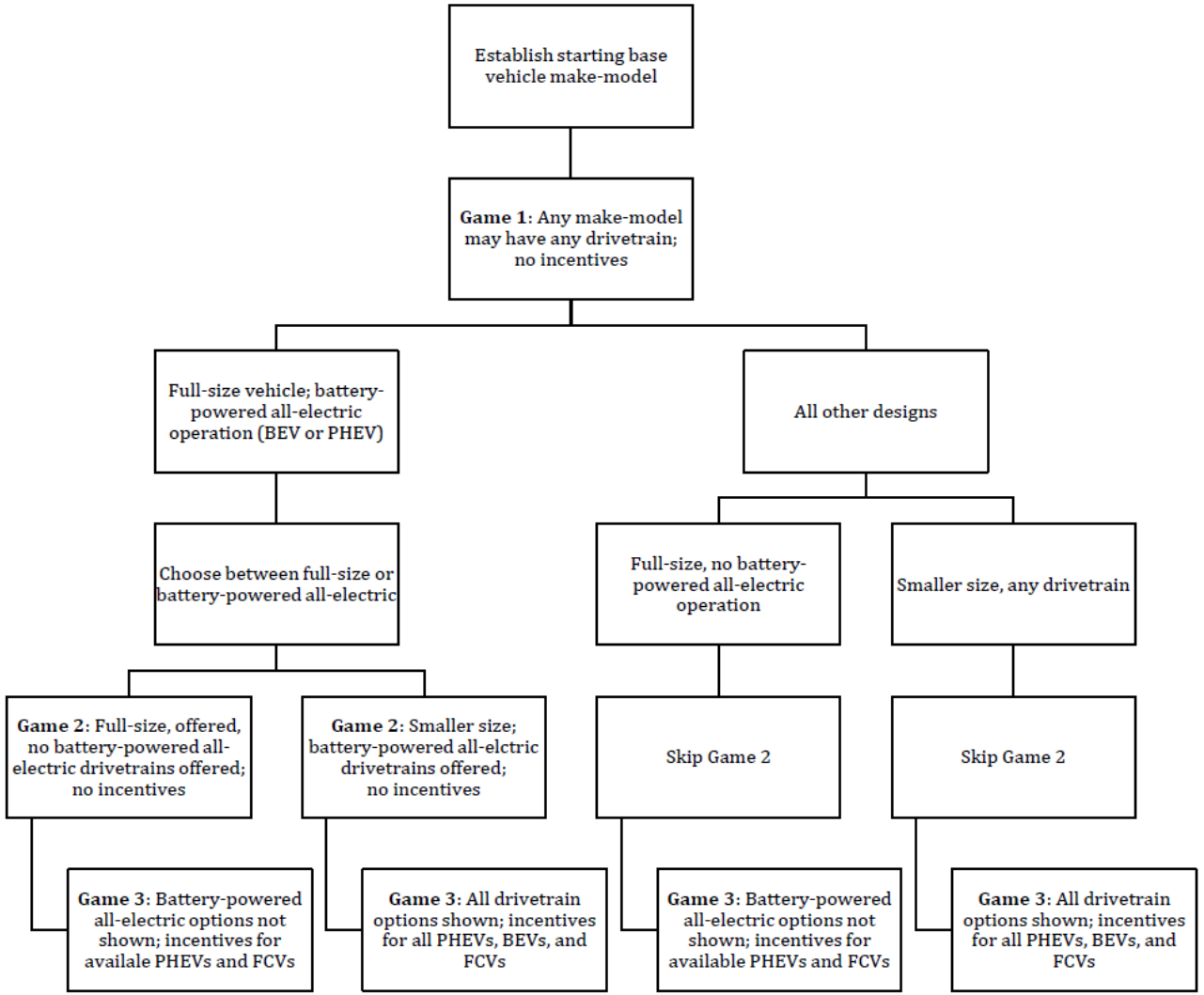
- Socio-economic and demographic data
- Household travel characteristics
- Awareness, knowledge, experience with ZEV
- Environmental beliefs
- **A series of vehicle design games**
- **Motivations for design choice**

Data: Vehicle Design Games

- Make and model
- Body type
- Price
- Fuel economy

- Drivetrain type (ICEV, HEV, PHEV, BEV, or FCEV)
- ZEV: driving range, charging location

