Economics 134 L18. Electric vehicles

Will Rafey

UCLA

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Announcements

1. Course evaluation!

"Please ask your students to log into MyUCLA to complete the evaluations, as instructor encouragement is one of the best ways to ensure a high response rate."

- `https://my.ucla.edu/`

2. Extended office hours, 5–7.30pm today

3. Final exam: Saturday, 12/6, 8am–11am, in **Broad 2160E**

Announcements

3. As you study, keep in mind our course objectives:

   1. assess how economic behavior gives rise to environmental destruction (or protection)
      - market failures—externalities, public goods
      - data can be helpful if we can disentangle correlation from causality
   2. evaluate outcomes in terms of welfare
      - free market outcomes can be very inefficient
      - range of distributional outcomes compatible with efficiency
   3. propose **policies** designed to improve welfare
      - tradeoffs—balance traditional measures of economic value (costs) against environmental benefits
      - better environmental policy design can improve efficiency without compromising environmental objectives

Clean technology

Innovation:

- renewable energy (L16)
- electric vehicles (today)

Clean technology

Two types of technologies:

- dirty, which produces an externality in proportion to inputs, k_d
- clean, which produces no externality

Both types have a production function $f(k)$, and incur k in input costs, so that each firm's net output is

$$f(k) - k.$$

All firms are initially dirty, but each firm can switch to clean for a fixed cost $\mathcal{C} > 0$.

Clean technology

Dirty firm. Equilibrium profits for the dirty firm are given by

$$\pi_d^*(\tau) = f(k_d^*) - k_d^* - \tau k_d^*,$$

where τ is the tax on the externality and k_d^* are the inputs used by the dirty firm.

Clean firm. Equilibrium profits for the clean firm are given by

$$\pi_c^*(S) = f(k_c) - k_c + S$$

where S is the subsidy for clean firms.

Equilibrium clean technology adoption. If the fraction of clean firms is $q \in (0, 1)$, firms must be indifferent between adopting clean or staying dirty:

$$\pi_c^*(S) - \mathcal{C} = \pi_d^*(\tau). \tag{$\star$}$$

If $\pi_c^*(S) - \mathcal{C} < \pi_d^*(\tau)$, then $q = 0$. If $\pi_c^*(S) - \mathcal{C} > \pi_d^*(\tau)$, then $q = 1$.

Clean technology: Optimal policy (recap)

Case I. Optimal tax. We calculated the optimal tax and found that it was Pigouvian.

We also found that the Pigouvian tax led to the first-best level of clean technology, q^{FB}. Why? Because to maximize W, we wanted

$$0 = \frac{\partial W}{\partial q} = f(k_c) - k_c - [f(k_d) - k_d] + k_d D'() - \mathcal{C}$$

which coincides with condition $(\star)$ at $S = 0$ and $\tau = D'(\cdot)$.

Clean technology: Subsidies only

Case II. Subsidies only. Suppose instead that we cannot directly regulate dirty production, so that $\tau = 0$.

Should we subsidize clean technology? Yes. ✓

To attain the efficient level of clean technology, we want

$$\frac{\partial W}{\partial q} = 0.$$

Equilibrium adoption is given by $(\star)$, which becomes $\frac{\partial W}{\partial q} = 0$ with a subsidy of

$$S = k_d D'(\cdot).$$

Clean technology: Subsidies only

Case II. Subsidies only (cont'd).

Clean technology subsidy without regulating existing dirty production is a **second-best** policy solution to the externality.

- will **not** reduce carbon emissions from the firms that remain dirty
- better than nothing
- worse than the optimal tax

Remark. A clean technology mandate is also second-best for the same reason.

Clean technology: Innovation spillovers

Case III. Spillovers. Finally, suppose that firms do **not** perfectly internalize the value of their clean technology adoption.

Specifically, with probability $\lambda > 0$, they will exit after investing in the clean technology (and someone else will use their invention).

This means equilibrium clean investment will only occur up to

$$(1 - \lambda)\,[\pi_c^*(S) - \pi_d^*(\tau)] = \mathcal{C},$$

i.e., firms **underinvest** in clean technology because they don't expect to capture the full value of this investment.

