Measuring Consumer Willingness to Participate in BEV Smart Charging Programs

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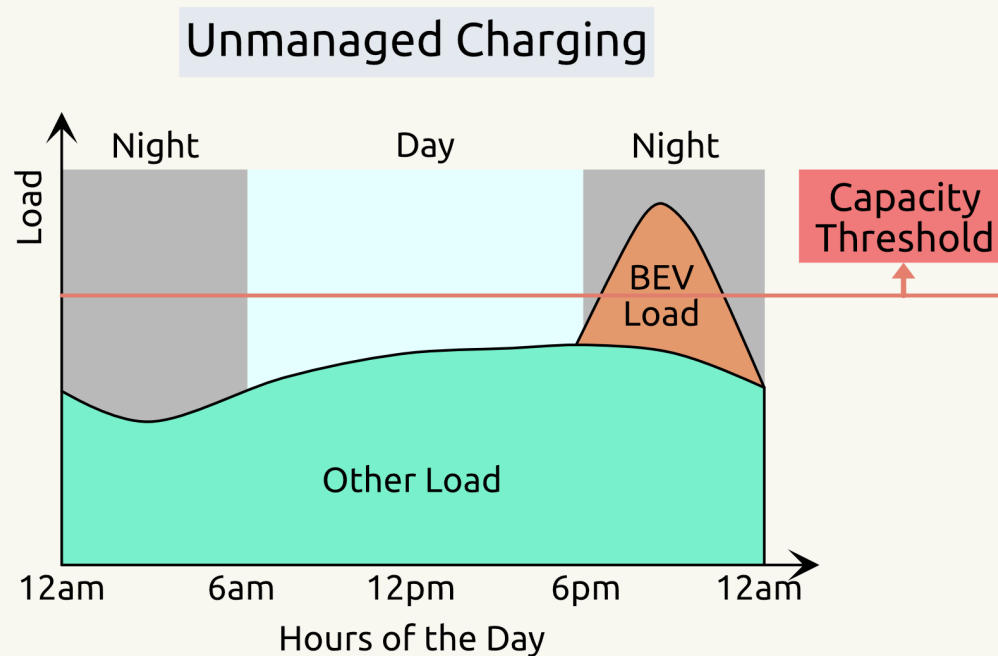
Introduction

- BEVs (Battery Electric Vehicles) can reduce CO_2 and prevent air pollution.
- But managing BEV charging can become a problem for the grid.
- Smart charging can help, but depends on user acceptance.

SMC - Supplier Managed Charging

- SMC smooths out overnight EV charging demand.

- Electricity demand is controlled below capacity threshold.

Unmanaged Charging

Night — Day — Night

Capacity Threshold

BEV Load

Other Load

Load

12am — 6am — 12pm — 6pm — 12am

Hours of the Day

SMC - Supplier Managed Charging

- SMC smooths out overnight EV charging demand.

- Electricity demand is controlled below capacity threshold.
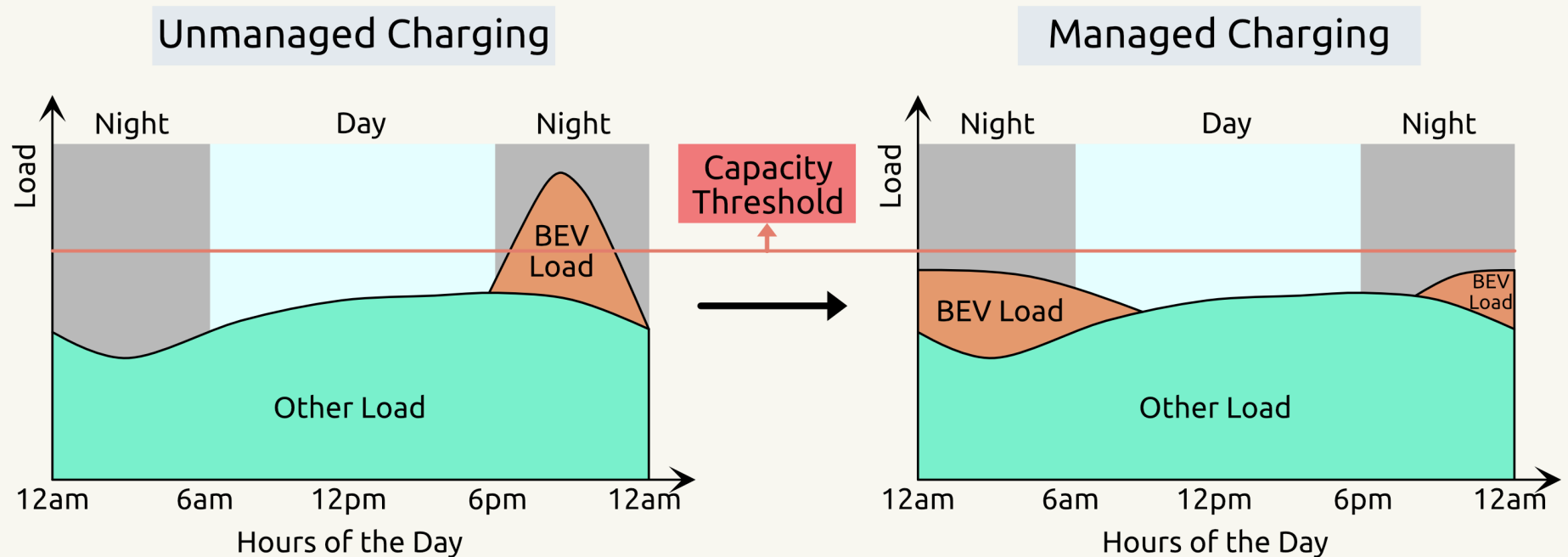
Managed charging avoids overload caused by BEV charging.
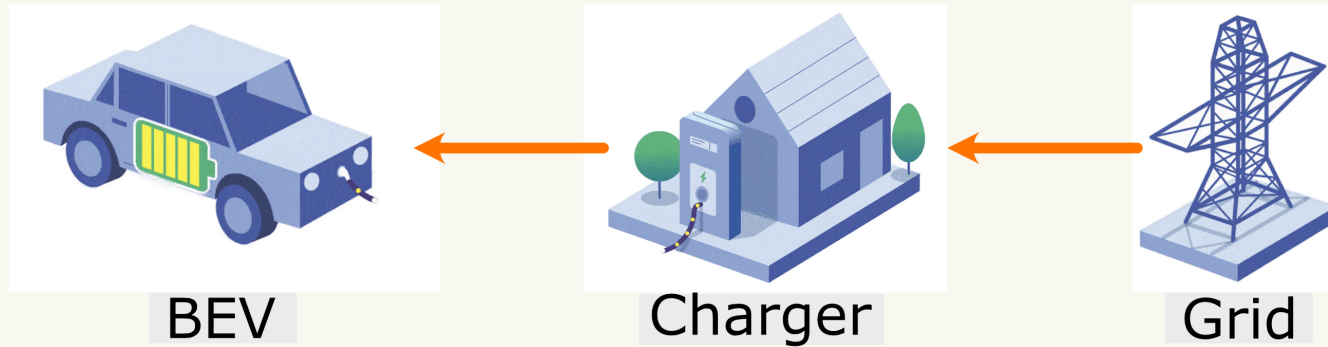
V2G - Vehicle-to-Grid
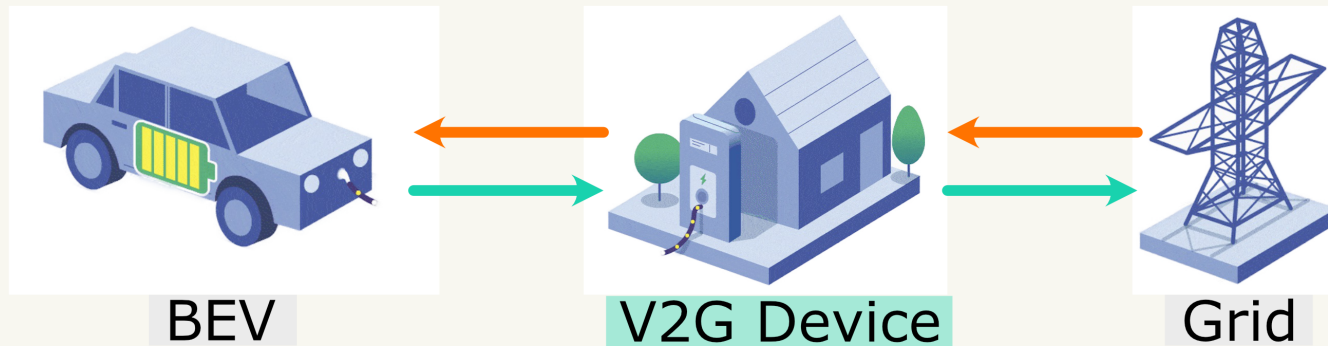
Non-V2G (Single Direction)