Data: Vehicle Design Games



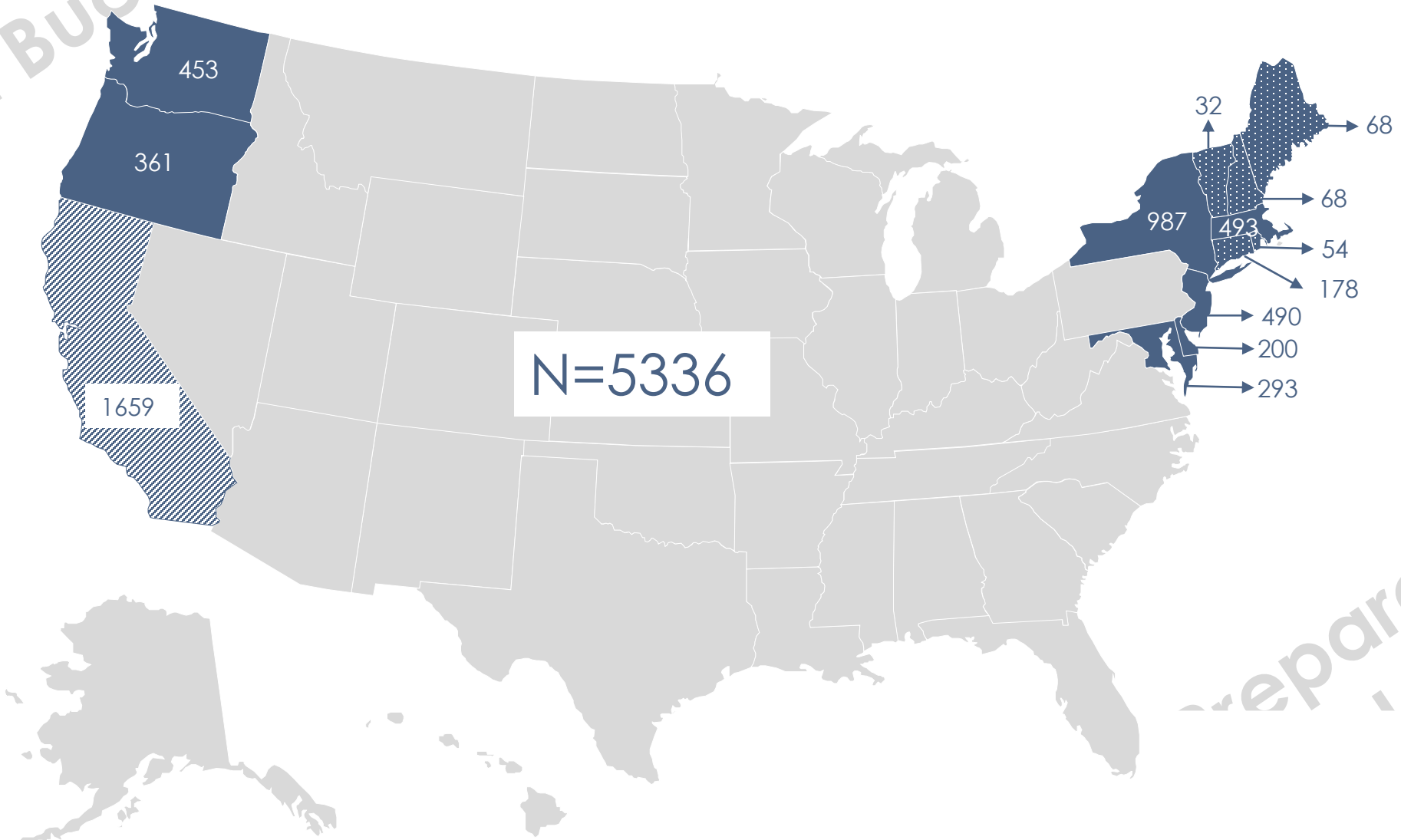
Data: Motivations

5	4	3	2	1	0
Highest importance	High importance	Moderate importance	Low importance	Very low importance	Absolutely no import.

