The Energy Transition and Climate Change

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This week

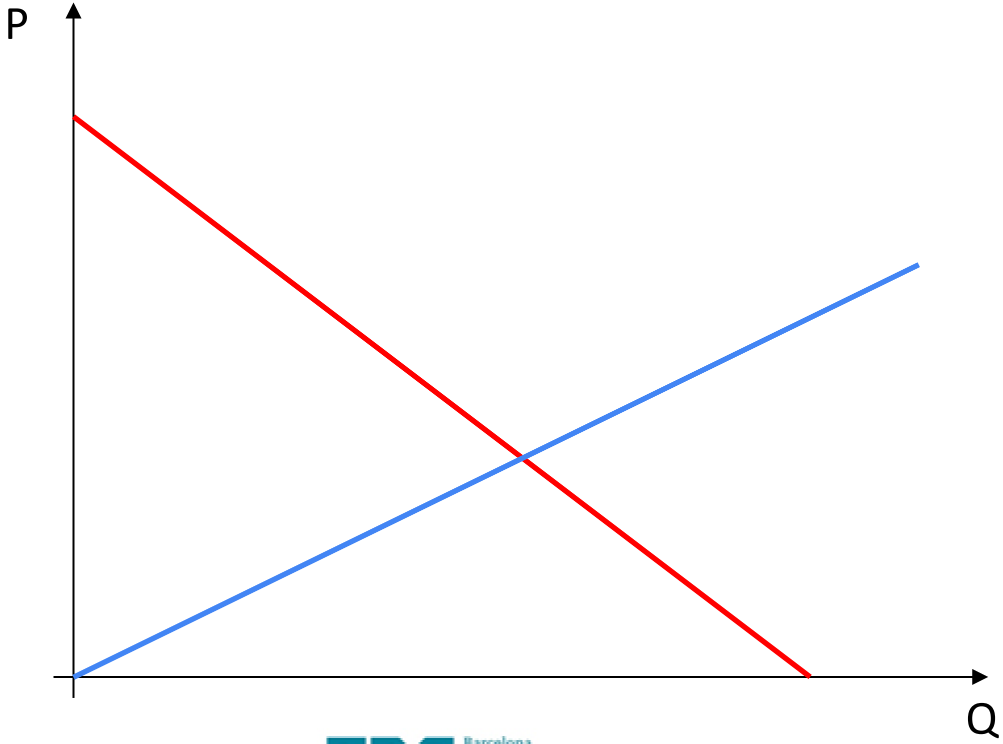
- We will discuss in detail two sets of policies relating to **emissions regulation**.
- We will compare carbon taxes, subsidies, and standards.
- We will examine leakage and carbon border adjustment mechanisms (CBAMs).

Today

- Comparing taxes, subsidies, and standards (continued) with a focus on **transportation policies**
- Numerical application
- Political economy of ethanol (reading)

Taxes, subsidies, and standards applied to transportation

Refresher: Externalities



Refresher: Externalities

- Markets work when firms and consumers face the true **social cost** of their actions
  - (And the demand curve represents society's marginal utility of consumption)
- Negative externalities drive a wedge between **social** marginal cost and **private** marginal cost
  - PMC < SMC
- Firms and consumers in the market over-produce/consume.
- They behave as if they faced lower costs.

Climate externalities from gasoline

- In transportation, GHGs are mostly carbon dioxide
- Rough numbers
  - 1 gal. of gasoline weighs about 6.3 lbs
  - Gasoline is about 87% carbon and 13% hydrogen by weight
    - 5.5 lbs carbon, 0.8 lbs hydrogen
  - When gasoline burns in a car's engine
    - Gasoline (C_xH_y) + Air (O_2, N_2) + CO_2 + H_2O + "other stuff"
    - But now the carbon is attached to two oxygen atoms in CO_2
    - 5.5 lbs of carbon * (44 lbs CO2/12 lbs C) = 20 lbs CO_2