BEV   Charger   Grid

Figure Source: *wri.org*

V2G (Bi-direction)

BEV   V2G Device   Grid

In a V2G event, BEVs can charge the grid when necessary. BEVs are charged back eventually. Owners earn money.

Literature Review

1. A study by Wong et al. (2023) examined **incentives** affect the EV owners' acceptance, but EV ownership is only 19%.

2. A study by Philip and Whitehead (2024) found **range anxiety** matters, but EV ownership is only 1.28%.

3. Another study by Huang et al. (2021) indicates the importance of **fast charging**, but the sample size is only 157.

None of them have demographics data to study heterogeneity.

> We need high EV ownership & large sample size, and consider heterogeneity.

Research Questions

1. **Sensitivity**: How do changes in smart charging program features influence BEV owners' **willingness** to opt in?

2. **Market Share**: Under what **conditions** will BEV owners be more willing to opt in to smart charging programs?

Conjoint survey to collect BEV owners' willingness.

Mixed logit model to evaluate utilities for simulations.

Survey Design with formr

Survey Components

1. **Conjoint Questions:**

   a. Monetary Incentives

   b. Charging Limitations

   c. Flexibility

2. **Demographic Questions:**

   a. BEV Ownership & Usage

   b. Personal & Household Info

Conjoint Attributes Sample

No.	Attributes	Range
1	Enrollment Cash	$50 to $300
2	Monthly Cash	$2 to $20
3	Monthly Override	0 to 5
4	Min Battery	20% to 40%
5	Guaranteed Battery	60% to 80%

Conjoint Question Explained

A Sample Conjoint Question

For example, if these were the only apples available, which would you choose? *

Option 1	Option 2	Option 3
Type: Fuji	**Type**: Pink Lady	**Type**: Honeycrisp
Price: $ 2 / lb	**Price**: $ 1.5 / lb	**Price**: $ 2 / lb
Freshness: Average	**Freshness**: Excellent	**Freshness**: Poor

1. You are provided with different **sets** of attributes.

2. You choose one **set** instead of one **attribute**.
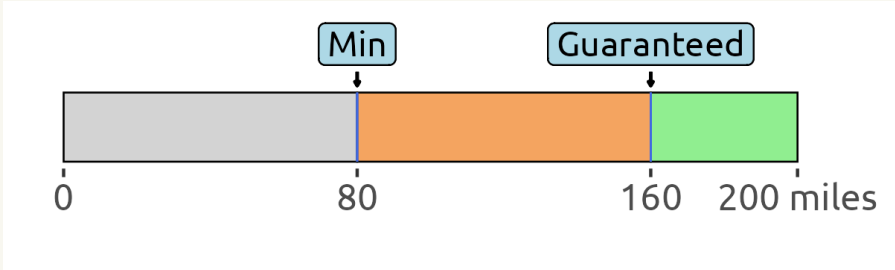
SMC Programs

Attributes

No.	Attributes	Range
1	Enrollment Cash	$50 to $300
2	Monthly Cash	$2 to $20
3	Monthly Override	0 to 5
4	Min Battery	20% to 40%
5	Guaranteed Battery	60% to 80%

Sample Program

Attributes	Values
Enrollment Cash	$300
Monthly Cash	$20
Monthly Override	5

Min ↓   Guaranteed ↓

0   80   160   200 miles
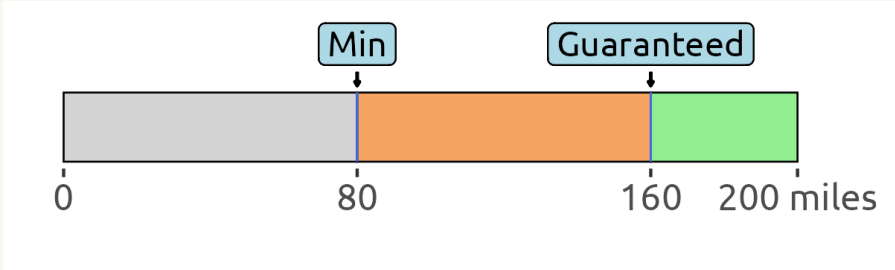
V2G Programs

Attributes

No.	Attributes	Range
1	Enrollment Cash	$50 to $300
2	Occurrence Cash	$2 to $20
3	Monthly Occurrence	1 to 4
4	Lower Bound	20% to 40%
5	Guaranteed Battery	60% to 80%

Sample Program

Attributes	Values
Enrollment Cash	$300
Occurrence Cash	$20
Monthly Occurrence	1
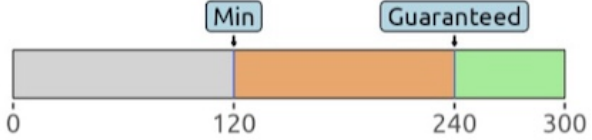
Sample SMC Question

(1 of 6) If your utility offers you these 2 SMC programs, which one do you prefer? (Your BEV has maximum range of **300** miles.)
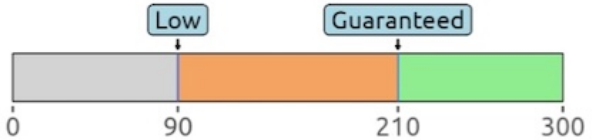
Access the SMC Attributes

Option 1	Option 2	Option 3
Enrollment Cash: $100	Enrollment Cash: $200	
Monthly Cash: $20	Monthly Cash: $10	
Override Allowance: 1 per Month	Override Allowance: 1 per Month	
Battery Thresholds (in Miles):	Battery Thresholds (in Miles):	Not Interested
Min ... Guaranteed	Min ... Guaranteed	
0 60 240 300	0 120 240 300	

Sample V2G Question

(1 of 6) If your utility offers you these 2 V2G programs, which one do you prefer? (Your BEV has maximum range of **300** miles.)

