Electric Vehicle Subsidies: Cost-Effectiveness and Emission Reductions

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Motivation

- Transportation sector is a major contributor to air emissions that cause global warming and climate changes
- Provided clean electricity production upstream, **electrification** is one way of abating these emissions
- Several factors impede widespread adoption:
  - Price is prohibitive
  - Availability of charging points
- **Network effects:** While adoption is high, market demand for charging services is high $\rightarrow$ increases adoption

This paper

- **Policy**: Electric vehicle subsidies as a tool to boost adoption
- **Context:** Charging networks are provided as a public good
- Interaction between **subsidies** and **public provision** of stations
- **Research question:** *"Should we subsidize EV as an emission abatement tool?"*
  - Focus on Canada's car market
  - **Quebec** province, between 2012–2020
  - Subsidies are substantial $\approx$ 17% of list price ($\approx$ \$9,800)
  - $\approx$ 83% of charging stations are public

Context

- Public network developed in partnership with local governments
- **Provincial government** provides platform
  - Software infrastructure (billing, phone app, technical support)
  - Prices are regulated (wholesale and retail)
- **Local governments** decide on deployment strategy in their region
- Friction between provincial and local governments objectives
  - **Provincial-level:** Increase adoption
  - **Municipal-level:** Provide a service to local population

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  - Could be unique to the Canadian setting
- Evidence of **small environmental gains**
  - Total spending on program: $723M
  - Abated emissions: -0.7% (over lifetime of vehicles)
  - Marginal abatement cost: $338 / ton

Plan

1. Effect of EV subsidies on **sales** and **station deployment**
   - Comparing **Ontario** and **Quebec** rebate programs
   - Difference-in-difference analysis
   - Study the **short-run effects** of subsidies

2. Effect of EV subsidies on **emissions** and **policy design**
   - Zoom-in on **Quebec**
   - Structural estimation
   - Charging station infrastructure provided as **public good** by **forward-looking** local planner (county-level governments)
   - Unified framework for conducting **cost-benefit analysis**