Other pollution externalities

- Nitrogen Oxides (NO_X): From the air and high temperatures during combustion
- Volatile organic compounds (VOC's): From fuel that is partially burned
- Carbon monoxide (CO): From partially burnt fuel
- Particulate matter (PM): Partially burnt fuel (carbon soot), brake dust, roadway friction

- These pollutants also generate substantial damages.
  - Can be reduced at the vehicle "tailpipe" via engine controls (why you have a computer in your car) and catalytic converter –can also be cheated away!
  - Can also clean some of it by refining product differently

Other externalities when driving

Other externalities related to vehicle use (not directly related to gasoline):

- Congestion/traffic/noise
- Road utilization/depreciation
- Vehicle weight
- …

Climate policies applied to gasoline

- For policy, we would like to have some idea of **the *size* of the externality and tax the damage**
  - This requires measuring the costs of each of these
  - Obviously difficult to measure
  - And difficult to implement
- An alternative is to have some idea of the **optimal level of the externality**
  - That is, how much GHGs is best to have in the atmosphere
    - Understanding that GHGs are tied to benefits as well as costs
- A further alternative is to set **standards on the efficiency of cars**
- Another option is to **limit car use** (in cities, by day of week, etc.) or **ban cars**

Types of policies

- **Policy instruments** used in transportation
  - Taxes
  - CAFE standards
  - Renewable Fuel Standard (RFS) or Low Carbon Fuel Standards (similar to RFS)
  - Ethanol subsidies
  - Combustion engine phase-outs
  - Subsidies to car alternatives, in-home charging, etc.
  - Low-emissions zones, preferential lanes, toll discounts, import tax exemptions, etc.

- **Comparison** across policy instruments:
  - How does this change the marginal decisions of firms and consumers?
    - Will use both math and intuition for this
  - What is the evidence on ***their relative efficiency***?

US policies

- US has relied most heavily on:
  - **CAFE standards**: requires the average fuel economy of new vehicles sold by auto manufacturers to be above a certain level, allowing for trade
  - **Pro-Ethanol policies**:
    - Direct subsidies (up to 12/31/2012)
    - Renewable Fuel Standard

- More minor policies:
  - State and federal gasoline taxes
  - Subsidies for EV vehicles, priority lanes
  - “Cash for clunkers”

EU policies

- Much **higher fuel taxes**
  - Now gradually explicitly taxing carbon
- Also have **standards for new cars by manufacturing companies** (or groups) (Regulation (EU) 2019/631, Regulation (EU) 2023/851)
- Increasing ambition (95 g CO2 / km today to 0 g CO2 / km by 2035).
- Other regulations:
  - State subsidies (e.g., EV purchases), French “feebate” (see Durrmeyer et al. papers)
  - Low emissions zones
  - Priority parking/lanes for zero emission vehicles
  - Tax exemptions

Gaining intuition

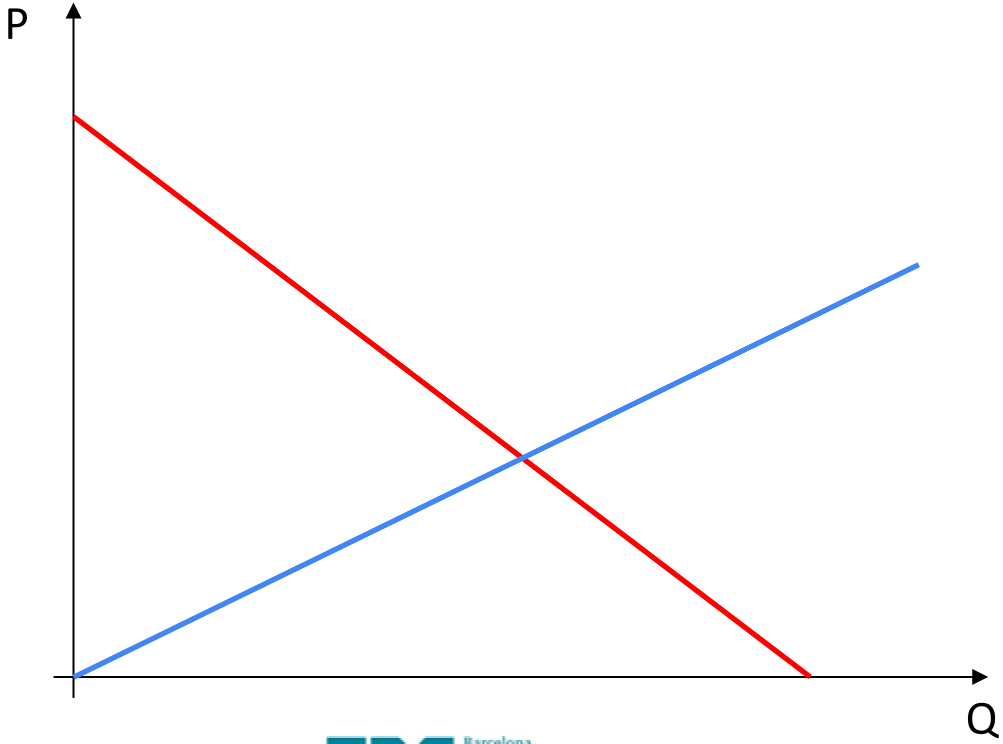
Taxes, cap-and-trade and tradable standards