Access the V2G Attributes

Option 1	Option 2	Option 3
Enrollment Cash: $100	Enrollment Cash: $100	
Occurrence Cash: $5	Occurrence Cash: $20	Not Interested
Monthly Occurrence: 2	Monthly Occurrence: 2	
Battery Thresholds (in Miles):	Battery Thresholds (in Miles):	
Low 90 / Guaranteed 210 (0–300)	Low 120 / Guaranteed 180 (0–300)	

Survey Fielding

Meta: Facebook, Messenger, Instagram - **Voluntary**

- Fielding from March to July in 2024
- **803** results after filtering

Dynata: Survey Panel - **Payment to real BEV owners only**

- Fielding from September to November in 2024
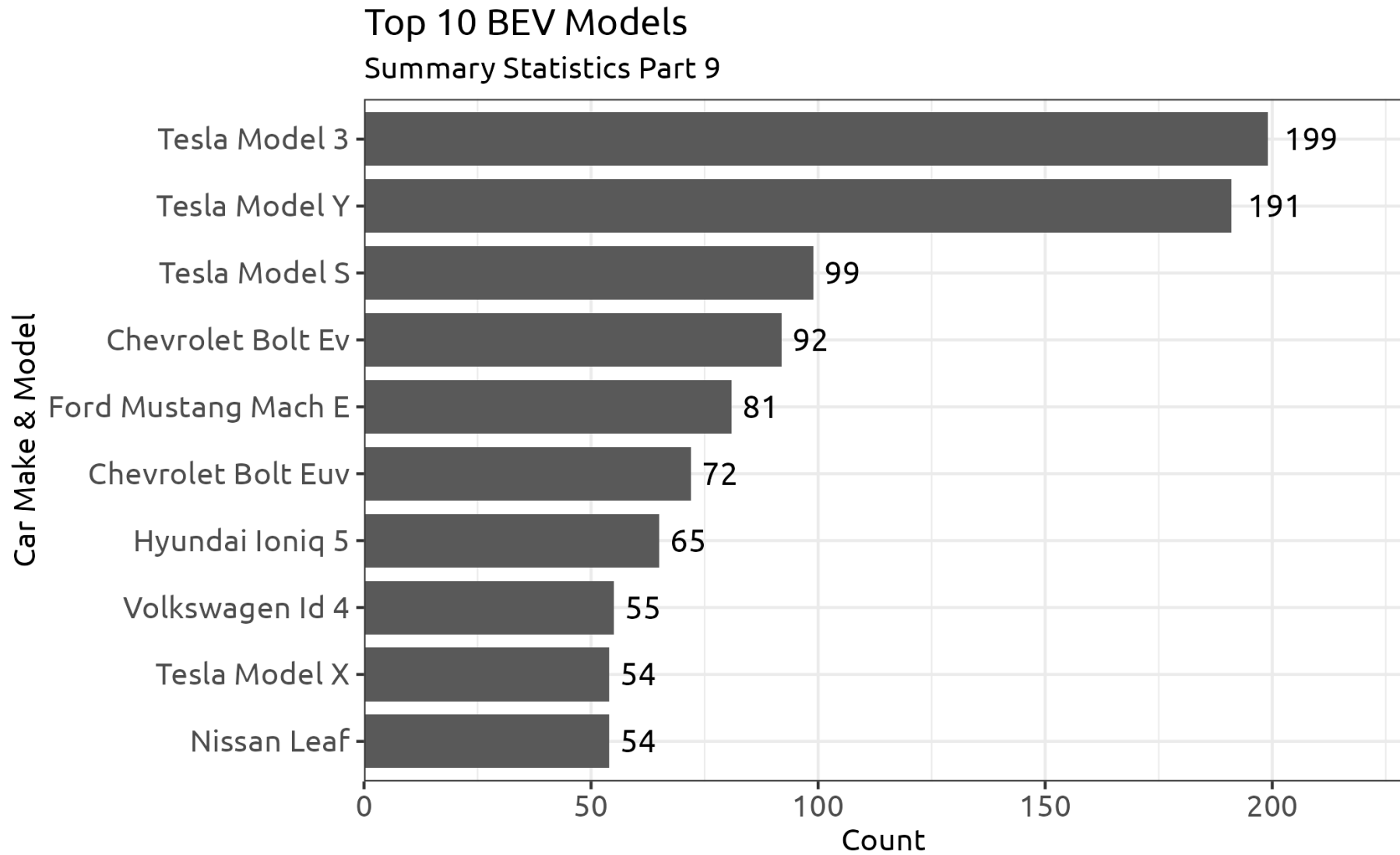- **553** results after filtering
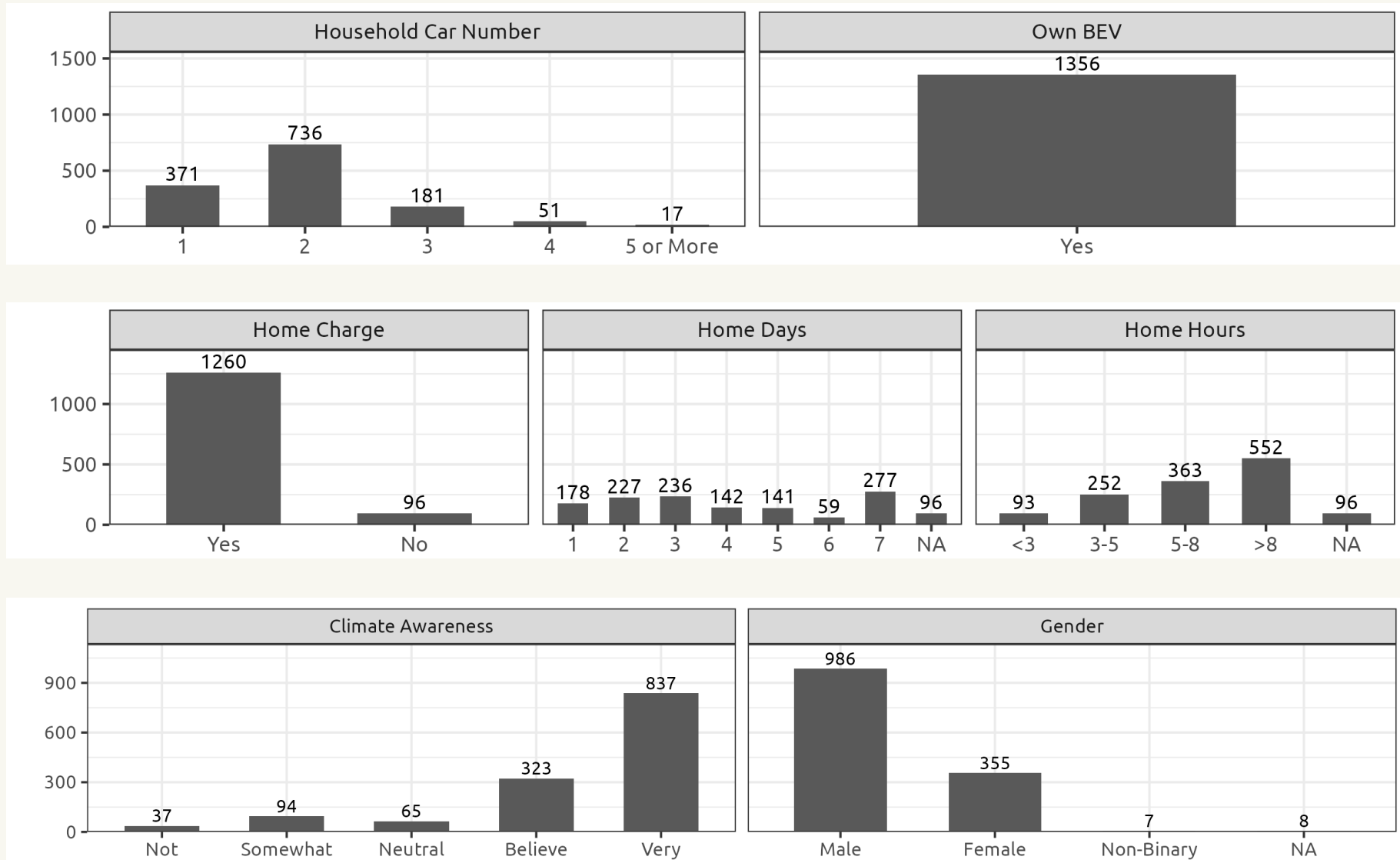

