ADDRESSING ELECTRIC-VEHICLE RANGE ANXIETY IN URBAN AND RURAL AREAS

Bassem Haidar¹,², Pascal da Costa², Jan Lepoutre³, Fabrice Vidal¹

¹Stellantis, Route de Gisy, Vélizy-Villacoublay, 78140, France
²Université Paris-Saclay, CentraleSupélec, Laboratoire Génie Industriel, 3 rue Joliot-Curie 91190 Gif-sur-Yvette, France
³ESSEC Business School, 3 Avenue Bernard Hirsch, 95021 Cergy-Pontoise, France

DECEMBER 9TH, 2021
SUMMARY

• Introduction
• Literature review
• Methodology
• Results
• Robustness checks
• Conclusion
Stellantis is created in January 2021

Stellantis is the 4th world biggest automotive manufacturer

Stellantis is 14 brands

Stellantis is 400,000 employees in 50 countries
SUMMARY

• Introduction
• Literature review
• Methodology
• Results
• Robustness checks
• Conclusion
**INTRODUCTION – THE NEED FOR ELECTRIC VEHICLES**

### Climate change

**Carbon neutrality** needed by **2050** to limit global warming by **1.5°C**.

(IPCC, 2018)

**GHG emissions**

Europe (EEA, 2019)

**Public interventions**

- Low emission zones in cities.
- Ban combustion vehicle sale.
- Penalty on automakers.

**Electrification**

Automakers are committed in electric models.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Energy Supply</th>
<th>Transport</th>
<th>Industry</th>
<th>Residential and commercial</th>
<th>Agriculture</th>
<th>Other</th>
<th>Cars</th>
<th>Heavy duty trucks</th>
<th>Light duty trucks</th>
<th>Aviation</th>
<th>Maritime</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Supply</td>
<td>11.3</td>
<td>11.5</td>
<td>19</td>
<td>19.5</td>
<td>11.3</td>
<td>29.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>40</td>
<td>14</td>
<td>14</td>
<td>10</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(IPCC, 2018)

Europe (EEA, 2019)
ACTUAL SITUATION OF THE ELECTRIC VEHICLE TRANSITION

Countries with the highest share of EV in new passenger car sales in 2020 (ACEA, CAAM, EV-Volumes (2020)).

Innovation Adoption Curve

Market Share Evolution

LARGE HETEROGENEITY BETWEEN COUNTRIES
INTRODUCTION – ADOPTION BARRIERS

DIFFERENCE BETWEEN ICEV AND EV ECOSYSTEMS

The ICEV Case

The EV Case

CHICKEN AND EGG ELECTRIC-MOBILITY DILEMMA

Stations Availability
Refuelling/Charging Duration
Vehicle’s Investment
Vehicle’s Autonomy
1. Should we invest in charging infrastructure deployment and/or charger installation subsidies? If so, which charging power?

2. Should we have higher subsidies for EV purchasing? If so, which EV size?

3. Should we have bigger batteries or more charging stations?
SUMMARY

• Introduction

• Literature review

• Methodology

• Results

• Robustness checks

• Conclusion
The question “Which combination of battery capacity and charging power” is rarely studied the literature

<table>
<thead>
<tr>
<th>Paper</th>
<th>Country</th>
<th>Stream</th>
<th>Used data / Methodology</th>
<th>Daily/long trips</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jabbari and Mackenzie (2017)</td>
<td>-</td>
<td>3</td>
<td>A simulation of cost comparison to deploy more fast charging points</td>
<td>-</td>
<td>High reliability of access and high utilization rate of charging stations could be achieved by installing a large number of chargers</td>
</tr>
<tr>
<td>Wood et al. (2015)</td>
<td>USA</td>
<td>3</td>
<td>A simulation of the driving behavior after increasing the battery capacity and installing fast charging points</td>
<td>-</td>
<td>It is more costly to add 100-km to the BEV autonomy than to increase the charging network</td>
</tr>
<tr>
<td>Funke et al. (2019)</td>
<td>Germany</td>
<td>3</td>
<td>400 real-world driver data from German commercial vehicles/ Cost model</td>
<td>Long trips</td>
<td>Cost comparison of the investments in bigger battery and in more charging stations: 50 kWh battery is the optimal solution. Invest in fast charging infrastructure rather than batteries</td>
</tr>
</tbody>
</table>

**Conclusion:** Invest in fast chargers than in bigger batteries for long trips needs (in the case of the USA and Germany)

1. What about daily trips needs (home-work)?
2. What about 7, 22, 50 kW chargers?
3. Which trade-off between battery capacity and types of chargers when no at-home sockets?

**Research Question:** For people who **cannot install a charger** at home: where should we invest? In **bigger batteries** or in more **available charging points**? And which **power** of charging?
THE FRENCH URBAN AND RURAL LAGGARDS

• Laggards: drivers willing to buy a BEV and do not have an at-home charger.