FOR
Fuel cost
ZEV technology
Climate change
Air quality
Oil imports to US
Withhold money from oil producers
Fun to drive
Safety compared to ICEVs
Home charge convenience
Maintenance cost
Vehicle appearance
Lifestyle fit
Purchase cost
Comfortable
Incentives
Impression on peers

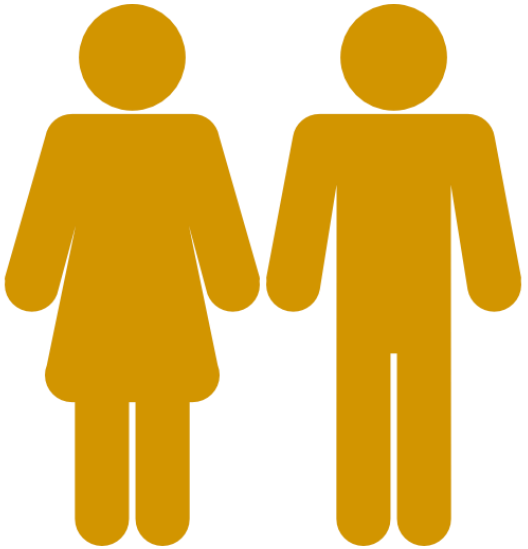
AGAINST
Limited charging network
Purchase cost
Unfamiliar technology
Electricity supply
Range
Charging duration
No home charging
Maintenance cost
Technology unreliable
Battery concerns
Charging cost
Higher incentives
Vehicle safety
Lifestyle (mis)fit
Vehicle appearance
Charging safety
Environmental concerns
Impression on peers

Data: Sample Size



Research Questions

1. Is the interest in ZEV among genders similar?
2. Are the motivations for or against ZEV differ among genders?



Methods Q1

1. Is the interest in ZEV among genders similar?
   - Design game results
   - Nominal logistic regression models
   - Alternative models
2. Are the motivations for or against ZEV differ among genders?
   - Motivation score results
   - One-way ANOVA

Methods Q1: Logistic Regression Model

Dependent variable

ICEV	HEV	PHEV	BEV	FCEV

Independent variable categories

Socio-economic and demographic	Household travel characteristics	Experience with ZEV	Environmental beliefs

Methods Q1: Alternative Models

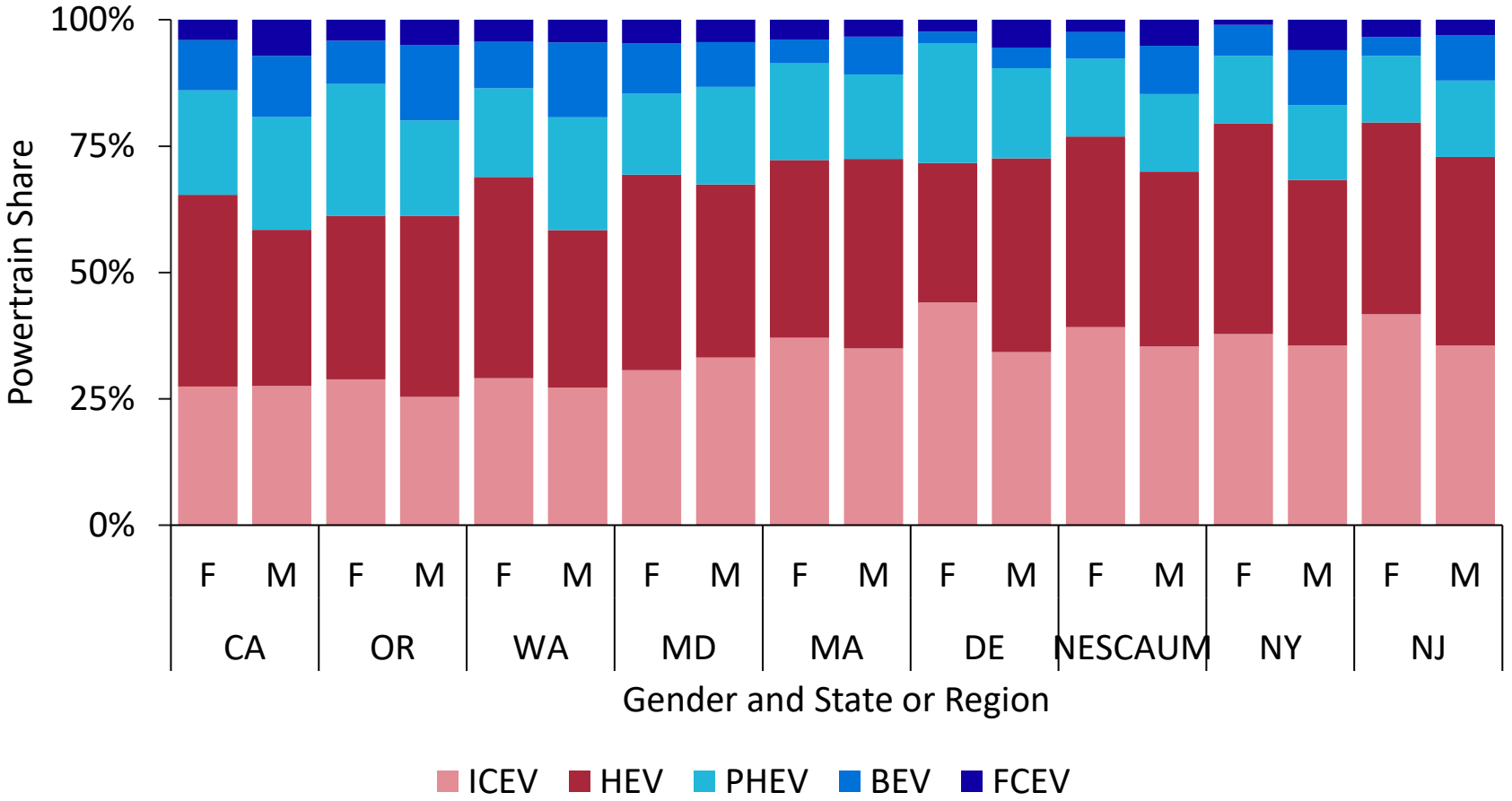
Past logistic regression model ✚ Sex identifier variable ✚ Interaction term: Sex identifier × explanatory variable