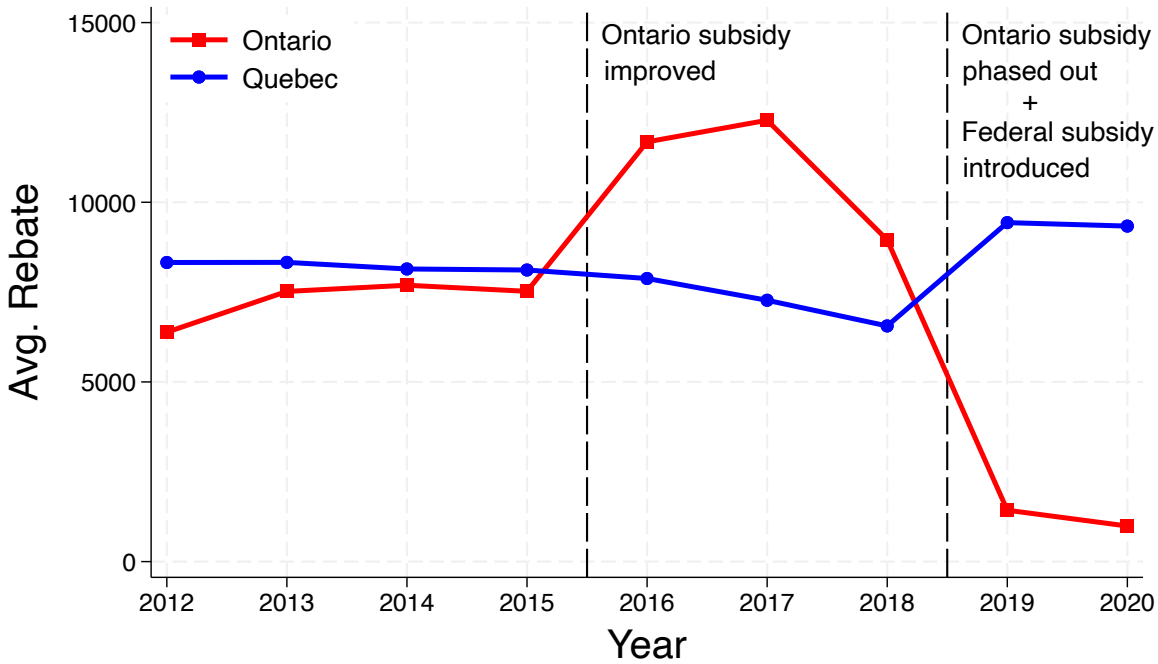
Data

1. **Car sales**
   - **Quebec**: All registered vehicles (micro data)
   - **Ontario**: New car registrations (agg. county-level)
2. **Car characteristics**
   - The Car Guide and the Auto Trader websites
   - Includes: retail price, power, size, fuel consumption, etc.
3. **Network**
   - Natural Resources Canada
   - Includes: installation date, coordinates, pricing, ownership, etc.
4. **Demographics**
   - Canadian Census of Households (2011, 2016, 2021)
   - Survey of Household Spending

Financial incentives

- 2012 – both provinces offer similar incentives ($8,000 – $8,500)
- 2016 – **Ontario** program **bonified** ($8,500 → $14,000)
- 2019 – **Ontario** program **phased out** ($14,000 → $0)