Facebook　　Messenger　　Instagram　　dynata

Survey Results - Top 10 BEV

Top 10 BEV Models
Summary Statistics Part 9

Survey Results - Demographics

Household Car Number

Category	Count
1	371
2	736
3	181
4	51
5 or More	17

Own BEV

Category	Count
Yes	1356

Home Charge

Category	Count
Yes	1260
No	96

Home Days

Category	Count
1	178
2	227
3	236
4	142
5	141
6	59
7	277
NA	96

Home Hours

Category	Count
<3	93
3-5	252
5-8	363
>8	552
NA	96

Climate Awareness

Category	Count
Not	37
Somewhat	94
Neutral	65
Believe	323
Very	837

Gender

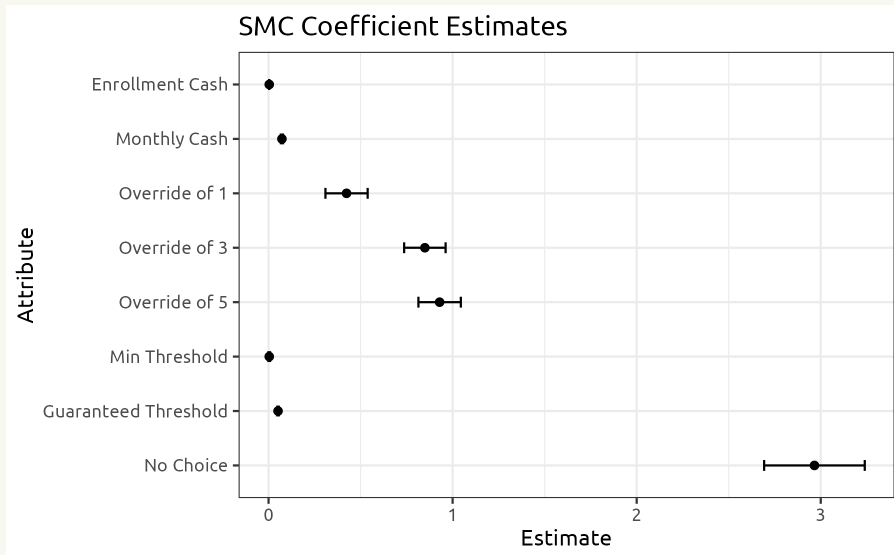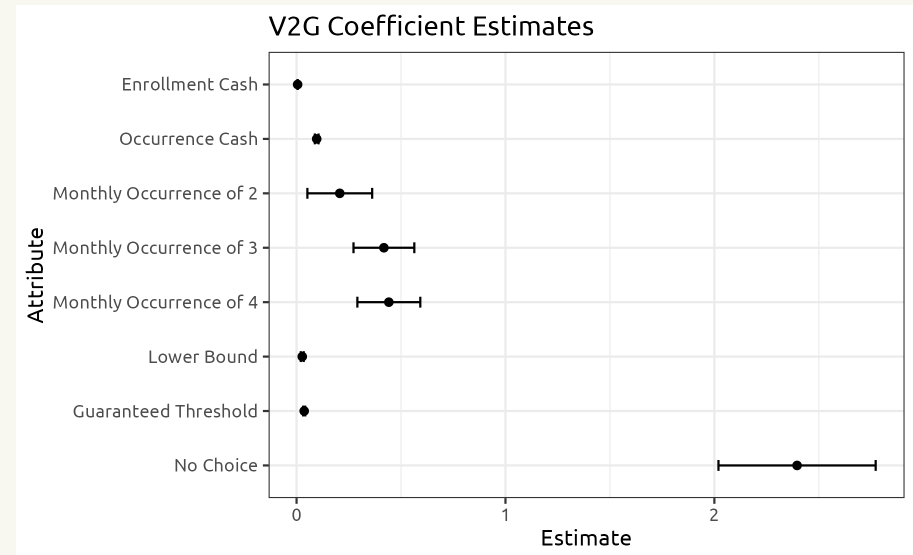| Category	Count
Male	986
Female	355
Non-Binary	7
NA	8

