What is the role of infrastructure in engaging car buyers?

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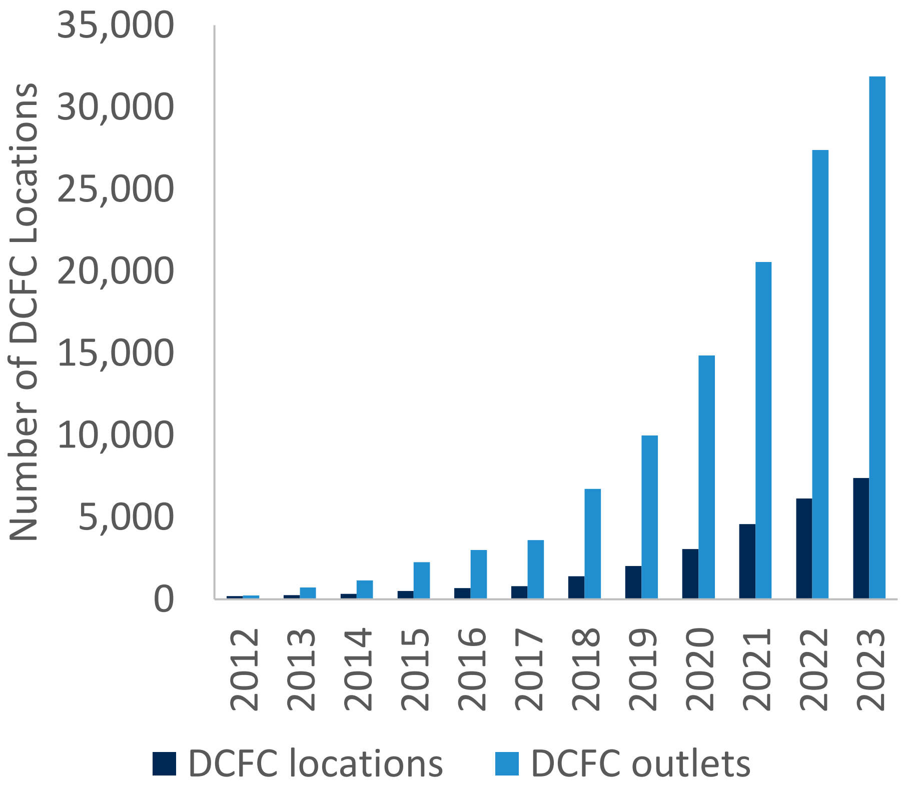
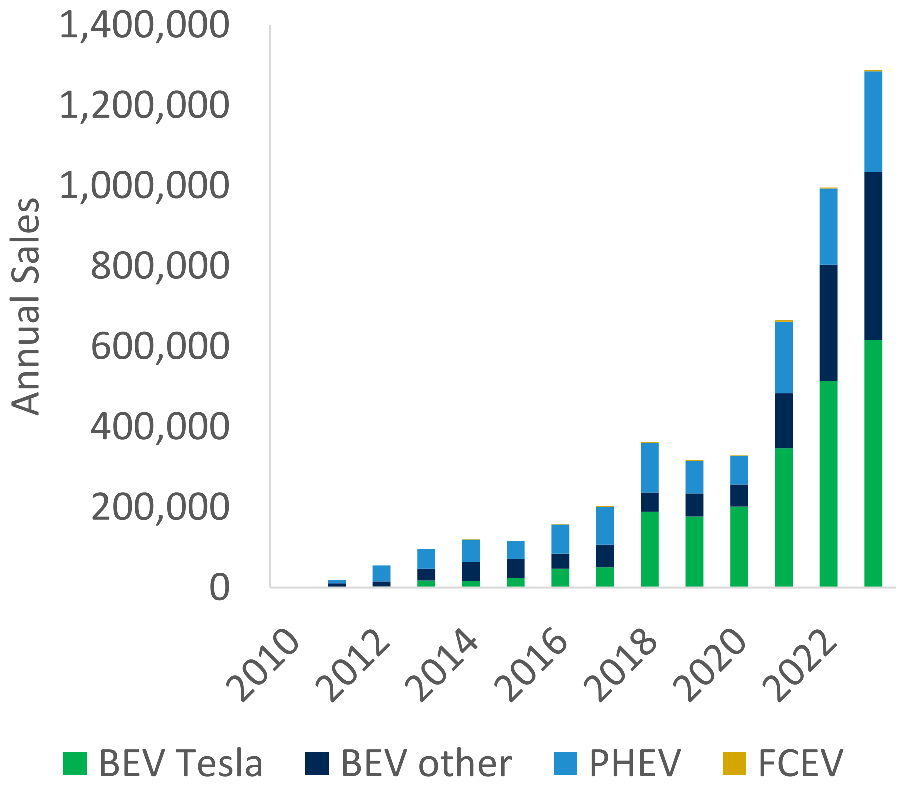
EV Infrastructure and EV sales





It is often assumed that infrastructure increases EV sales

Most studies on EV charging and EV sales are correlational

- Few papers meet all four requirements to detect a causal relationship
    - Statistically significant relationship
    - Logical explanation for the cause and effect
    - Relationship cannot be attributed to another variable
    - Time precedence (cause precedes effect)

      (e.g. see Mokhtarian and Cao 2008)
- Two studies that find a significant causal relationship:
    - Li et al. (2017), EV sales and EV infrastructure, 2011-2013
    - Narassimhan and Johnson (2018), EV sales and EV infrastructure, 2008-2016

Substantial investments in infrastructure

Infrastructure Spending:

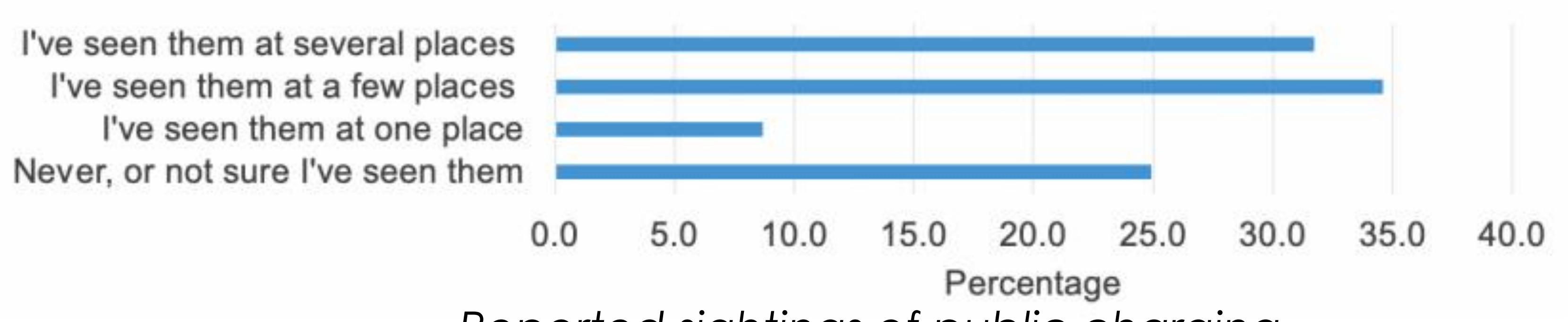
- U.S. Department of Transportation- $5 billion over 5-years
- California previously spent or committed $1 billion (CPUC, 2019; CEC, 2021)
- California committed another $2.9 billion in 2022 (CEC , 2023)
- The California Public Utilities Commission (CPUC) has authorized utilities spend $738 million over a 5-years
- $800 million from Electrify America in California