- We will compare how taxes, cap-and-trade, and tradable standards work in the context of cars.
- We will use a micro 101 example.
- We will also see evidence on what are the **political economy forces** that shape these regulations in practice.

Taxes

- The economist's favorite policy instrument is to **tax the negative externality**.
  - Fundamentally, the problem is that externalities don't have a "price" associated with it
  - Therefore, products that generate the externality are too cheap, so we consume too much of them
- So, a tax will "price the externality" and "get the prices right."
  - Intuitively, what is the right tax?

Taxes

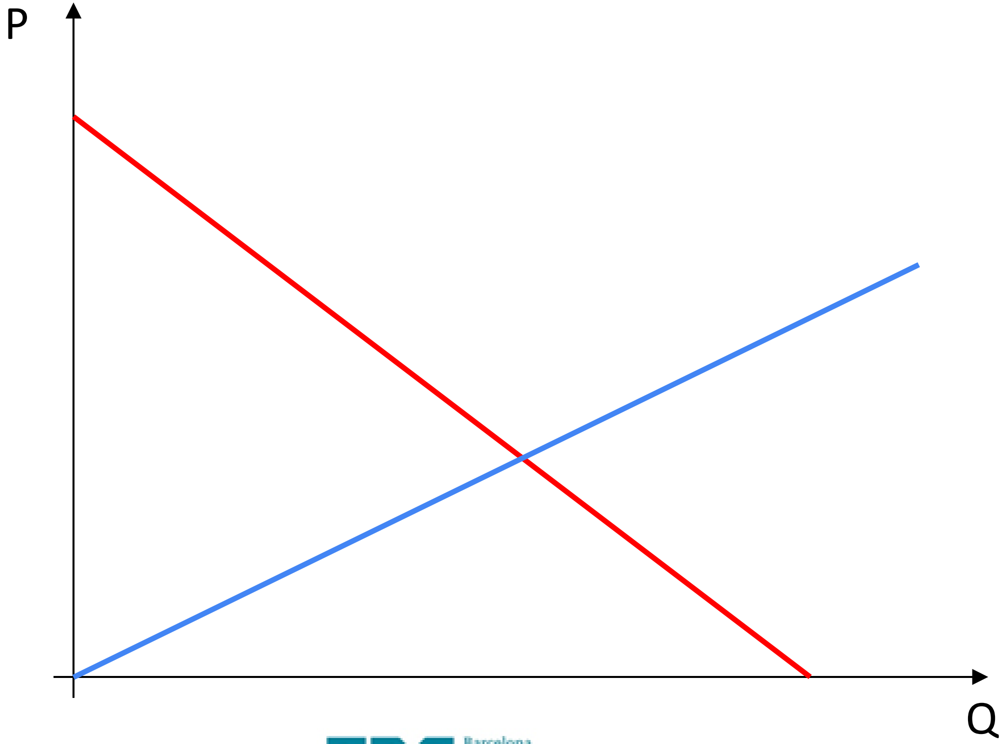


Cap-and-Trade

- Cap-and-trade sets a cap on emissions, instead of a price.
- Cap-and-trade can be equivalent to a tax (if we choose the right cap).