Survey Results - Willingness to Participate

Mixed Logit Models

$$u_j = v_j + \epsilon_j = \beta' x + \epsilon_j \qquad P_j = \frac{e^{v_j}}{\sum_{k=1}^{J} e^{v_k}}$$
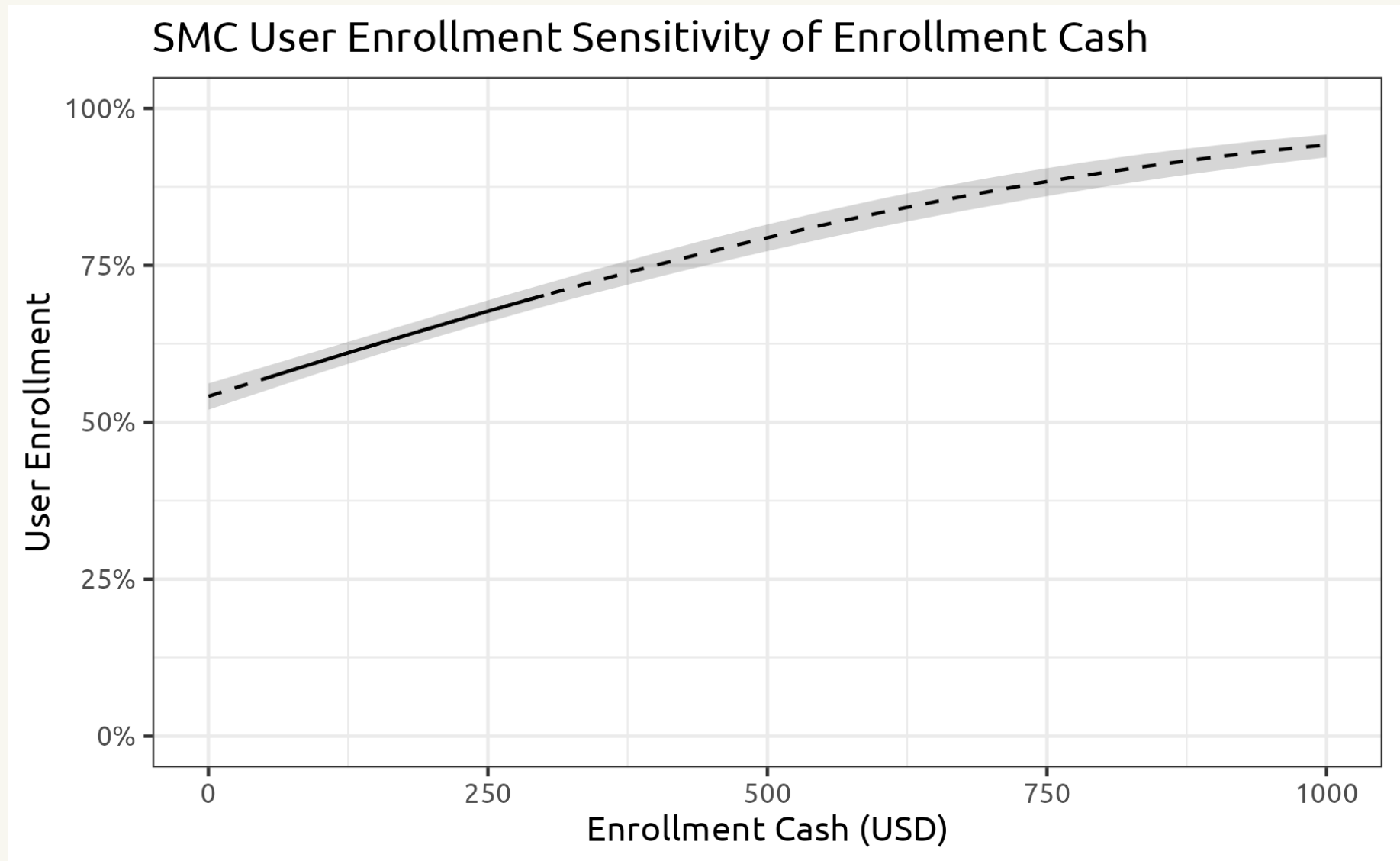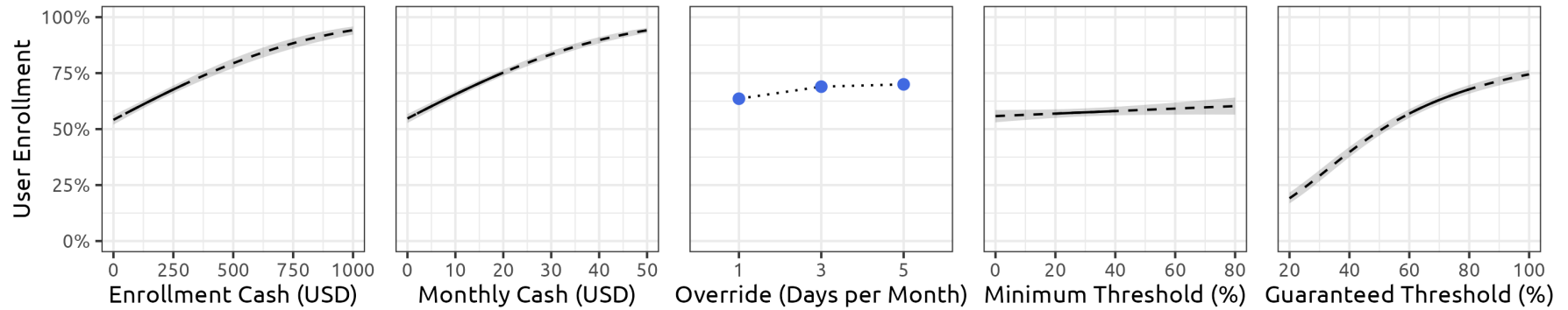
SMC Estimates

V2G Estimates

Without compensation, users will not participate.

Enrollment Sensitivity

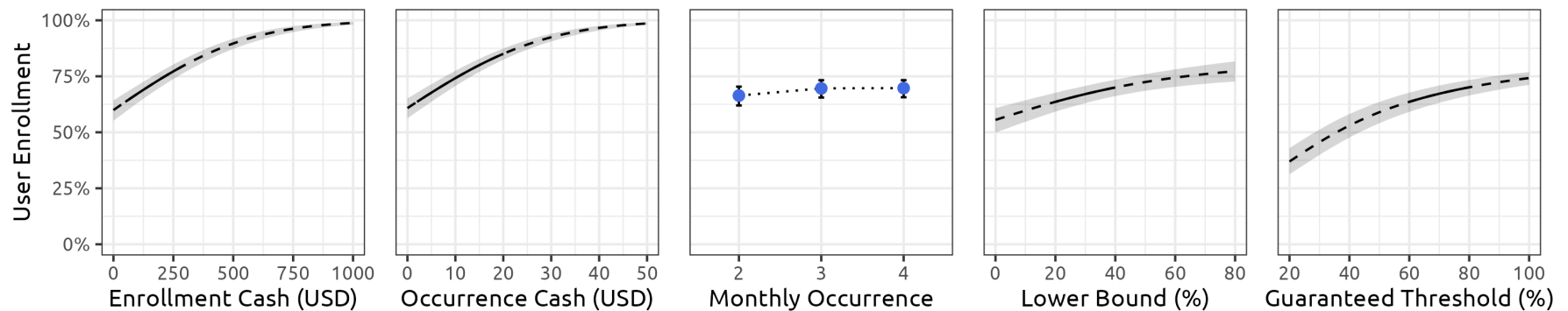SMC User Enrollment Sensitivity of Enrollment Cash