Research questions

- Does more EV charging infrastructure:
  - Increase non-EV owners reports of seeing EV charging infrastructure?
  - Increase non-EV owners consideration to purchase an EV?
- When people do see infrastructure does that increase consideration to purchase an EV?

Data

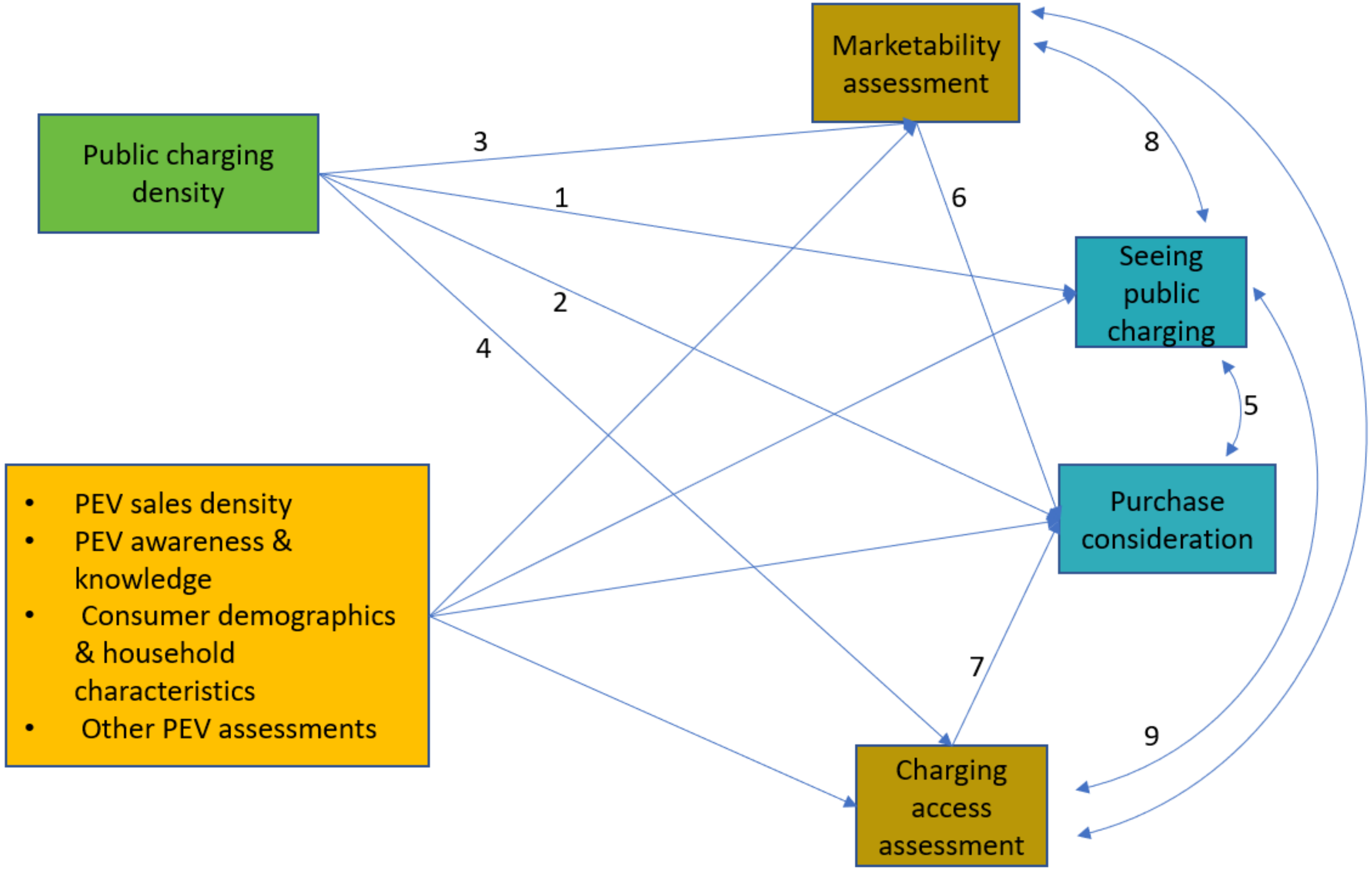
- 2021 Survey of 3000 car owning households in California:
  - EV purchase consideration
  - Awareness of public charging
  - Awareness, knowledge, and assessments of EVs
  - Demographics
- Density of public EV charging and EV registrations where they live and work



Reported sightings of public charging

Structural Equation Model Framework

- Allows for the simultaneous estimation of parameters of interconnected equations
- Variables capable of being both independent and dependent
- Capable of estimating both direct and indirect effects



Results

- No *direct or indirect* relationship between charging density and seeing charging, EV purchase consideration, or assessments of EV marketability and charging access
- No direct relationship between seeing public charging and EV purchase consideration
- There is an *indirect** effect of seeing public charging and EV consideration.
    - The positive relationship between seeing public charging and EV consideration exists when we account for assessments of EVs and charging access (measures of engagement)

*mediated by assessment of EV marketability and assessment of charging access

Results

Variables with a positive and significant correlation (notably not including infrastructure)

		BEV (PHEV) purchase consideration	Reporting seeing public charging
Awareness and knowledge:	Advertising awareness		✓
	Incentive awareness	✓	✓
	Able to name a BEV (PHEV)	✓	✓
	Knows how to refuel a BEV (PHEV)		✓
	Convo with BEV (PHEV) owner	✓	
	BEV (PHEV) Familiarity	✓	
	BEV (PHEV) Experience	✓	
Assessments:	BEV (PHEV) safety/reliability	✓	
	BEV (PHEV) Marketability	✓	✓
	BEV (PHEV) Charging access	✓	✓
Socio-demographics:	Being younger	✓	
	Being female		✓
	Using HOV lanes	✓	✓
	Electricity access at the res. Parking spot	✓	✓
	Higher income		✓
	More household vehicles		✓
EV market:	EV sales density		✓