Model performance

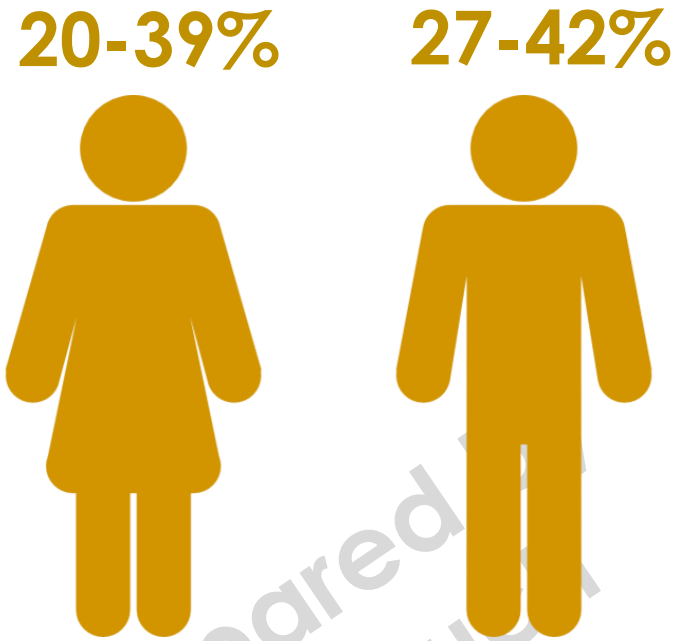
R^2 ⇧ AIC_c ⇩ BIC ⇩

Results Q1: Design Games

Drivetrain types from design games by gender and state



Designed a ZEV:



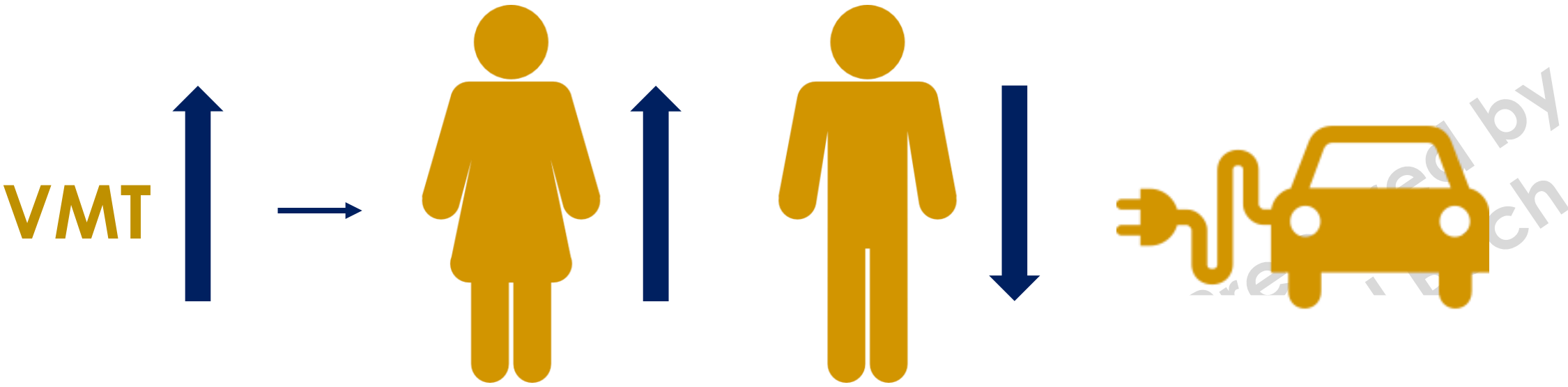
Results Q1: California

"...**female** and **male** respondents [in California] share **similar** distributions of **interest** in the next new vehicle for their household being a plug-in electric vehicle (**PEV**) or fuel cell electric vehicle (**FCEV**)."