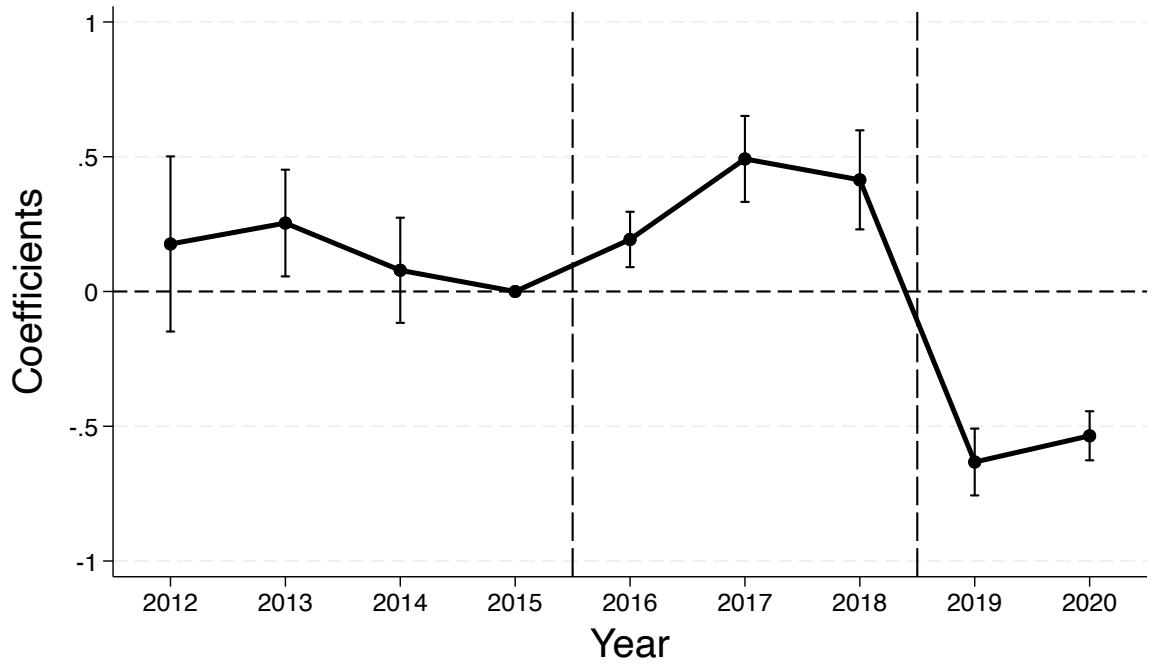
Figure 1: Financial incentives



Effect on electric vehicle sales

- **Event study:** Dependent variable $\rightarrow \ln(\text{SalesEV}_{mt})$

Figure 2: Effect of subsidizing EV on adoption

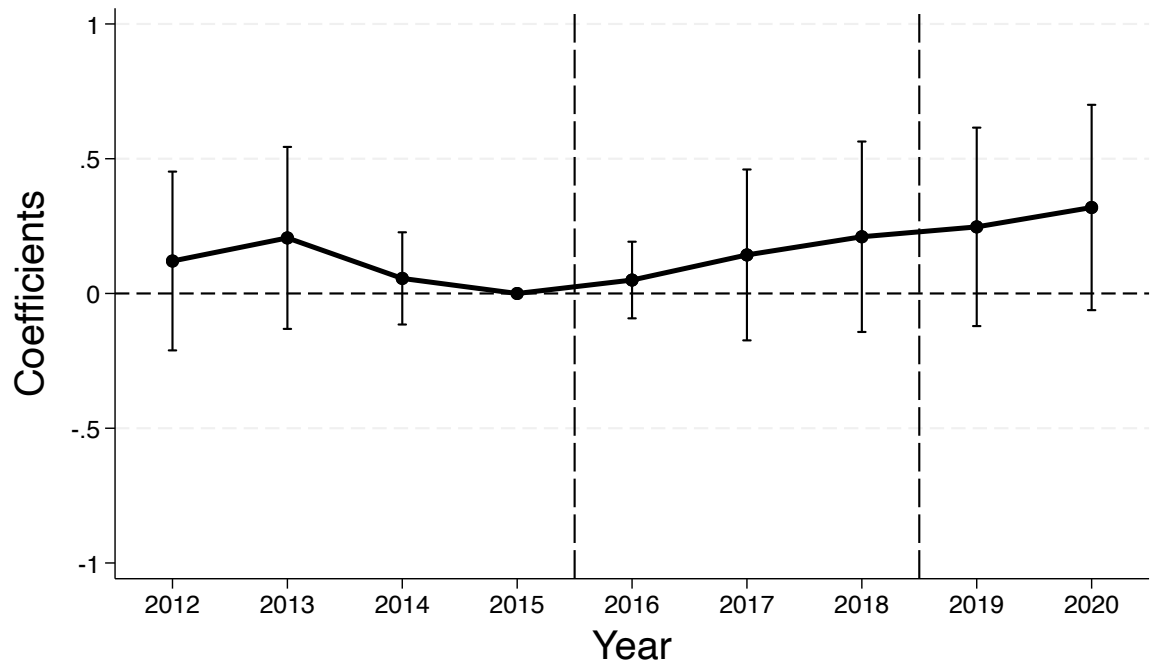


- **Takeaway:** Subsidizing EV generates additional sales

Effect on network size

- **Event study:** Dependent variable $\rightarrow$ $\ln(\text{NetworkSize}_{mt})$

Figure 3: Effect of subsidizing EV on charging station provision



- **Takeaway:** Charging station networks do not respond to increased adoption from EV subsidies (short run)

Structural model

- Study **environmental performance** and **cost-effectiveness** of subsidies

- Rely on a **structural model**

  1. **Demand** (static)
     - Discrete choice model (RC logit)
     - Consumers care about the **opportunity of recharging** when purchasing an EV
  2. **Network supply** (dynamic)
     - Model of **public good** provision by **forward-looking** local planners
     - Local planners install charging capacity to maximize the **aggregate utility of charging** in their region

- Perform **cost-benefit analysis**

Results

- **Counterfactual:** Focus on **Quebec**
  - Remove all subsidies
  - Reevaluate equilibrium sales + network provision

Table 1: Counterfactual simulation

		Counterfactuals: No Subsidies			
	Baseline	Fixed network		Network adjusts	
Δ Total sales	3.248M	-12,415	(-0.38%)	-13,126	(-0.40%)
Δ Sales (electric)	84,174	-37,920	(-45.05%)	-40,187	(-47.74%)
Δ Charging stations	2,811	0	(0.00%)	-257	(-9.14%)
Δ CO_2 emissions	141.46Mt	+0.995Mt	(+0.70%)	+1.053Mt	(+0.74%)
Total cost	723.2M				

Cost-benefit analysis

- **Policymaker** takes into account:
  - Welfare (i.e. consumer surplus, profits)
  - Total cost of policy
  - Total value of environmental damage (in dollars)