Note: We will see more on this when we get to electricity, as cap-and-trade is a common regulation.

Cap-and-Trade



Performance standards

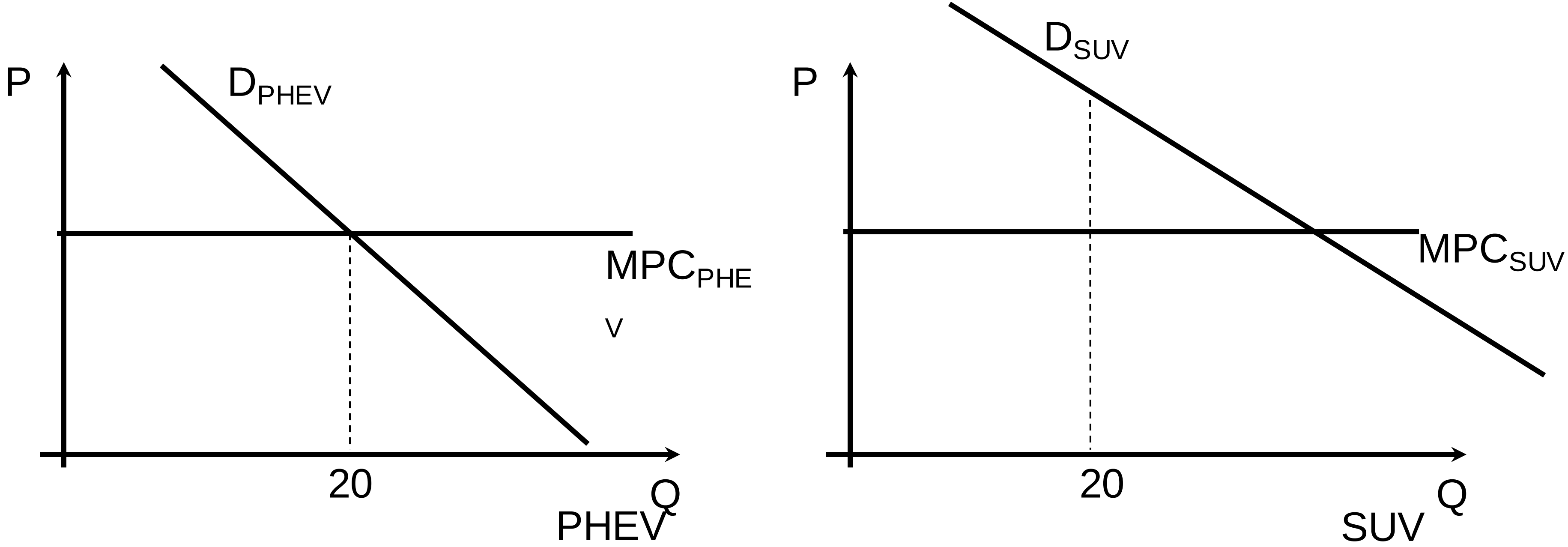
- There are a number of “performance standards” used
  - CAFE, LCFS, and RFS (the way it is implemented)
  - Also used in renewable policies, **renewable portfolio standards (RPS)**
- In each case, the firms’ average production of something has to meet a standard
  - In the case of CAFE, the firms’ average fuel economy has to be above a certain level (based on sales)
  - In the case of the LCFS (in CA and UK), the firms’ average carbon intensity of its fuels has to be below a certain level
  - The RFS is implemented in such a way that it mimics the LCFS

Performance standards: intuition

- Let’s imagine you’re a European car manufacturer
- You make SUVs and small plug-in hybrids
    - SUV = 6 l/km
    - small PHEV = 2 l/km
    - standard = 4 l/km
    - So, need equal amounts of both
- Before standard you were selling 40 SUVs and 20 small PHEVs
    - Flat demand to make things simple