Kurani, K.S. et al., 2017, "Are we Hardwiring Gender Differences into the Market for Plug-in Electric Vehicles?"

Results Q1: New York

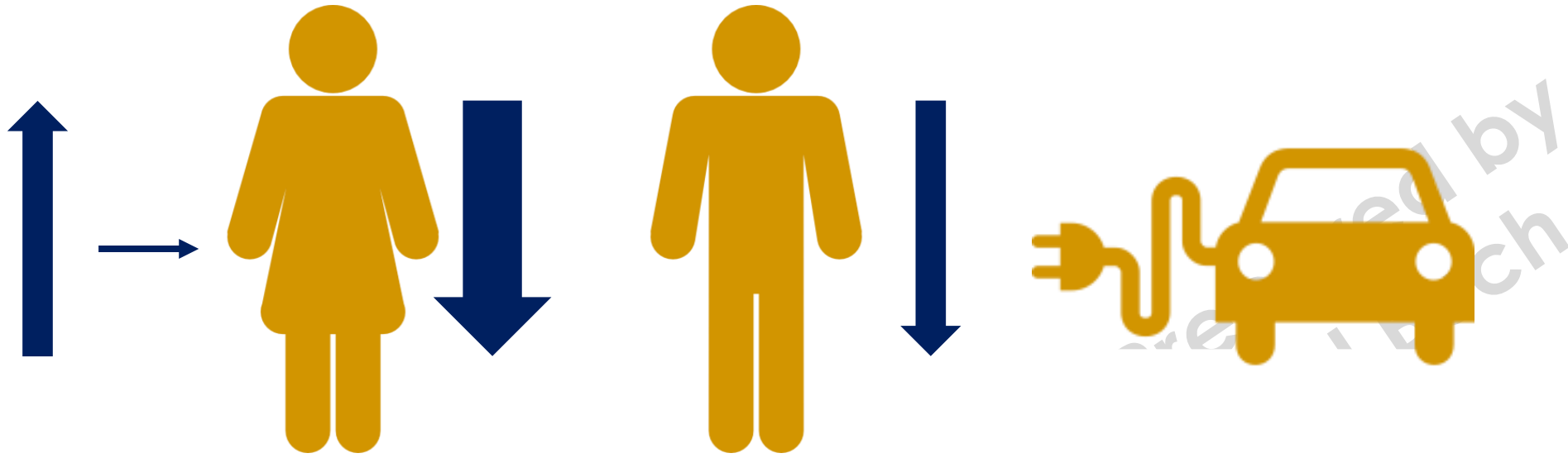
Past logistic regression model + Sex identifier Variable* + Interaction term: Sex identifier × Monthly VMT



Results Q1: NESCAUM

Past logistic regression model + Sex identifier Variable* + Interaction term: Sex identifier × ICEV vs. PEV safety score