Clean technology: Innovation spillovers

Case III. Spillovers (cont'd). We need to subsidize clean technology so that $\frac{\partial W}{\partial q} = 0$, which we know can be written as

$$\pi_c^*(0) - \pi_d^*(\tau) = \mathcal{C}. \tag{1}$$

However, we know that equilibrium clean investment satisfies

$$\pi_c^*(S) - \pi_d^*(\tau) = \frac{1}{1-\lambda}\mathcal{C}. \tag{2}$$

So we need to pick S^{FB} that turns (2) into (1). Subtracting both sides of (1) from (2), we get

$$\underbrace{\pi_c^*(S^{\text{FB}}) - \pi_c^*(0)}_{=S^{\text{FB}}} = \underbrace{\frac{1}{1-\lambda}\mathcal{C} - \mathcal{C}}_{\frac{\lambda}{1-\lambda}\cdot\mathcal{C}}$$

so $S^{\text{FB}} = \frac{\lambda}{1-\lambda}\cdot\mathcal{C}$ is the **first-best subsidy** when there are spillovers.

Discussion

Main conclusions:

1. Without spillovers, subsidies for clean energy are **unnecessary** if we can correct the environmental externality directly
2. If subsidies are the **only available** policy instrument, they can improve welfare
    - "second-best"
3. With spillovers, subsidies are necessary for efficiency

Note that the political economy of subsidies may differ from taxes

- e.g., possibly can be given out in advance, to avoid time-consistency issues

1. Subsidies for EVs in the US

Obama stimulus (2009 American Recovery and Reinvestment Act) offered

- tax credits of $\$2500 + \alpha \cdot \$5000$, where $\alpha \in [0, 1]$ measures battery capacity
- basically, $\alpha = 1$ for EVs and $\alpha = 0$ for plug-in hybrids

for all vehicles produced after 2010.

Max 200,000 per manufacturer ($1.5 billion)

- Tesla (July 2018), GM (Nov 2018); phased out by 2020.

Additional subsidies by states:

- e.g., California ($2500 + carpool lane access), Colorado ($6000), New Jersey ($5000), Connecticut ($3000)

Biden proposed increasing incentives to $12,500/EV (for union-made); IRA allocates up to $7,500/EV (for North American-made)

Musk

Elon Musk
@elonmusk

Replying to @marenkahnert @Kristennetten and 7 others

It has always been Tesla's view that all subsidies should be eliminated, but that must include the massive subsidies for oil & gas.

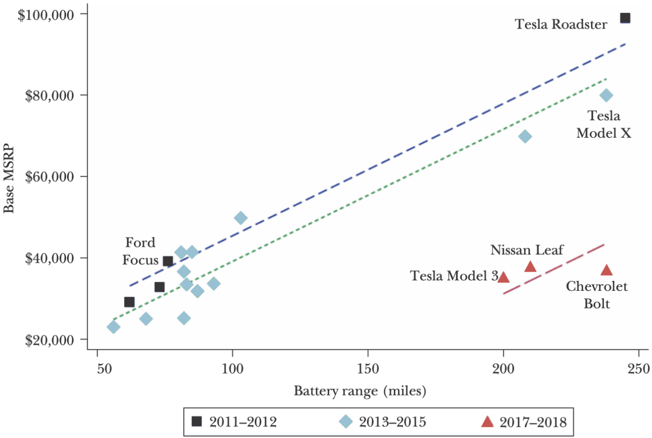
For some reason, governments don't want to do that …