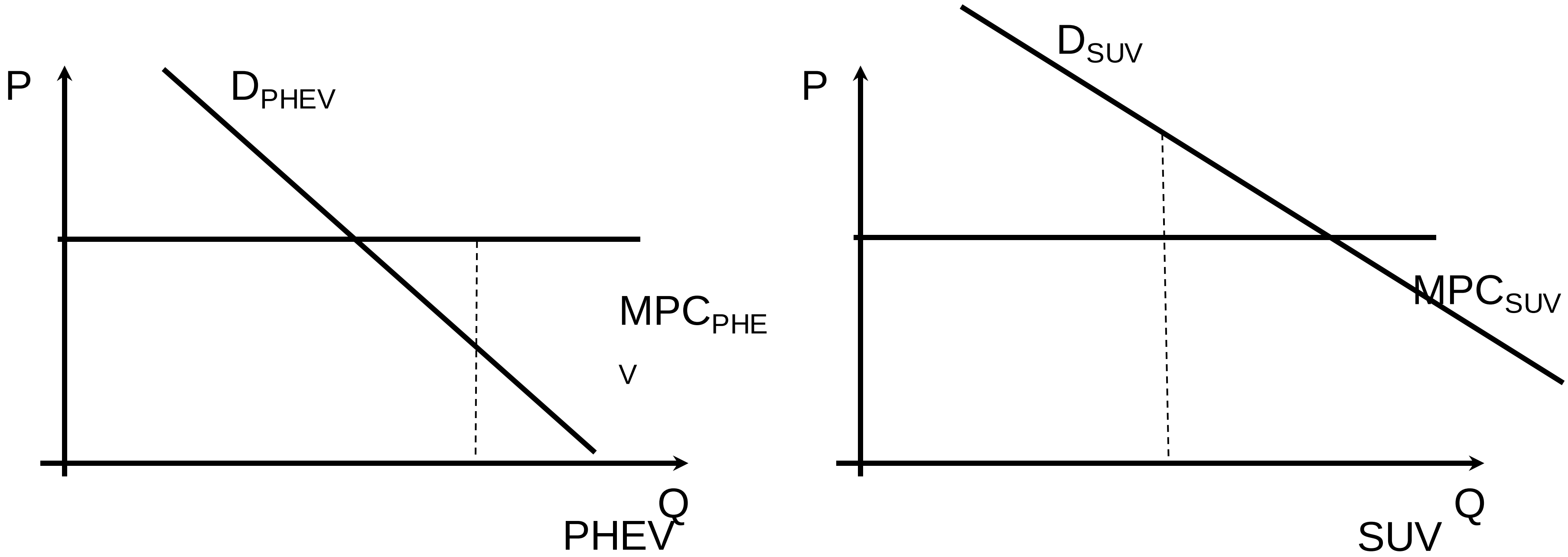
The intuition

Initial strategy: Reduce SUV sales



The efficient outcome

Optimal strategy: Equalize opportunity cost



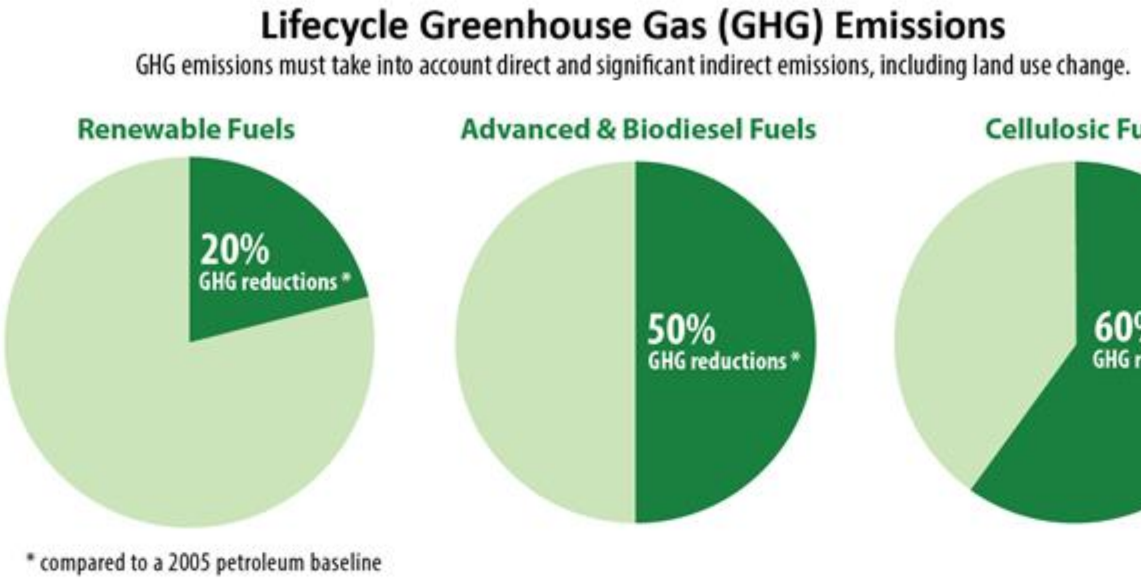
More intuition

- The firm wants to equate the marginal loss in PHEV sales with the marginal gain in SUV sales.
- Because the marginal loss in PHEV sales is “zero” (very small) and the marginal gain in SUV sales is not at the initial strategy, we know we can do better off.
- The company ends up subsidizing some PHEV sales while charging a markup on SUV cars.

Note: If the standard isn’t a simple average of the two, notice the marginal losses and gains must be weighted by the relative increase in the dirty product that the firm can get if she sells one more clean product.

An application to ethanol

Renewable Fuel Standards



Renewable/Low-Carbon Fuel Standards

- Some regulations are focused on **gasoline content**.
- Instead of affecting the initial cost of the car, they affect the relative mix of fuels by making alternative fuels more attractive.
- Note: *mechanics of how the standard works are very similar* (e.g., same math to incentives provided by the EU policy on g CO_2/km of new cars).

- Implemented in the form of **blending requirements**,
  - E.g., goal 4 billion gallons of ethanol targeted by establishing percentage standards on blend