ICEV vs. PEV safety score



Methods Q2

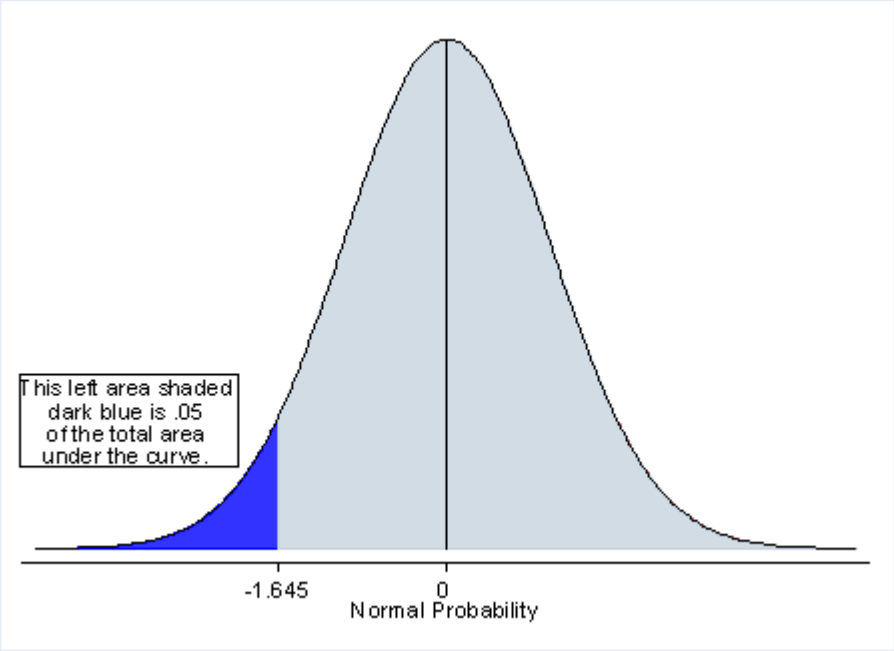
1. Is the interest in ZEV among genders similar?
   - Design game results
   - Nominal logistic regression modeling
   - Alternative models
2. Are the motivations for or against ZEV differ among genders?
   - Motivation score results
   - One-way ANOVA

Methods Q2: One-Way ANOVA

H_0: mean female = mean male

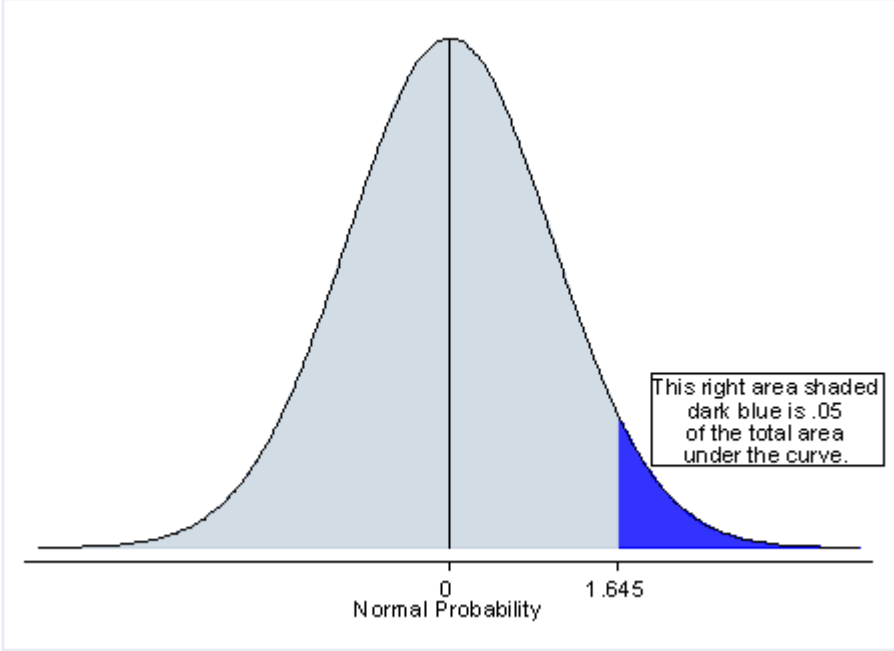
mean score female is statistically significantly higher