Discussion

- Not much published evidence that infrastructure causes sales of electric vehicles
- No evidence in this analysis to support the idea that more infrastructure:
    - Increases the odds of seeing public charging
    - Improves perceptions/assessments of EVs
    - Or increases consideration to purchase a EV
- Positive assessments of EVs, existing knowledge and awareness of EVs do correlate with seeing charging and consideration

Conclusion

- We need more charging but, developing EV charging isn't itself an engagement strategy
- In situations where there isn't much pushing people towards (e.g. California and Australia) EVs we may need to more actively engage people
- Progress on "big three barriers", but less on EV engagement, knowledge, awareness, etc.
    - $5.5 billion in state spending on charging
    - $0.0025 billion ($2.5 million) in state spending on engagement
- Home charging is important for many reasons

Thanks

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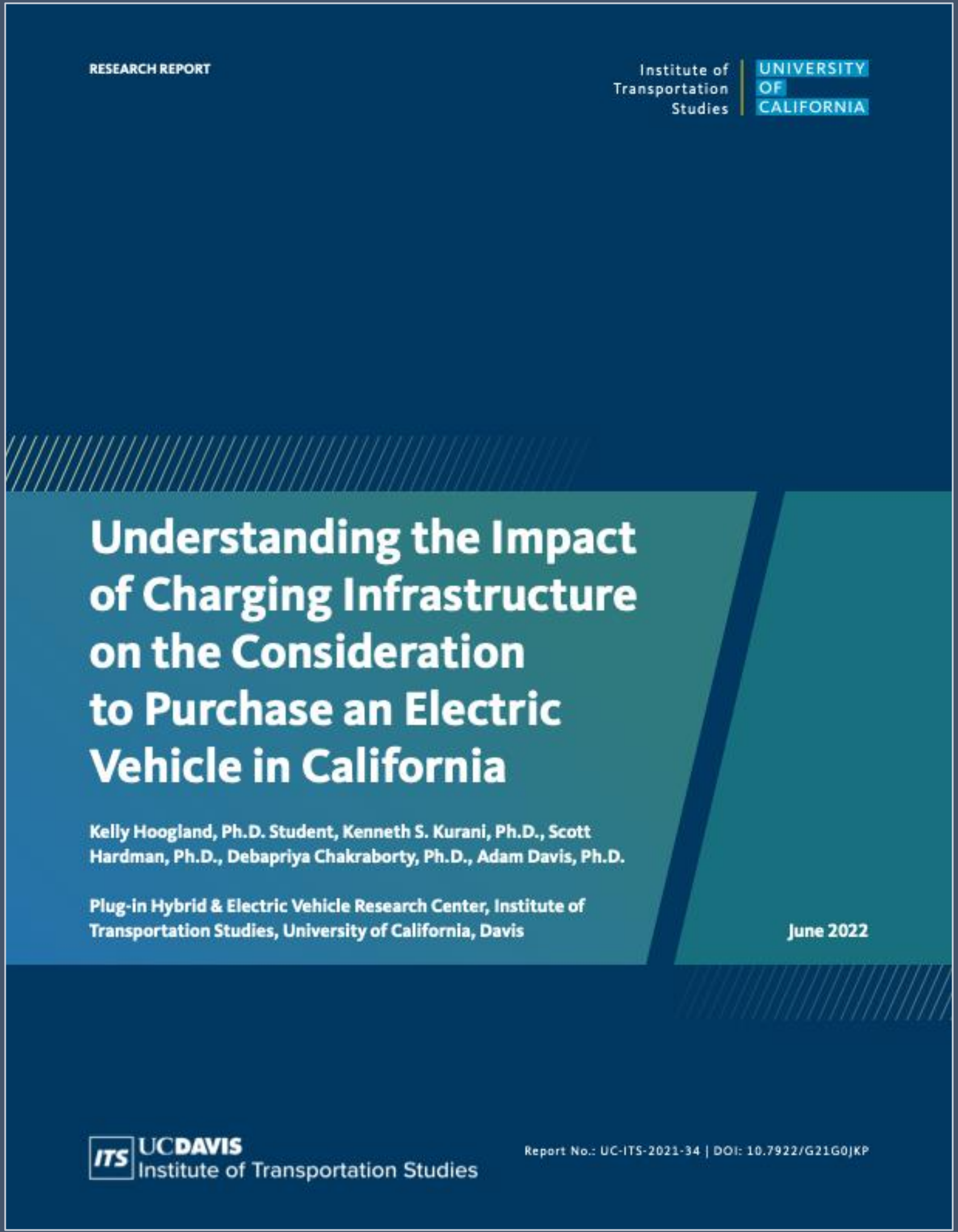
RESEARCH REPORT

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Understanding the Impact of Charging Infrastructure on the Consideration to Purchase an Electric Vehicle in California

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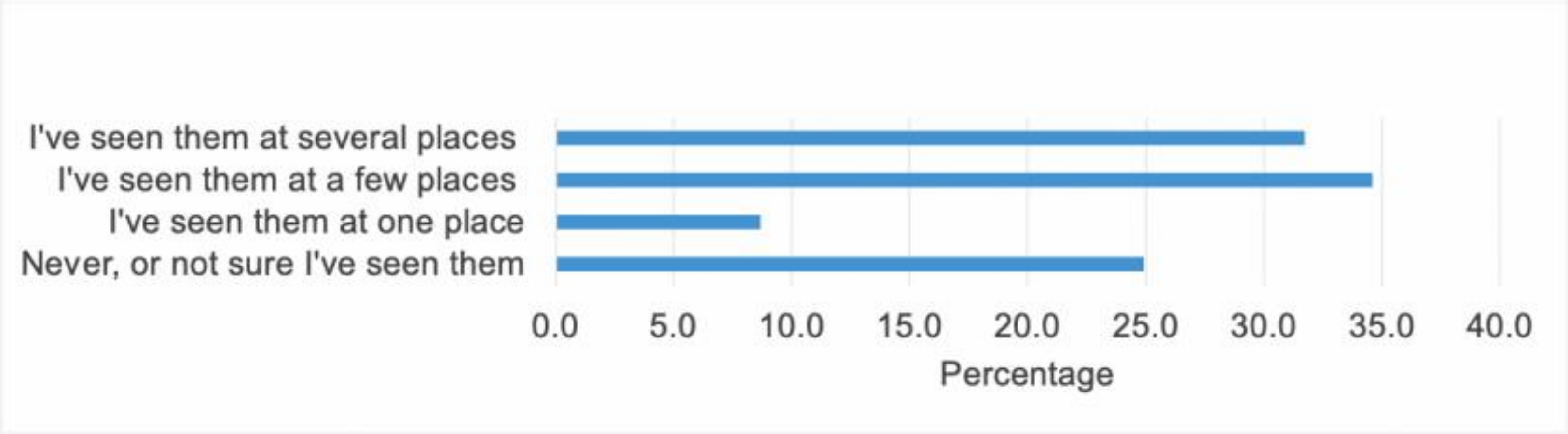


