

# Paving the Road for Electric Vehicles: Lessons from a Randomized Experiment

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**enel**

# Introduction

- International context
  - Norway: EV 39.2% car sales- 10,000 charging stations
  - China: EV 2.2% car sales- 214,000 charging stations
  - Switzerland: EV 0.53% car sales- 2,500 charging stations
- National Context (Introductory market)
  - 200 EV (October 2017)\* - ~142 charging stations  
[Mostly company cars]

(\*)ANAC (2017). Ventas anuales de vehículos eléctricos, híbridos enchufables e híbridos convencionales.

## Purpose of this research

- Impact of EV usage on environmental **attitudes** and on the **perceptions** and **valuations** of EV's attributes
- **Policy and marketing lessons** for an introduction-stage market, such as the Chilean





## Research Questions

- Subsidy?
- Large public charging network?
- Home charging?
- Attributes to highlight to mitigate prejudice or to enhance adoption?
- Willingness to pay for attributes?  
Tailored products?
- Impact on environmental attitudes?



## Methodology

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- Enel raffled a subsidized EV purchase plan for employees
- Randomized experiment
  - **Treatment:** 5 month ownership&usage
  - **Control:** Raffle participant (non-users)
- Study attitudes, perceptions and valuations due to treatment by:
  - Focus groups
  - Opinion surveys
  - Stated preferences surveys

# Enel e-mobility program for employees (2017)

## Availability: 30 EVs

3 models: Nissan Leaf, Hyundai Ioniq, BMW i3

## Benefits:

- Price discount (17-20%)
- 0% interest loan
- Re-sale option at the end of a predefined period (depending on the brand)
- Preferential parking with free charging
- Home charger (7 kW)
- Car insurance discount
- Maintenance included until 60,000 km



65 applications

Public raffle January 6, 2017

30 vehicles allocated (25 Nissan Leaf, 5 Hyundai Ioniq, 0 BMW i3)



# Focus Groups





## Focus Groups: Benefits of EVs

|                 | Factors                             | users | non-users |
|-----------------|-------------------------------------|-------|-----------|
| <b>Benefits</b> | Being pioneers                      | ■     | ■         |
|                 | Comfort (-noise, +features, +clean) | ■     |           |
|                 | Easier conduction                   | ■     |           |
|                 | Excellent second car                | ■     |           |
|                 | More acceleration                   | ■     | ■         |
|                 | More efficiency                     | ■     | ■         |
|                 | Projection of good image            | ■     | ■         |
|                 | Reduced exhaust and noise emissions | ■     | ■         |
|                 | Smaller energy costs                | ■     | ■         |
|                 | Smaller maintenance costs           | ■     | ■         |
|                 | WhatsApp community                  | ■     |           |





## Focus Groups: Barriers of EVs

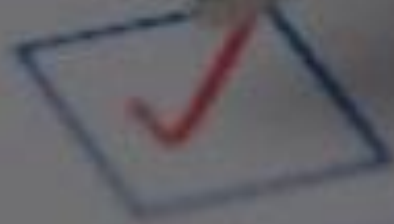
|          | Factors                           | users | non-users |
|----------|-----------------------------------|-------|-----------|
| Barriers | Access to maintenance facilities  | ■     | ■         |
|          | Actual vehicle functionalities    | ■     |           |
|          | Being noiseless (prone accidents) | ■     | ■         |
|          | Charging network (*)              | ■     | ■         |
|          | Large charging time               | ■     | ■         |
|          | Purchase cost                     | ■     | ■         |
|          | Purchase taxes                    | ■     |           |
|          | Range                             | ■     | ■         |
|          | Registration fee                  | ■     |           |

(\*) users mentioned charging network only as an issue at the interurban level



Excellent

# Opinion Survey





# Opinion Survey: Environmental Attitudes

| Transport Problem  | Change in Stated Degree of Importance | p-value 2 Tails | p-value Right Tail |
|--|---------------------------------------|-----------------|--------------------|
| Vehicle emissions that affect local air quality and contribute to global warming | +0.317                                | 22%             | 11%                |
| Traffic noise that is heard at work, home or school                              | +0.292                                | 30%             | 15%                |
| Traffic congestion that you experience while driving                             | +0.217                                | 33%             | -                  |
| Accidents caused by aggressive or absent-minded drivers                          | -0.0833                               | 78%             | -                  |
| Accidents caused by speeding   | -0.167                                | 61%             | -                  |