$(P < t) \leq 0.05$



mean score male is statistically significantly higher

$(P > t) \leq 0.05$



Results Q2: Motivations

Mean of FOR ZEV motivations

	CA		DE		MA		MD		NESCAUM		NJ		NY		OR		WA		Global
	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	Mean
Fuel cost	3.0	3.0	3.0	2.5	3.2	3.0	3.2	2.5	3.1	2.8	3.4	3.0	2.8	2.7	3.7	3.1	3.3	3.0	3.0
ZEV technology	2.3	2.6	2.3	2.6	2.6	2.5	2.3	2.8	2.2	2.7	2.1	3.0	2.2	2.8	2.0	2.7	2.5	2.5	2.5
Climate change	2.1	1.7	2.0	1.4	2.1	1.8	2.3	1.7	1.9	1.7	2.2	1.9	1.8	1.4	2.4	1.8	2.1	1.9	1.9
Air quality	2.2	1.6	1.5	1.7	2.3	1.7	1.9	1.5	1.9	1.7	2.3	1.9	1.6	1.6	2.3	1.9	2.2	1.9	1.9
Oil imports to US	1.7	1.4	1.4	1.9	1.9	1.6	1.3	1.2	1.7	1.5	1.8	1.3	1.5	1.5	1.9	1.7	1.7	1.5	1.6
Withhold money from oil producers	1.6	1.4	1.2	1.6	2.0	1.7	1.4	1.3	1.7	1.4	2.3	1.7	1.4	1.2	1.8	1.7	1.6	1.5	1.6
Fun to drive	1.4	1.7	1.3	1.8	1.3	1.6	1.5	1.6	1.4	1.7	1.4	2.1	1.5	1.6	1.2	1.6	1.7	1.7	1.5
Safety compared to ICEVs	1.4	1.7	1.6	1.6	1.5	1.7	1.4	1.7	1.6	1.5	1.8	1.5	1.7	1.5	1.1	1.4	1.3	1.0	1.5
Home charge convenience	1.3	1.4	1.7	1.6	1.4	1.2	1.5	1.8	1.3	1.4	1.6	1.7	1.1	1.4	1.5	1.6	1.3	1.7	1.5
Maintenance cost	1.0	1.2	1.2	1.2	1.3	1.3	1.1	1.0	1.2	1.2	1.1	1.2	1.2	1.2	1.1	1.1	1.1	1.3	1.2
Vehicle appearance	1.1	1.3	0.9	1.0	1.1	1.3	0.9	0.8	1.1	1.2	1.0	1.5	1.3	1.1	1.0	1.0	1.0	1.2	1.1
Lifestyle fit	1.2	1.2	1.0	0.9	1.0	1.1	1.1	1.0	1.1	1.1	0.7	1.1	1.3	1.2	1.0	1.3	1.1	1.6	1.1
Purchase cost	0.9	0.9	1.4	1.1	1.0	1.3	1.2	1.5	1.1	1.1	1.1	0.9	1.2	1.1	0.8	0.9	1.1	0.8	1.1
Comfortable	1.0	1.1	0.9	1.0	0.8	1.4	0.8	1.0	1.0	1.1	0.9	0.9	1.2	1.2	0.5	1.0	0.7	0.9	1.0
Incentives	1.0	1.0	1.3	1.0	1.0	1.1	0.9	1.1	0.9	1.0	0.9	1.1	0.7	1.1	0.8	0.6	0.7	1.1	1.0
Impression on peers	0.7	0.8	0.9	0.6	0.8	1.0	0.6	0.9	0.8	0.9	0.8	0.9	0.7	1.0	0.8	0.7	0.8	0.6	0.8

Results Q2: One-Way ANOVA

Statistical significance of differences
Mean of FOR ZEV motivations

Motivation for Designing and Selecting a ZEV:	p-value of test for difference between mean score for female and male participants									Global Mean Score
	CA	DE	MA	MD	NES	NJ	NY	OR	WA	
Fuel cost				0.03	0.04			0.02		3.0
ZEV technology	0.04				0.00	0.01	0.02	0.00		2.5
Climate change	0.01			0.03			0.03	0.04		1.9
Air quality	0.00							0.05		1.9
Oil imports to US	0.02									1.6
Withhold money from oil producers					0.02					1.6
Fun to drive	0.02				0.01	0.02				1.5
Safety compared to ICEVs	0.02									1.5
Home charge convenience										1.5
Maintenance cost	0.04									1.2
Vehicle appearance										1.1
Lifestyle fit									0.03	1.1
Purchase cost										1.1
Comfortable			0.03					0.02		1.0
Incentives							0.04		0.04	1.0
Impression on peers							0.05			0.8