Enrollment Sensitivity

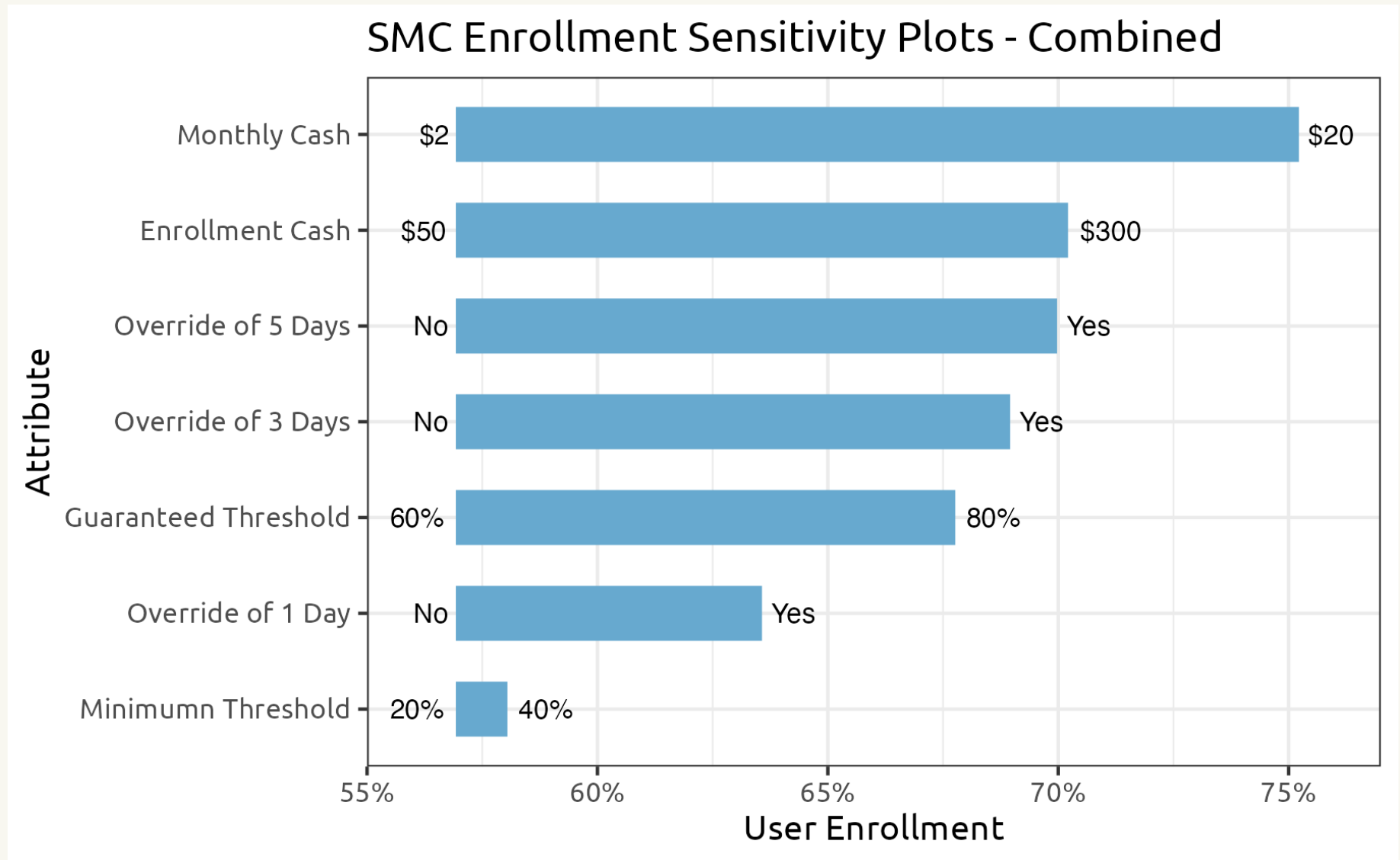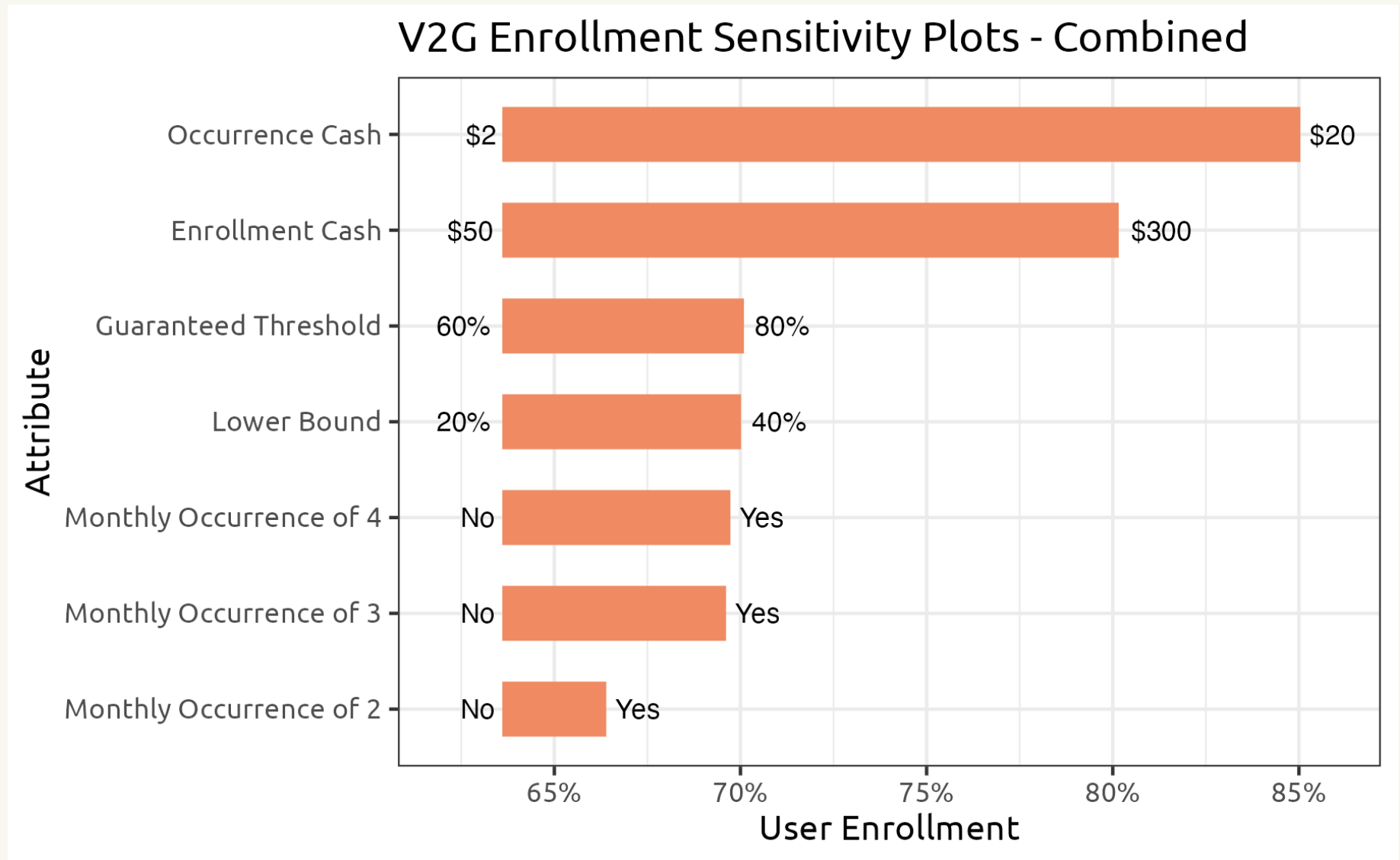SMC Enrollment Sensitivity Plots