4:53 AM · Nov 26, 2021 · Twitter for iPhone

1,813 Retweets **219** Quote Tweets **23.1K** Likes

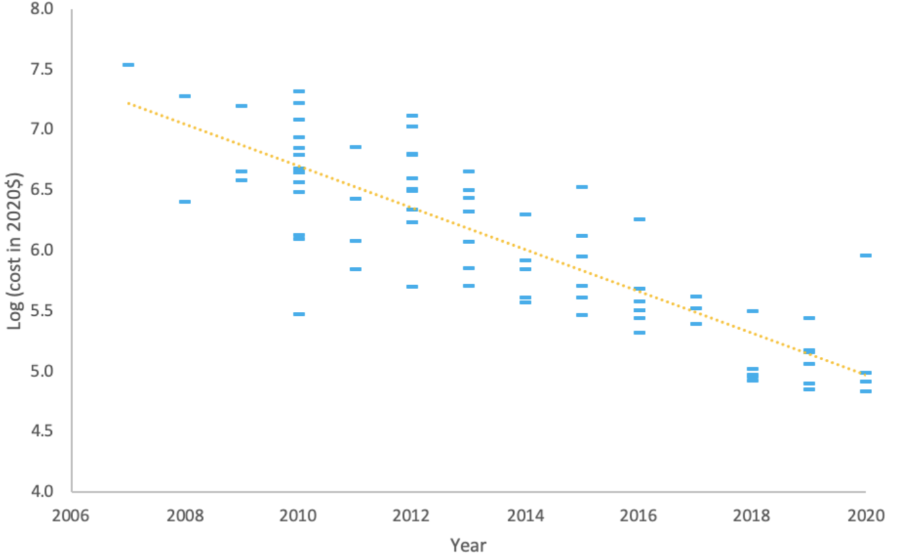
2. Electrical vehicle retail prices

Electric Vehicle Manufacturers Suggested Retail Price (MSRP) Plotted against the Battery Range Shows Impressive Technology Improvements within a Short Time



Source. Gillingham and Stock 2018.

Industry-wide average cost of batteries, $/kWh



Source. Mack Institute, University of Pennsylvania (Wharton), 2021.

Back-of-the-envelope cost declines

Substantial cost declines:

- 16% annual decline between 2007 and 2020
- the battery of a 50kWh car cost approximately
  - $\$900 \cdot 50 = \$45000$ in 2010
  - $\$144 \cdot 50 = \$7200$ in 2020

As before, it is not clear how much of these cost declines is driven by government support and whether, if it was **caused** by the government support, how much of these reflect

- economies of scale
- within-firm learning-by-doing
- across-firm learning-by-doing (spillovers)

3. Externalities from electric vehicles

As before, depends on the **counterfactual**—how much worse for the environment is driving a gas car?

- depends on the damages from local electricity generation v. local air pollution

Moxion Power Co. transportable battery on film shoot scene in Venice, CA, 13 May 2024.

Moxion Power Co. transportable battery in Venice, CA

13 May 2024.

3. Externalities from batteries in CA

This unit, `Moxion MP-75/600`, manufactured 1/19/2024, probably received a $247,000 cash subsidy from the California Clean Off-Road Equipment (CORE) program in 2024

- program aims to "deploy zero-emissions equipment throughout California"

What is it plugged into?

Cummins Inc.
QSB7-G9 diesel generator
in Venice, CA
13 May 2024.

3. Externalities from electric vehicles

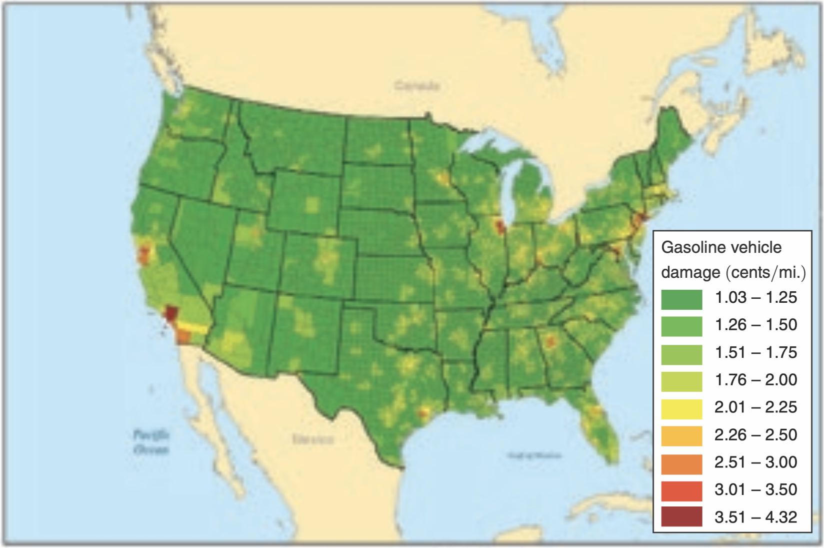
As before, depends on the **counterfactual**—how much worse for the environment is driving a gas car?