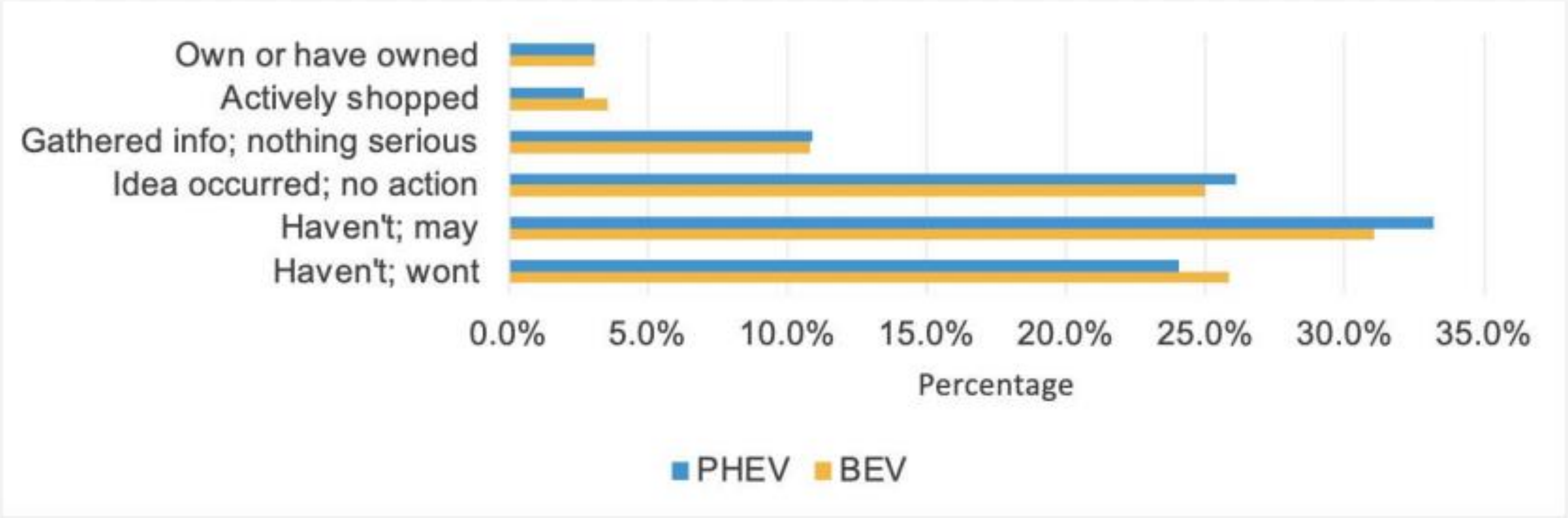


Figure 3. Distribution of BEV and PHEV Consideration: "Have you considered buying an PEV for your household?"

Supplementary material

Table 2. PEV Assessment Factors in the Analysis (Latent variable)

Factor Name	Description	Survey Question	Survey Question Variable Name
BEV (PHEV) Charging Access	Extent to which participants believe they could charge a BEV (PHEV) at home and whether there is enough charging for BEVs (PHEVs)	"My household would be able to plug in a battery electric vehicle to charge at home." "There are enough places to charge battery electric vehicles. "	BEV (PHEV) Plug in at home BEV (PHEV) Enough charging
BEV (PHEV) Safety and Reliability	Safety and reliability of BEVs (PHEVs) compared to conventional gasoline vehicles	"Gasoline powered cars are safer than battery electric vehicles. "Gasoline powered cars are more reliable than battery electric vehicles.	(inverse) BEV (PHEV) gasoline safer (inverse) BEV (PHEV) gasoline more reliable
BEV (PHEV) Marketability	Environmental effects of BEVs (PHEVs) compared to conventional gasoline vehicles and whether BEVs (PHEVs) are ready to be mass marketed.	"Battery electric vehicles are less damaging to the environment than gasoline powered vehicles. "Battery electric vehicle technology is ready for mass automotive markets."	BEV (PHEV) Less damage to environment BEV (PHEV) Mass market
BEV (PHEV) Charging Duration and Range	Perception of charge time and electric range	"It takes too long to charge battery electric vehicles." "Battery electric vehicles do not travel far enough before needing to be charged."	(inverse) BEV (PHEV) range too short (inverse) BEV (PHEV) charging too long
BEV (PHEV) Price	BEV (PHEV) purchase price compared to conventional gasoline vehicles	"Battery electric vehicles cost more to buy than gasoline vehicles."	(inverse) BEV (PHEV) Price

Why would non-EV owners notice chargers?

"Five factors that guide attention in visual search" (Wolfe and Horowitz, 2017):