# Opinion Survey: Perception of EV Attributes

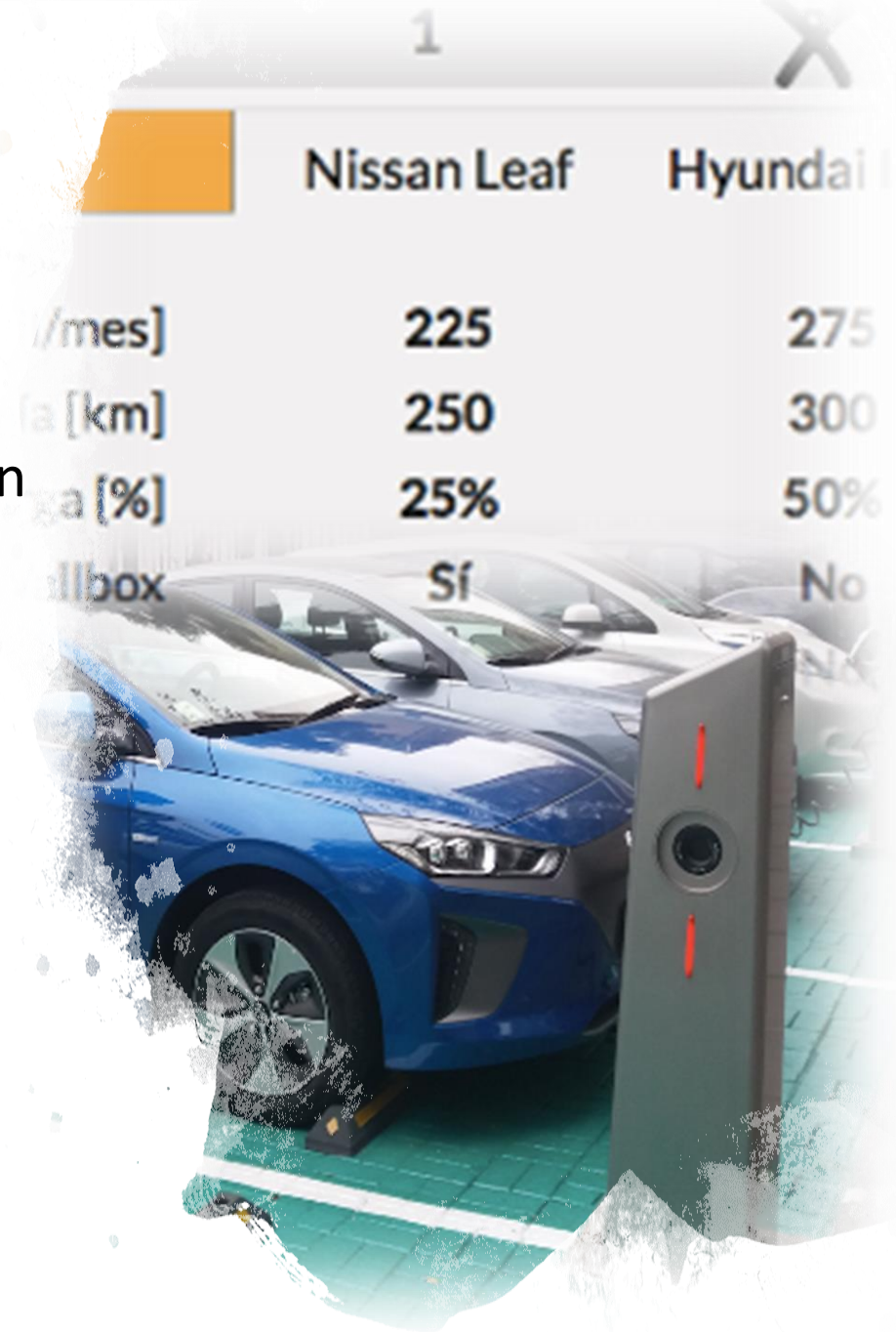
| EV Attribute                | Average Stated Degree of Adv - Disadv | p-value 2 Tails |
|-----------------------------|---------------------------------------|-----------------|
| Energy consumption          | +0.225                                | 13%             |
| Exhaust and Noise Emissions | -0.0333                               | 33%             |
| Maintenance Cost            | +0.292                                | 8%              |
| Home Charging               | -0.0583                               | 49%             |
| Public Network Charging     | -0.0750                               | 73%             |
| Range                       | -0.225                                | 7%              |
| Price                       | +0.0167                               | 86%             |
| Comfort                     | +0.200                                | 24%             |
| Safety                      | -0.0583                               | 69%             |

| NINGUNO           | 1           | X             | 3   |
|-------------------|-------------|---------------|-----|
| <b>EJEMPLO</b>    | Nissan Leaf | Hyundai Ioniq | BMW |
| Cuota [\$mil/mes] | 225         | 275           | 350 |
| Autonomía [km]    | 250         | 300           | 325 |
| Red de carga [%]  | 25%         | 50%           | 70% |
| Wallbox           | Sí          | No            | Sí  |
| Estacionamiento   | Sí          | No            | Sí  |
| Wallbox           | Sí          | No            | Sí  |
| Estacionamiento   | Sí          | No            | Sí  |
| Wallbox           | Sí          | No            | Sí  |
| Estacionamiento   | Sí          | No            | Sí  |
| Wallbox           | Sí          | No            | Sí  |
| Estacionamiento   | Sí          | No            | Sí  |