V2G Enrollment Sensitivity Plots

Steeper slope indicates higher sensitivity.
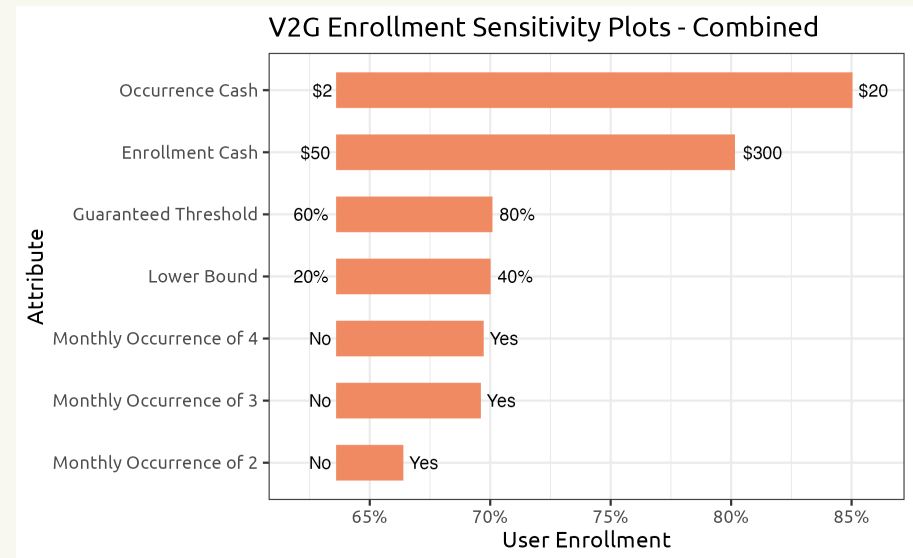
Enrollment Sensitivity Combined - SMC

SMC Enrollment Sensitivity Plots - Combined

Enrollment Sensitivity Combined - V2G

V2G Enrollment Sensitivity Plots - Combined

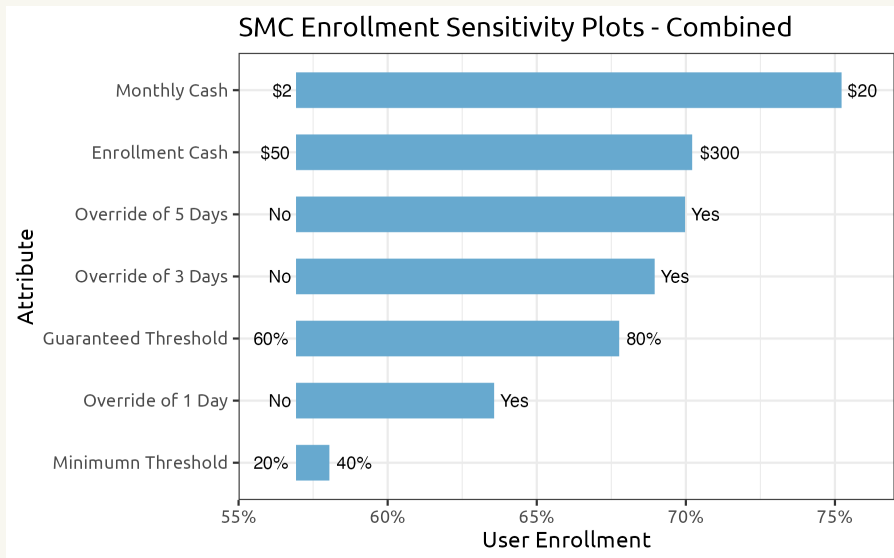# Enrollment Sensitivity Combined - Summary
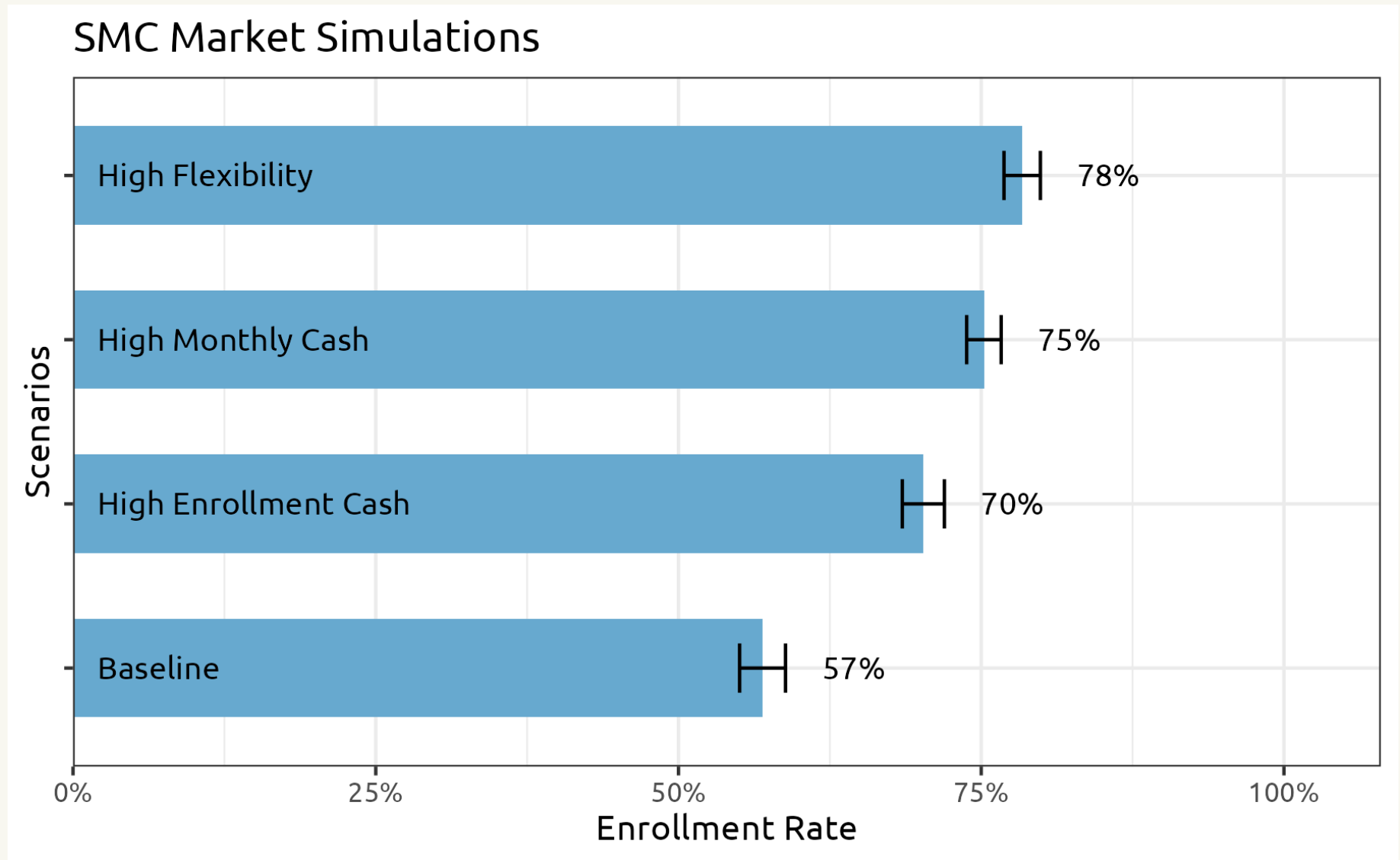