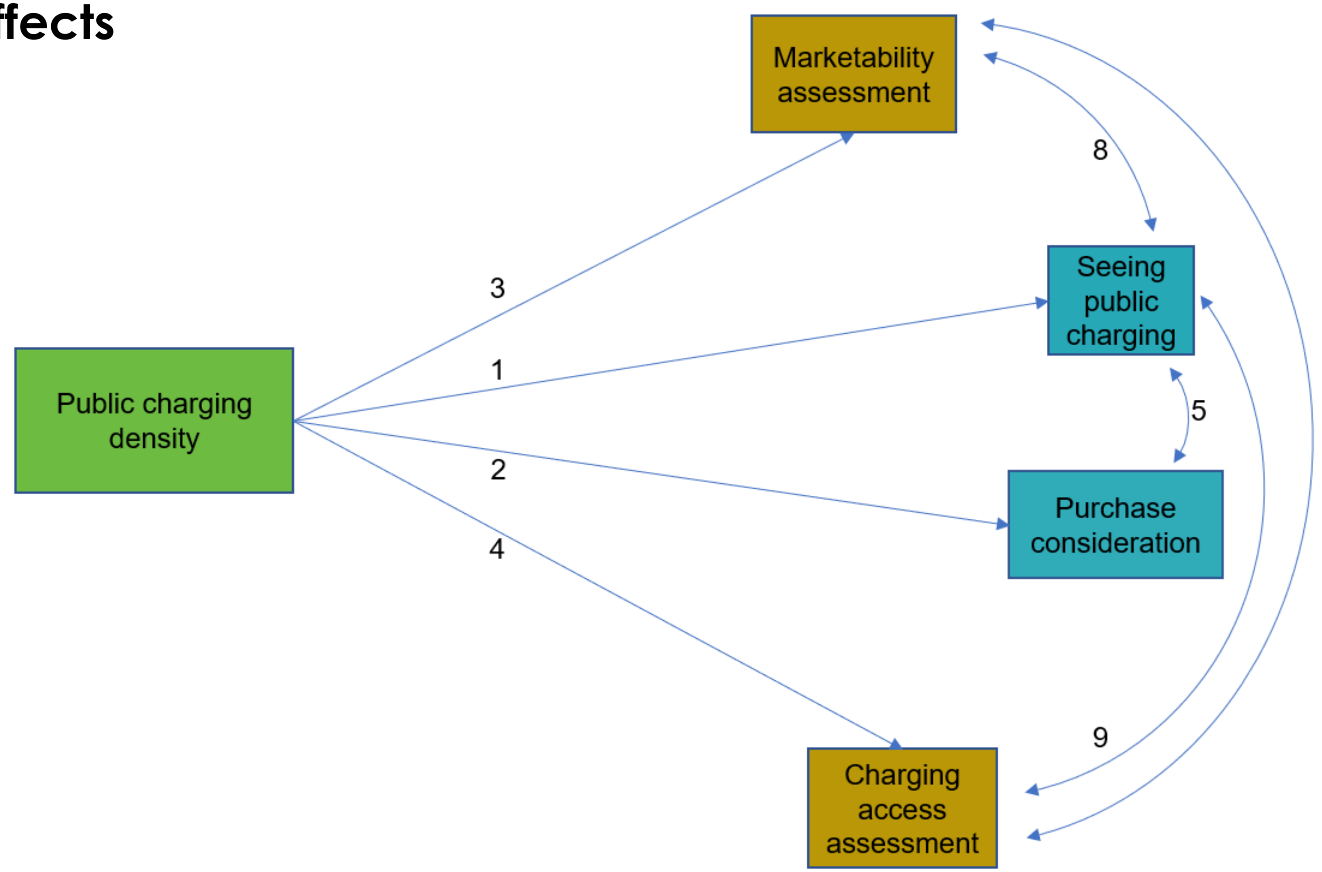
- Bottom-up, guidance driven to the visual properties of the scene (e.g. the existence of chargers)
- **Top-down, user-driven guidance where attention is directed to desired objects (seeing chargers because your are interested in them)**
- Scene guidance, attributes of the scene guide attention to areas likely to contain targets (e.g. looking for chargers in a parking lot)
- Guidance based on the perceived value of the desired object (e.g. looking for a charger because you need to use it)
- Guidance based on the history of prior search (having seen a charger before)

Model Framework

Hypothesis 6 – 7: Public charging indirect effects on seeing public charging:

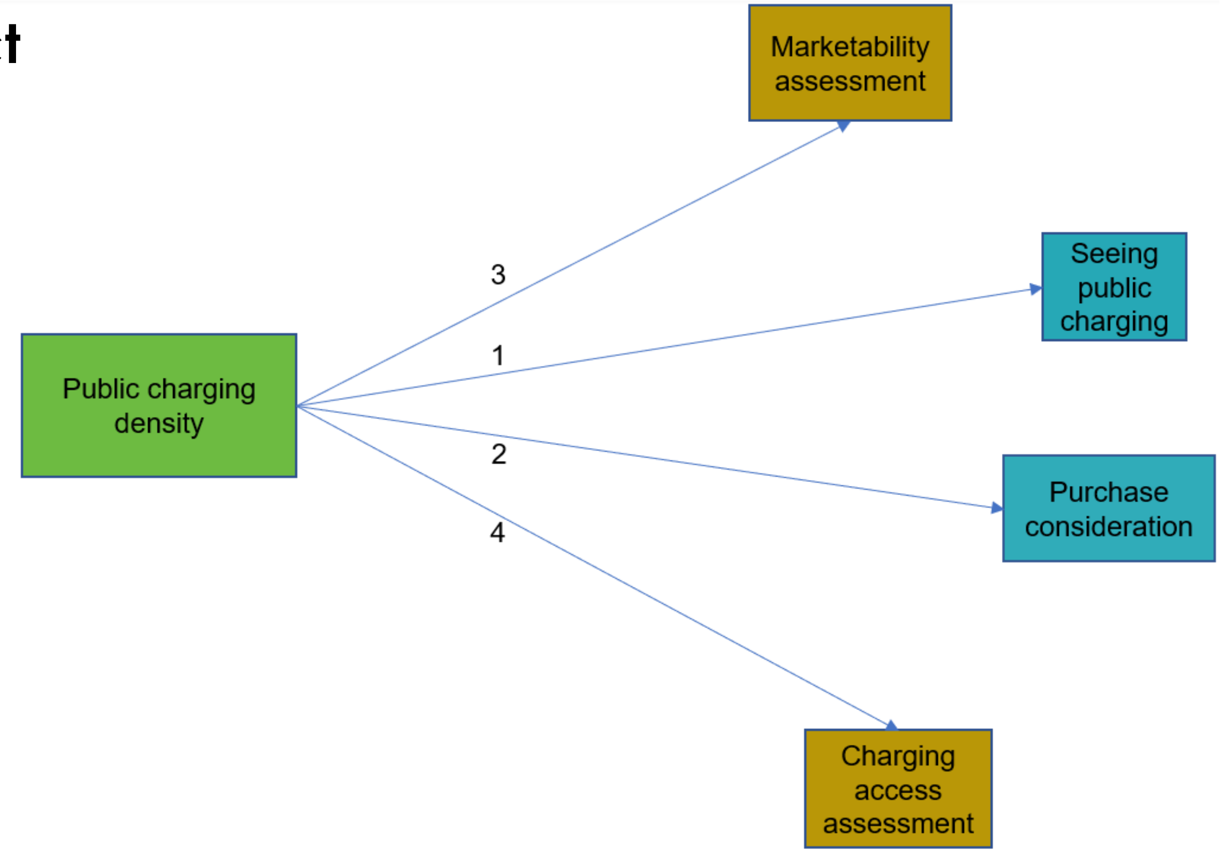
Mediated by:

- EV marketability: Paths 3 & 8
- EV charging access: Paths 4 & 9



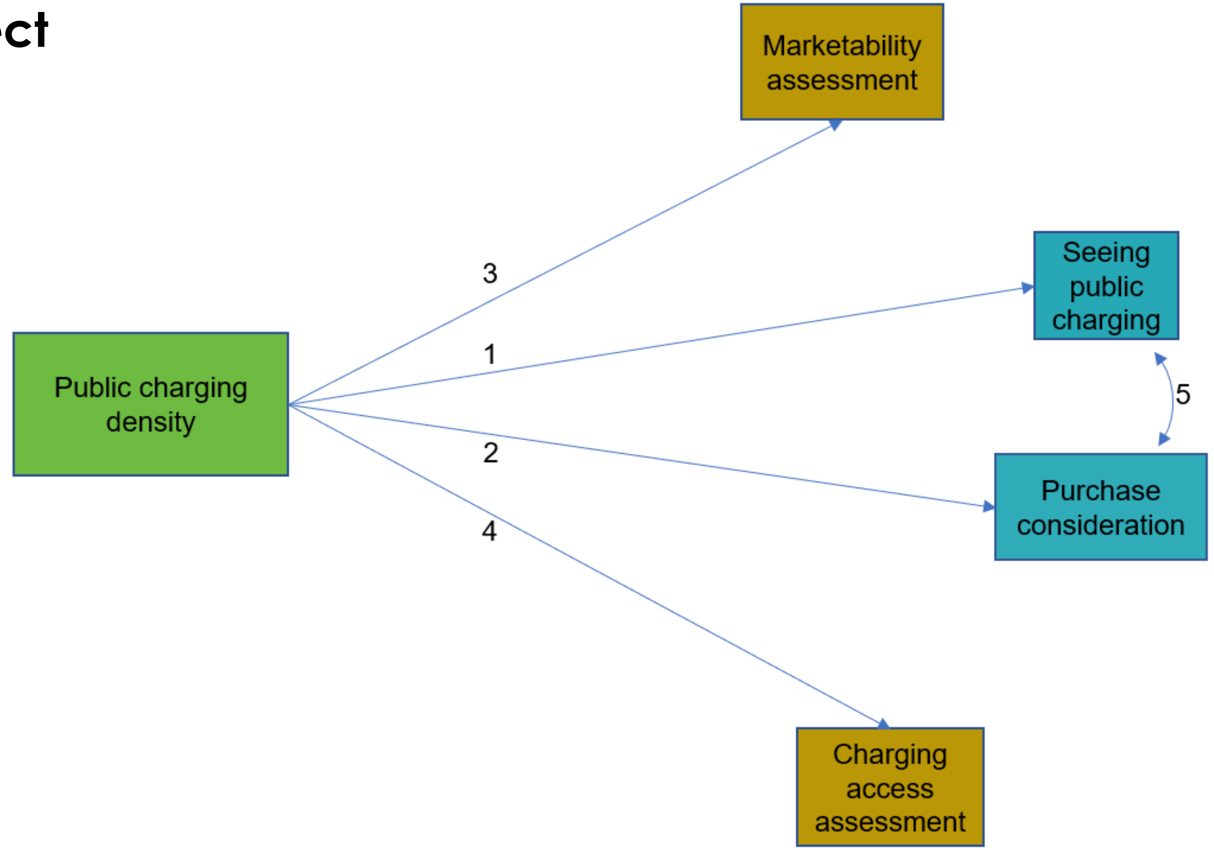
Model Framework

Hypotheses 1 – 4: Public charging direct effects:



Model Framework

Hypothesis 5: Reporting public charging direct effects:

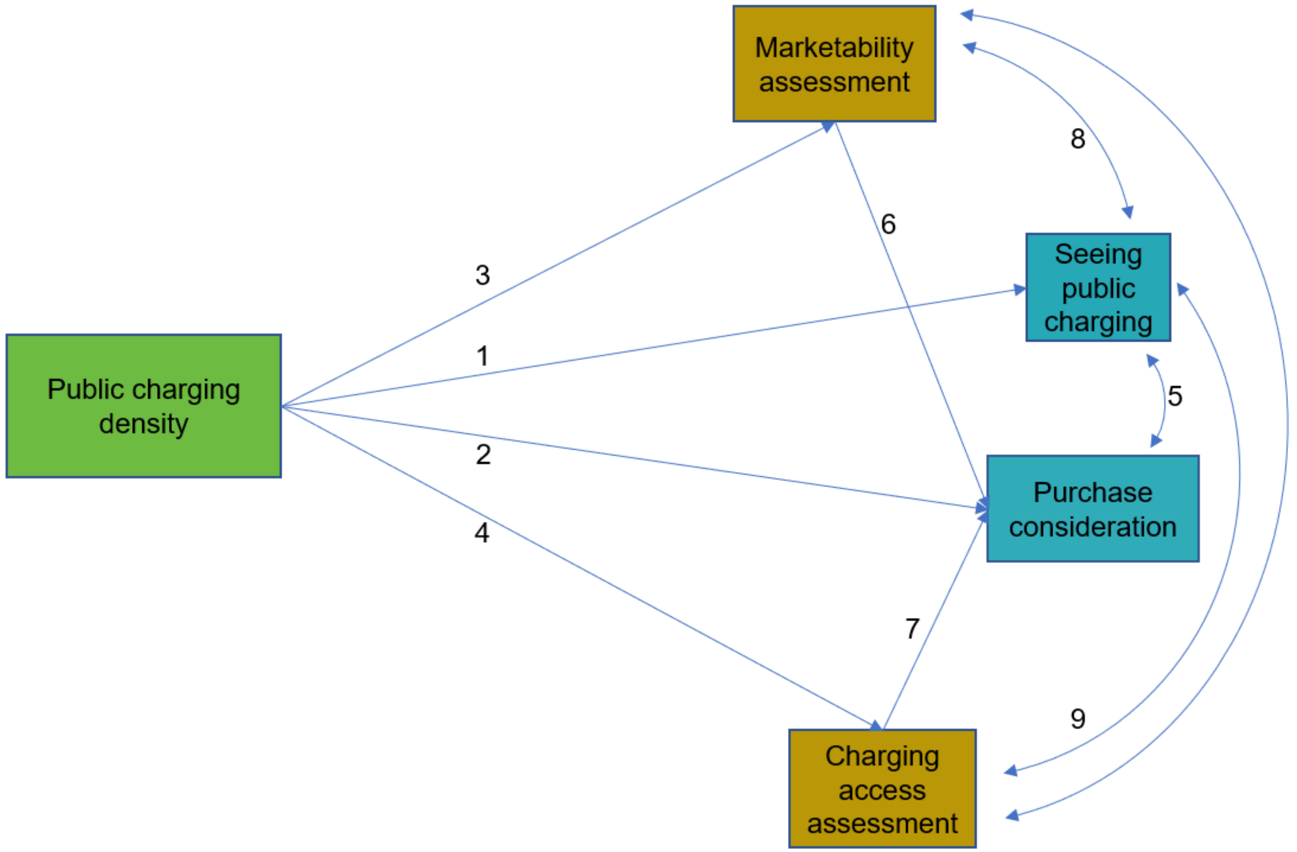


Model Framework

Hypothesis 8 – 10: Public charging indirect effects on EV purchase consideration:

Mediated by:

- Seeing public charging: Paths 1 & 5
- EV marketability: Paths 3 & 6
- EV charging access: Paths 4 & 7