Female

Male

Results Q2: Motivations

Mean of AGAINST ZEV motivations

	CA		DE		MA		MD		NESCAUM		NJ		NY		OR		WA		Global
	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	Mean
Limited charging network	2.7	2.6	3.2	2.9	3.2	2.9	2.5	2.6	2.8	2.8	2.9	2.8	2.8	2.9	2.5	2.7	2.5	2.5	2.8
Purchase cost	2.2	2.3	1.9	2.8	2.1	2.3	2.3	2.4	2.1	2.1	2.1	2.2	2.3	2.1	2.4	2.5	1.9	2.1	2.2
Unfamiliar technology	2.1	1.6	2.4	2.1	2.4	2.1	2.1	1.6	2.3	1.9	2.4	1.9	2.3	2.1	1.9	1.7	1.9	1.8	2.0
Electricity supply	1.7	1.4	2.0	2.0	2.0	2.0	1.9	1.7	2.0	1.8	1.9	1.9	2.2	2.0	1.7	1.4	1.7	1.1	1.8
Range	1.7	2.2	1.4	1.9	1.6	1.9	1.4	2.1	1.7	1.8	1.8	1.7	1.7	1.8	1.8	1.8	1.6	2.1	1.8
Charging duration	1.4	1.5	1.5	1.1	1.4	1.6	1.4	1.3	1.5	1.6	1.5	1.5	1.7	1.7	1.1	1.4	1.3	1.7	1.5
No home charging	1.7	1.4	1.6	1.6	1.6	1.6	1.6	1.7	1.6	1.4	1.7	1.3	1.6	1.6	1.2	1.0	1.2	0.7	1.4
Maintenance cost	1.3	1.3	1.5	1.4	1.5	1.2	1.5	0.9	1.3	1.2	1.1	1.3	1.3	1.1	1.5	1.1	1.4	1.3	1.3
Technology unreliable	0.9	1.1	0.8	1.2	0.8	1.3	0.7	0.9	0.9	1.1	0.9	0.9	1.1	1.1	1.0	1.4	0.9	1.2	1.0
Battery concerns	1.0	1.2	0.8	1.2	0.9	1.1	1.0	1.2	0.9	1.0	0.9	1.0	0.9	0.9	1.1	1.1	1.0	1.0	1.0
Charging cost	1.2	0.9	1.3	0.7	1.0	0.8	1.0	0.9	1.0	1.0	0.8	1.1	1.2	1.0	1.1	1.1	1.1	0.4	1.0
Higher incentives	1.0	1.0	1.3	1.0	1.0	1.1	0.8	1.1	0.9	1.0	0.9	1.1	0.8	1.1	0.8	0.6	0.6	1.1	1.0
Vehicle safety	1.0	0.9	1.2	0.5	1.2	0.5	1.1	0.7	0.9	0.9	1.0	0.9	0.8	0.9	1.0	0.7	0.9	0.9	0.9
Lifestyle (mis)fit	0.6	0.7	0.5	0.9	0.7	0.8	0.4	0.7	0.7	0.8	0.7	0.7	0.6	0.7	0.7	0.8	0.7	0.6	0.7
Vehicle appearance	0.6	0.5	0.8	0.6	0.8	0.6	0.4	0.6	0.5	0.5	0.4	0.5	0.3	0.5	0.7	0.4	0.4	0.5	0.5
Charging safety	0.5	0.3	0.4	0.4	0.6	0.3	0.5	0.4	0.5	0.4	0.5	0.5	1.2	0.6	0.4	0.3	0.3	0.3	0.5
Environmental concerns	0.4	0.4	0.2	0.1	0.4	0.2	0.3	0.2	0.2	0.3	0.1	0.3	0.2	0.3	0.3	0.3	0.2	0.2	0.3
Impression on peers	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.3	0.2	0.4	0.2	0.2	0.3	0.2	0.2	0.1	0.2

Results Q2: One-Way ANOVA

Statistical significance of differences
Mean of AGAINST ZEV motivations

Motivation against Designing and Selecting a ZEV:	p-value of test for difference between mean score for female and male participants									Global Mean Score
	CA	DE	MA	MD	NES	NJ	NY	OR	WA	
Limited charging network										2.8
Purchase cost		0.02								2.2
Unfamiliar technology	0.00				0.00	0.01				2.0
Electricity supply	0.03				0.03				0.01	1.8
Range	0.00			0.01					0.02	1.8
Charging duration									0.04	1.5
No home charging	0.02								0.01	1.4
Maintenance cost				0.01			0.05			1.3
Technology unreliable			0.01					0.04		1.0
Battery concerns	0.02									1.0
Charging cost	0.03	0.03							0.00	1.0
Higher incentives									0.01	1.0
Vehicle safety		0.01	0.01	0.02						0.9
Lifestyle (mis)fit	0.05			0.02						0.7
Vehicle appearance							0.02			0.5
Charging safety	0.02		0.01							0.5
Environmental concerns						0.05				0.3
Impression on peers					0.01	0.05				0.2

Female

Male

Conclusions

- Motivation: What is the gender split in the PEV market?

  Women registered only 25% of the new PEVs

- Methods: How to analyze the differences between women and men regarding PEVs?

- Results: Do women and men differ in their interest in PEVs?

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Koral Buch // kbuch@ucdavis.edu
Kenneth S. Kurani // knkurani@ucdavis.edu

Thank you!

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of the Institute of Transportation Studies