- depends on the damages from local electricity generation v. local air pollution

We'll discuss the results of a nice approach to quantify the answer to this question:

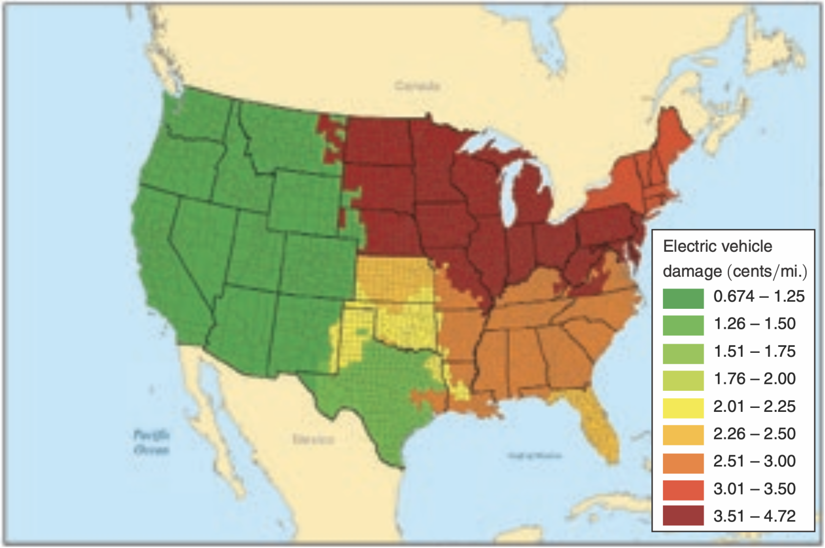
- Holland, Mansur, Muller and Yates (2016). "Are there environmental benefits from driving electric vehicles? The importance of local factors." American Economic Review, **106**(2), pp. 3700–3729.

Marginal externalities from gas vehicles, by county



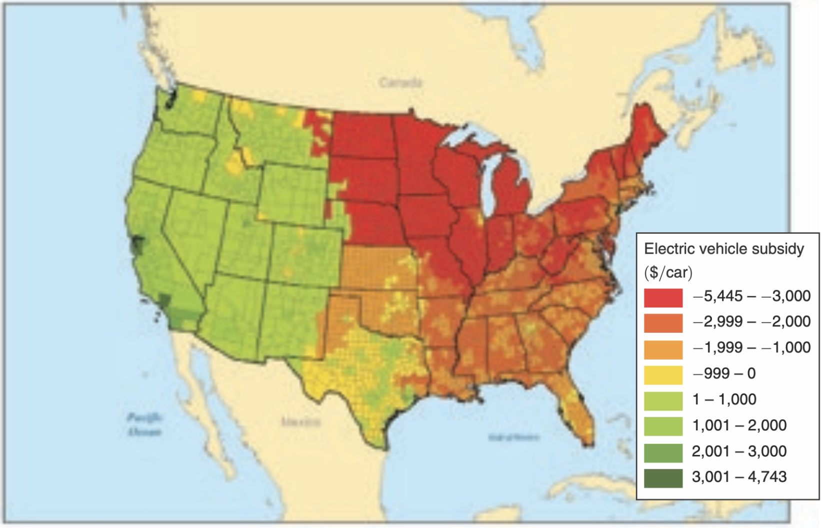
Source. Holland et al. (2016, Figure 1).

Marginal externalities from electric vehicles, by county



Source. Holland et al. (2016, Figure 1).

Second-best electric vehicle subsidy, by county



Source. Holland et al. (2016, Figure 2).

Thank you!

Final exam: 12/6 Saturday, 8am–11am.

Have a great holiday! ☃️