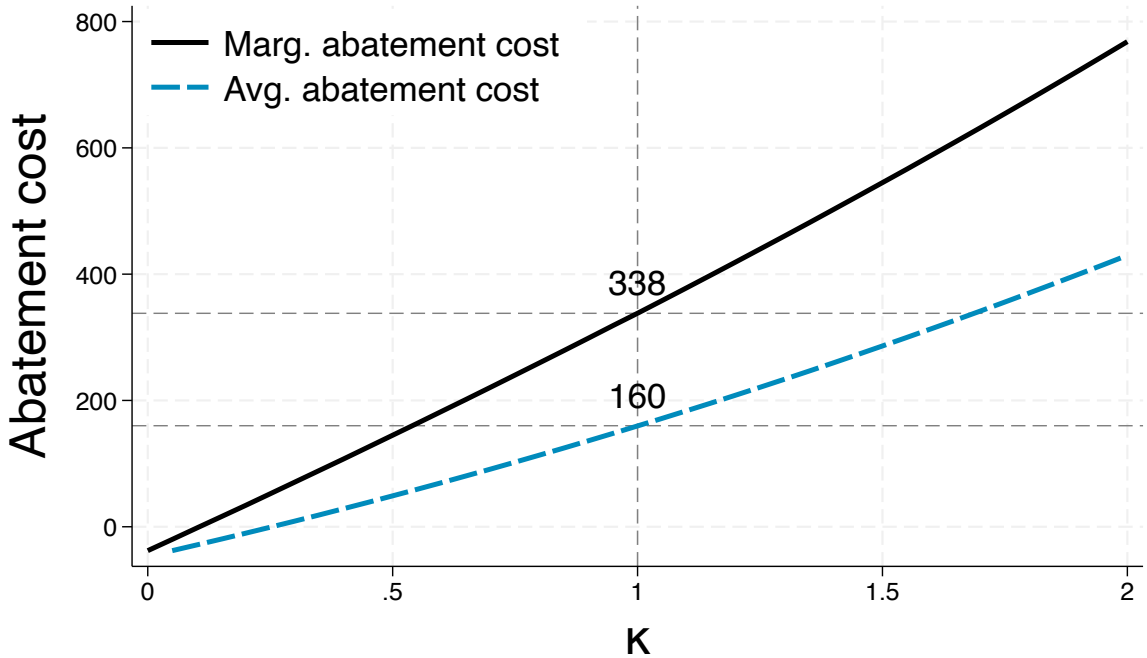
- Picks policy such that

$$\underbrace{\frac{\partial Welfare}{\partial Emission} - \frac{\partial TotalCost}{\partial Emission}}_{\substack{\text{Marginal} \\ \text{Abatement} \\ \text{Cost}}} = \underbrace{P^E}_{\substack{\text{Cost of} \\ \text{Carbon}}}$$

- Welfare, total cost, and CO_2 emissions can all be obtained using primitives of the model

Marginal abatement cost curve

Figure 4: Marginal and average abatement cost curve



- **Social cost of carbon:** $183 per ton
- **Takeway:** Over-investment on policy (beyond optimal level)

Cost-effective policy

Table 2: Cost-benefit analysis and cost-effective policies

	Calibration						
Description	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Parameters							
• Profit weight (ψ_1)	0	0	0	0.27	0.27	1	1
• Consumer surplus weight (ψ_2)	0	1	1	1	1	1	1
• Marginal cost of public funds (ϕ)	1	1.3	1	1.3	1	1.5	1.3
Cost estimates							
• Marginal abatement cost	873	600	338	552	290	595	420
• Average abatement cost	696	368	160	321	112	330	191
Cost-effective policy (High SCC: $183)							
• Provincial rebate	0	1,208	4,808	2,016	5,808	2,168	4,176
• Federal rebate	0	755	3,005	1,260	3,630	1,355	2,610

Notes: The provincial rebate and federal incentive programs subsidize electric vehicle by up to $8,000 and $5,000 respectively. The federal incentive is available as of 2019.

Conclusion

- Develop a structural model of the EV market, where charging is provided as a **public good**
- Study the impact of **subsidies** on the Canadian EV market
- Findings:
  - Subsidies are very effective at **increasing adoption**
  - Not as effective at **abating emissions**
  - Cost-benefit analysis suggests an **over-investment** on rebates
- More findings:
  - Evidence of **low synergy** between subsidies and the public provision of stations (weak network effects)
  - Evidence that **ignoring dynamics** leads to over-estimating these network effects

Thank you!