# Stated Preferences (SP) Survey

## SP Profiles

- Context: new version of Enel's plan
- Same conditions
- Same three vehicle alternatives
- Attributes varied:
  - Monthly share (\$)
  - Range (km)
  - Charging Network (%)
  - Wallbox (at home)
  - Parking Privileges



# Attitudes and Perceptions of EV attributes

- Cost is the most relevant factor
- Range is the second
- Users value more Wallbox than Parking
- Charging Network effect negligible for users
- Female more willing to buy an EV than men
- Frequent drivers (7daw) less willing to buy

## ~Marginal rate of substitution wrt monthly share

|                | Users   | Non-Users |
|----------------|---------|-----------|
| Range[\$/Km]   | 600     | 750       |
| Network [\$/%] | 0       | 4,000     |
| Wallbox [\$]   | 105,000 | 115,000   |
| Parking [\$]   | 90,000  | 175,000   |



# Probability of purchase

|                 |           |                |                  |           |             |
|-----------------|-----------|----------------|------------------|-----------|-------------|
| Enel<br>program | P (x) [%] | Nissan<br>Leaf | Hyundai<br>Ioniq | BMW<br>i3 | Opt-<br>out |
|                 | Users     | <b>78.66</b>   | 10.97            | 6.70      | 3.66        |
|                 | Non-users | <b>59.66</b>   | 23.30            | 3.86      | 13.17       |

|                      |           |                |                  |           |              |
|----------------------|-----------|----------------|------------------|-----------|--------------|
| Market<br>conditions | P (x) [%] | Nissan<br>Leaf | Hyundai<br>Ioniq | BMW<br>i3 | Opt-<br>out  |
|                      | Users     | 0.17           | 0.20             | <0.01     | <b>99.63</b> |
|                      | Non-Users | 3.05           | 3.39             | 0.08      | <b>93.48</b> |

# Conclusions

- Subsidy? Current prices => purchase prob.  $\sim 0$
- Large public charging network? Not for urban
- Home charging? By default
- Attributes to highlight? Range, maintenance cost, energy consumption
- Willingness to pay for attributes? 600 \$/Range Km; 105.000 \$/Wallbox ; 90.000 \$/Parking
- Tailored products? Female, Frequent driver
- Impact on Env. attitudes? Weak or nil



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# Logit, Panel data

Users

Non-users

| Variable                       | $\beta_{gan}$ | $\sigma_{gan}$ | $\tau_{gan}$ | $\beta_{pos}$ | $\sigma_{pos}$ | $\tau_{pos}$ |
|--------------------------------|---------------|----------------|--------------|---------------|----------------|--------------|
| Cuota                          | -0.00974      | 0.00251        | <u>-3.88</u> | -0.00321      | 0.00241        | <u>-1.33</u> |
| Auton                          | 0.00595       | 0.00148        | <u>4.02</u>  | 0.00301       | 0.00188        | <u>1.60</u>  |
| Red                            | 0.00198       | 0.00570        | <u>0.35</u>  | 0.0126        | 0.00595        | <u>2.12</u>  |
| Wall                           | 1.05          | 0.211          | <u>4.99</u>  | 0.619         | 0.131          | <u>4.72</u>  |
| Est                            | 0.885         | 0.182          | <u>4.88</u>  | 0.775         | 0.232          | <u>3.34</u>  |
| <i>Inercia</i>                 | 2.54          | 0.652          | <u>3.90</u>  | -             | -              | -            |
| <i>Hombre<sub>optout</sub></i> | 2.11          | 1.19           | <u>1.77</u>  | -             | -              | -            |
| <i>U7<sub>optout</sub></i>     | 1.28          | 0.779          | <u>1.65</u>  | 1.37          | 0.721          | <u>1.93</u>  |
| <i>Cte<sub>ioniq</sub></i>     | 2.56          | 0.665          | <u>3.84</u>  | -0.419        | 0.317          | <u>-1.32</u> |
| <i>Cte<sub>i3</sub></i>        | 1.96          | 0.541          | <u>3.63</u>  | -1.61         | 0.705          | <u>-2.28</u> |
| <i>Cte<sub>NP</sub></i>        | -1.37         | 1.62           | <u>-0.84</u> | -1.55         | 0.775          | <u>-2.00</u> |
| Nº individuos                  | 22            |                |              | 15            |                |              |
| Observaciones                  | 333           |                |              | 230           |                |              |
| $\rho^2$ ajustado              | 0.223         |                |              | 0.157         |                |              |
| Log-verosimilitud              | -263.088      |                |              | -195.543      |                |              |