• Identifying a solution for laggards could accelerate energy transition.

Large heterogeneity among French driving behaviors.

• Long-distance trips for rural drivers.

• No availability of public transportation means in rural areas.

Large heterogeneity among French at-home charging availability.

50% of French households are not equipped with a private parking.

Daily Trips Needs (km).

Percentage of households equipped with a private parking (%)
Our representation based on INSEE 2016 database.
• Introduction
• Literature review
• Methodology
• Results
• Robustness checks
• Conclusion
RESULTS 2: COST-EFFECTIVENESS OF DEPLOYED SOLUTIONS

METHODOLOGY: ADAPTED FROM (FUNKE ET AL., 2019)

- Daily travelled kilometres for French urban and rural needs
- BEV energy consumption

- Charging power
- M/M/2 queue characteristics

- Vehicle investments
  - Battery packs price
  - Purchasing subsidies
  - Charging instalment subsidies
  - O&M costs (for CPs and BEVs)
  - Electricity and fuel prices
  - Charging tariffs

BEV needs
Simulating 5000 individual BEV profiles over a year for urban and rural laggards

Charging Infrastructure
Determining the number of 2-charger stations for 15-min waiting time using M/M/2 queue model

Cost model determination
- BEV customer cost model
- Charging Point Operator cost model

Cost comparison
Determining win-win situation(s) based on Pareto fronts
Equivalent Annual Cost (EAC) is the annual cost of owning, operating, and maintaining an asset over its entire life.

\[ EAC = \text{Amortized Investment} + OPEX - Revenues \]

**BEV driver**

Minimizing the investments and the costs

\[ \min(\Delta EAC_i) = \min(EAC_{BEV,i} - EAC_{ICEV,i}) \]

The difference in annual costs between purchasing a BEV and an ICEV

**Charging Point Operator (CPO)**

Minimizing the costs

\[ \min(EAC_{CPO}) \]

\[ \min(Costs - Revenues) \]
SUMMARY

- Introduction
- Literature review
- Methodology
- Results
- Robustness checks
- Conclusion
RESULTS – WIN-WIN SITUATIONS IDENTIFICATION FOR URBAN AND RURAL NEEDS

- Win-win situations are defined based on Pareto fronts.
- Pareto front is a situation where no individual can be better off without making at least one individual worse off or without any loss thereof:
  - The driver if $\Delta EAC > 0$.
  - The CPO if $EAC > 0$.

- For Urban needs:
  - Solution 1: 35 kWh BEV and 22 kW chargers.
  - Solution 2: 40-50 kWh BEV and 50 kW chargers.

- For Rural needs:
  - Solution: 55 kWh BEV and 50 kW chargers.
SUMMARY

• Introduction
• Literature review
• Methodology
• Results
• Robustness checks
• Conclusion
**ROBUSTNESS CHECKS**

**ROBUSTNESS CHECK 1**
Mixing the usage between BEV sizes and charging powers: all BEVs could charge using all powers.

**ROBUSTNESS CHECK 2**
Changing the charging tariffs of other operators.

**ROBUSTNESS CHECK 3**
Increasing the charging tariffs by 50%

The results of the robustness checks are similar to our results.

**Policy recommendation:** The impact of increasing the charging tariffs on the drivers' behaviours
**VEHICLE MARKETING PER USAGE:**

- **Rural usage:** 55 kWh BEV
- **Urban usage:** 35-50 kWh BEV

**Deployment of 50 kW chargers.**

- **No tariffs increase for 50 kW charging services.**
- **Revising 7 and 22kW charging tariffs.**

**More BEV subsidies → Larger Pareto fronts → More BEV choices for customers**

**Charger installment subsidies:**
- **Rural usage:** 50 kW chargers
- **Urban usage:** 22-50 kW chargers
SUMMARY

• Introduction
• Literature review
• Methodology
• Results
• Robustness checks
• Conclusion
CONCLUSION

- Analysis of the trade-offs between charging infrastructure and battery sizes.
- We used the Equivalent Annual Cost, by analyzing the business models of the charging point operator and the BEV customer.

- For urban area:
  - 35 kWh BEVs + 22 kW chargers
  - 40-50 kWh BEVs + 50 kW chargers

- For rural area:
  - 55 kWh BEVs + 50 kW chargers

- The results of the robustness checks are similar to our results:
  - Future studies: Investigate for a win-win solution for the pricing method variation for rural area
  - Policy recommendation: The impact of increasing the charging tariffs on the drivers’ behaviours
THANK YOU FOR YOUR ATTENTION
QUESTIONS?

CONTACT

Bassem Haidar
Research & Development Department
Division for Research & Innovation

Stellantis, Route de Gisy, Vélizy-Villacoublay, 78140, France

bassem.haidar@stellantis.com