SMC Enrollment Sensitivity Plots - Combined

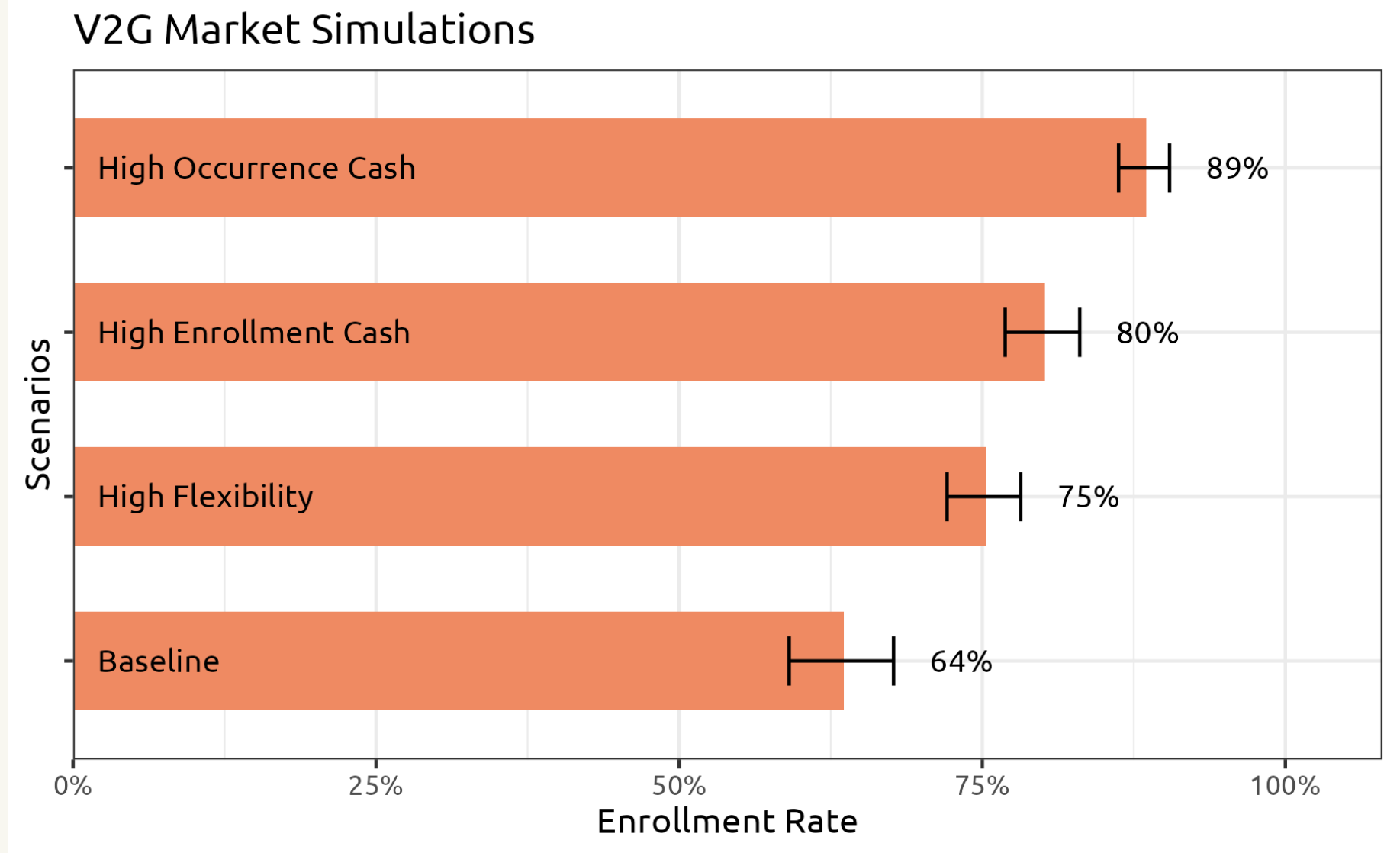V2G Enrollment Sensitivity Plots - Combined

1. **Monetary** incentives are important.

2. **Recurring** incentives are more important than one-time.

3. For SMC, **range anxiety** is vital, since it happens regularly.

4. For V2G, usability is compromised.

5. Diminishing returns exist.

Market Simulation - SMC

SMC Market Simulations

Market Simulation - V2G

V2G Market Simulations

Reference List

Huang, Bing, Aart Gerard Meijssen, Jan Anne Annema, and Zofia Lukszo. 2021. "Are Electric Vehicle Drivers Willing to Participate in Vehicle-to-Grid Contracts? A Context-Dependent Stated Choice Experiment." *Energy Policy* 156 (September): 112410. https://doi.org/10.1016/j.enpol.2021.112410.

Philip, Thara, and Jake Whitehead. 2024. "Consumer Preferences Towards Electric Vehicle Smart Charging Program Attributes: A Stated Preference Study." Rochester, NY. https://doi.org/10.2139/ssrn.4812923.

Wong, Stephen D., Susan A. Shaheen, Elliot Martin, and Robert Uyeki. 2023. "Do Incentives Make a Difference? Understanding Smart Charging Program Adoption for Electric Vehicles." *Transportation Research Part C: Emerging Technologies* 151 (June): 104123. https://doi.org/10.1016/j.trc.2023.104123.