- Female more willing to buy EV than men
- Frequent car users (7 days) less willing

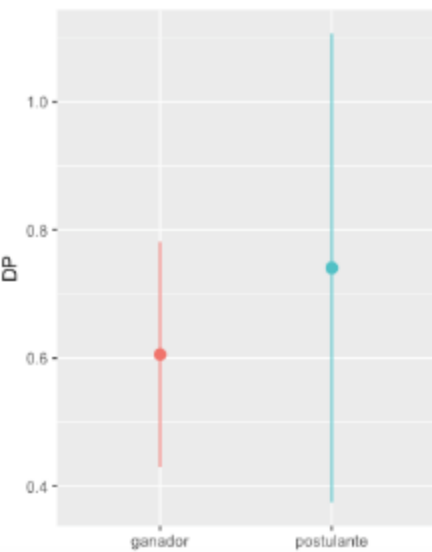
- ✓ Monthly Share [-]
- ✓ Range
- ✓ Wallbox
- ✓ Parking Privileges
- ✓ ~~Network~~



- ✓ Monthly Share (7%) [-]
- ✓ Range (7%)
- ✓ **Network**
- ✓ Wallbox
- ✓ Parking Privileges

# Marginal rate of substitution wrt monthly share

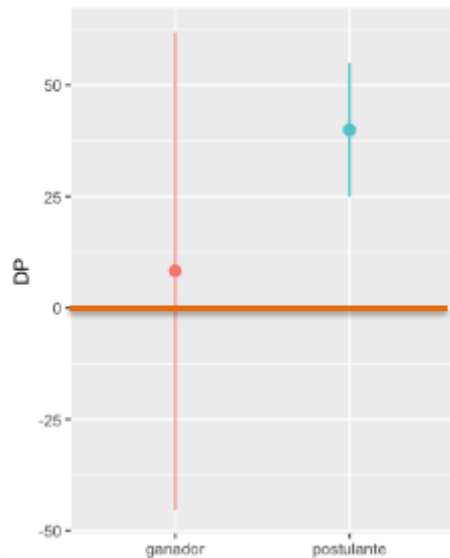
## Range



600

750

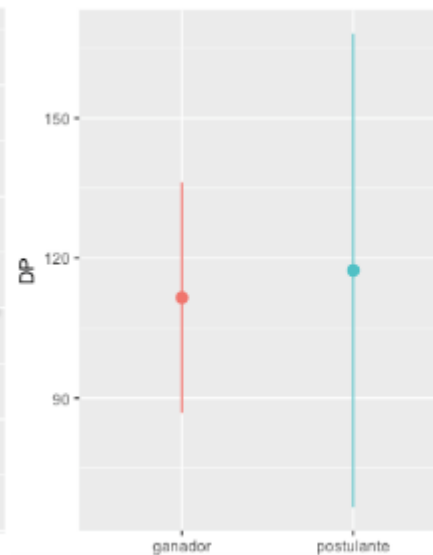
## Charging Network



0

4,000

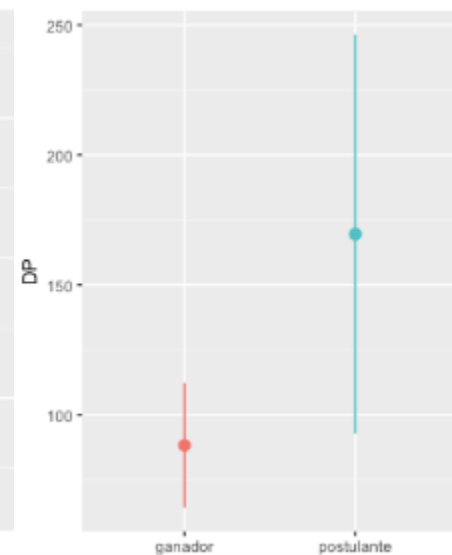
## Wallbox



105,000

115,000

## Parking



90,000

175,000

Grupo  
ganador  
postulante

Users

Non-users