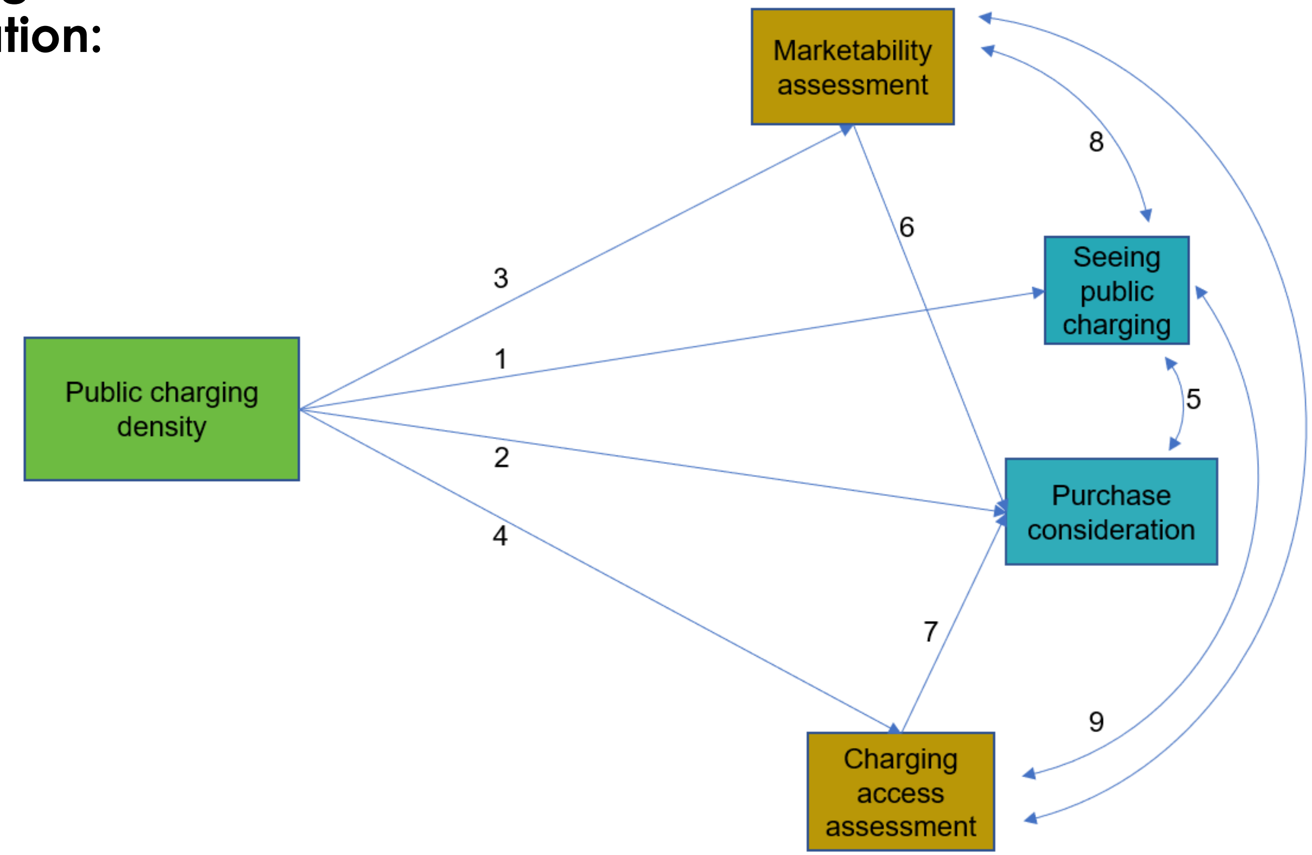


Model Framework

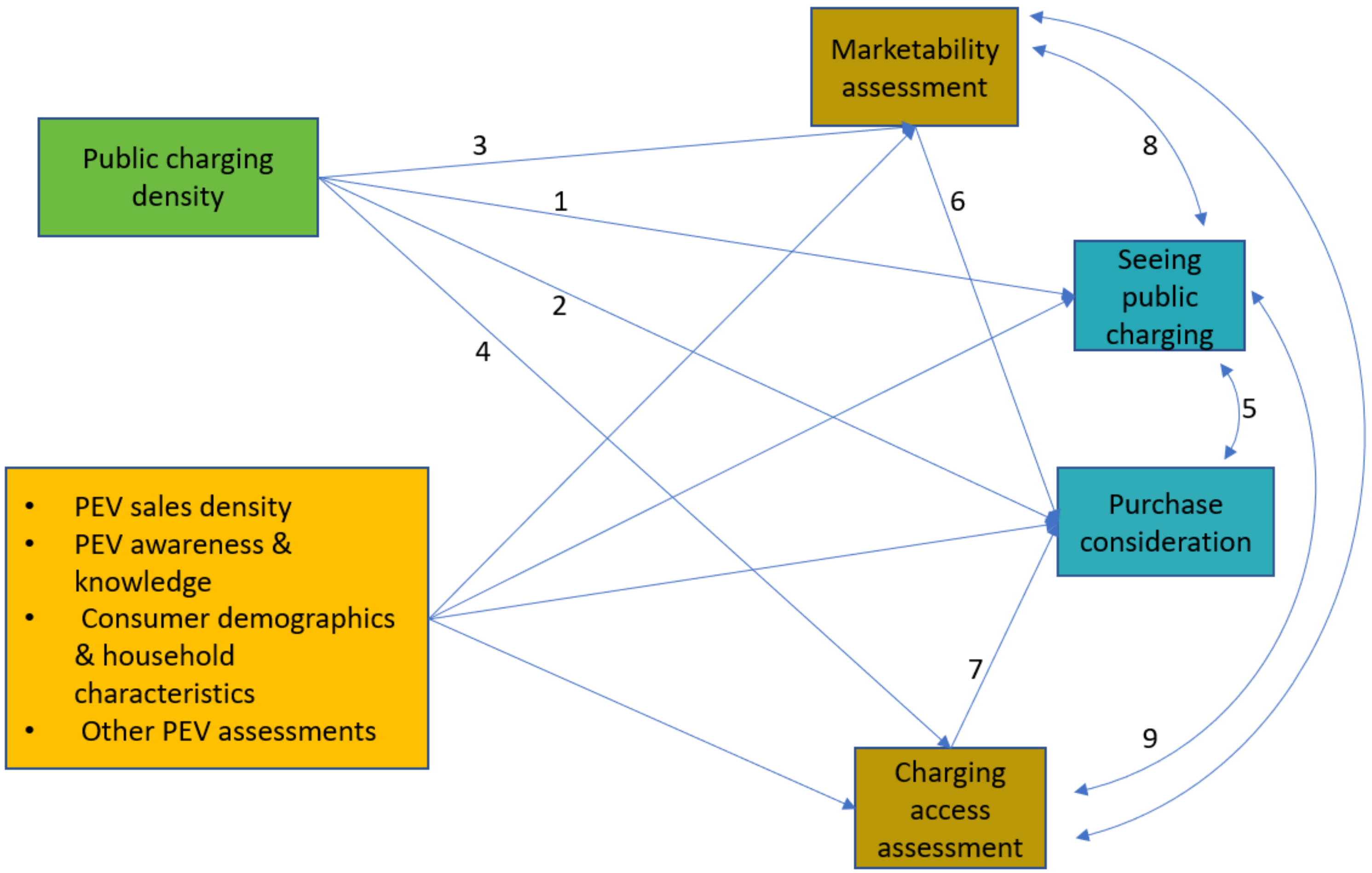
Hypothesis 11 – 12: Seeing public charging indirect effects on EV purchase consideration:

Mediated by:

- EV marketability: Paths 8 & 6
- EV charging access: Paths 9 & 7



Model Framework



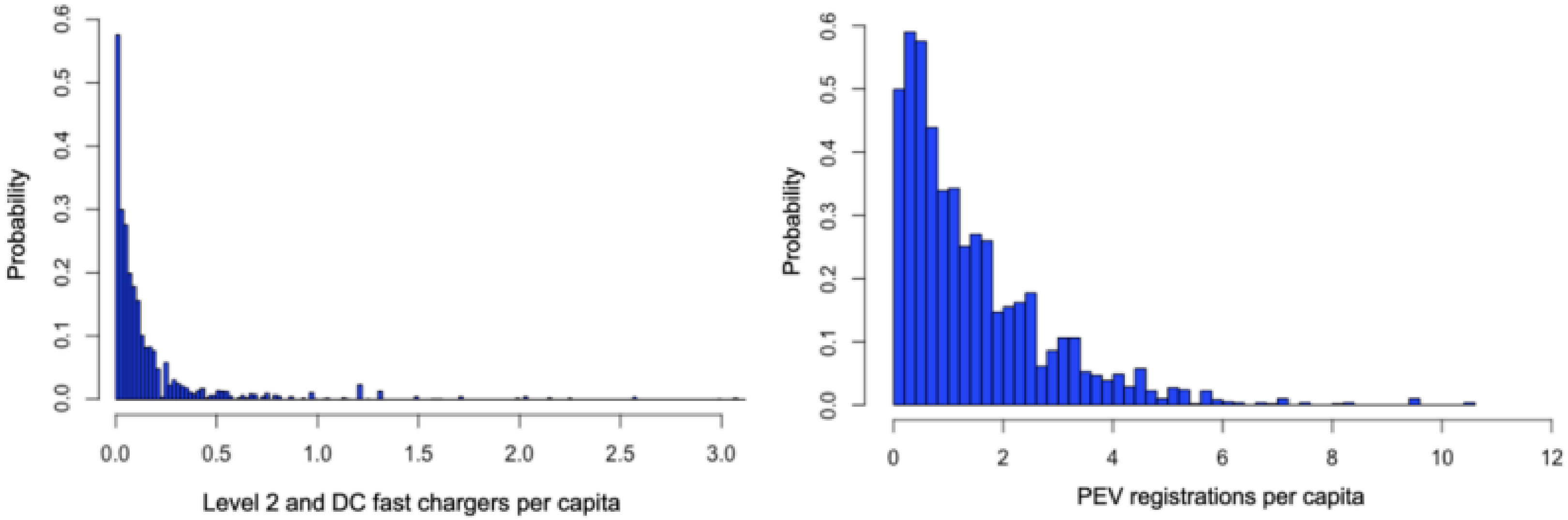


Figure 9. Distribution of Number of PEV charger locations and PEV registrations per 10,000 persons at the zip code level

Authors/ year	Region/ Time period	RP vs. SP	Methods	Dependent Variable	Causality stipulated	Unit for public charging	Controls			
							Public charging	*Access to home charging*	*Financial incentive*	*Non-financial incentive*
White et al. (2022)	U.S. 2019	SP	Structural equation model	BEV adoption intent	No	Charging stations per sq. mile within 20 miles of residential zip code	LA: + Dallas/ Atlanta: 0	LA/ Dallas: + Atlanta: 0		
Vergis and Chen (2015)	U.S. 2013	RP	Linear regression	Annual BEV/PHEV market share	No	Charging outlets per 1,000 residents	BEVs: + PHEVs: 0		BEVs: 0 PHEVs: +	
Clinton and Steinberg	U.S 2011-2014	RP	Fixed effects regression	Log of per capita BEV registrations	No	Total charging stations by state	0		Tax credit: 0 Rebate: +	
Hardman et al.	California 2018	SP	Ordered logistic regression	PEV purchase consider-ation	Not mentioned	Charging stations per sq. km in residential zip	0	+		
Bruckmann et al.	Switzerland 2018	RP	Mixed effect regression	BEV or ICEV	Not mentioned	Number of charging stations of residents' zip code	0	+		
Nazari et al.	California 2012-2013	RP	Multinomial nested logit	Vehicle fuel type	Not mentioned	Total charging stations in residential census tract	BEVs: 0 PHEVs: +	+		+

							Controls			
Authors/ year	**Region/ Time period**	**RP vs. SP**	**Methods**	**Dependent Variable**	**Causality stipulated**	**Unit for public charging**	***Public charging***	***Access to home charging***	***Financial incentive***	***Non-financial incentive***
Li et al. (2017)*	U.S. 2011-2013	RP	OLS Regression & GMM	Quarterly PEV sales	Yes	Total charging stations by MSA	+	+	+	
Narass-imhan and Johnson* (2018)	U.S. 2008-2016	RP	Fixed effect regression & GMM	Log of per capita PEV registrations	Yes	Charging stations per capita drivers by state	+		+	+
Wang et al. (2017)	China 2013-2014	RP	Linear regression	Per capita PEV sales	Yes	Chargers per million sq. kilometers by city	+			+
Carley et al. (2012)	U.S. 2011	SP	OLS regression	PEV purchase interest	Yes	Respondent has seen charging stations	+			
Sierzchula et al. (2014)	30 countries 2012	RP	OLS regression	Log of PEV market share	Likely	Charging stations per 100,000 residents at country level	+		+	
Bailey et al. (2015)	Canada 2013	SP	Binary regression	PEV purchase interest	Yes	Perceived charger existence & abundance	Abundant: + / 0 Existence: 0	+		
Mersky et al. (2016)	Norway 2000-2013	RP	Linear regression	Per capita PEV sales	No	Total charging stations at region/muni	+			0