- Allow firms to trade obligations (RINs).
- Alternatively, mandate **average emissions rate** of fuel.

Standards in mathematical framework

- Objective function:

$$\max_{q_g, q_e} \quad Pq_g + Pq_e - C_{pg}(q_g) - C_{pe}(q_e)$$
$$s.t. \quad \frac{\beta_g q_g + \beta_e q_e}{q_g + q_e} \leq \sigma$$

- Lagrangian:

$$L = Pq_g + Pq_e - C_{pg}(q_g) - C_{pe}(q_e) + \lambda(\sigma(q_g + q_e) - (\beta_g q_g + \beta_e q_e))$$

- First order condition (wedge):

$$P = C'_{pg}(q_g) - \lambda(\sigma - \beta_g)$$
$$P = C'_{pe}(q_e) - \lambda(\sigma - \beta_e)$$

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First-order condition intuition

- We can think of the price of the permits as helping define the equilibrium.
- **The price of permits equilibrates** to:
  - Equalize marginal costs between cars/technologies
  - Satisfy the constraint on the average

- FOC: $$P = C'_{pg}(q_g) - \lambda(\sigma - \beta_g)$$

$$P = C'_{pe}(q_e) - \lambda(\sigma - \beta_e)$$

with a λ that makes the standard hold. $\frac{\beta_g q_g + \beta_e q_e}{q_g + q_e} \leq \sigma$

RFS Numerical Example

- Emissions: $\beta_g = 1, \beta_e = 0.8$.
- Total quantity is fixed equal to 20 (consumers don't care if it is gasoline or ethanol, to keep math simpler).
- Regulation states that **10% of consumption needs to be ethanol**.
- Marginal costs increasing for ethanol (e.g., due to competing land use, cost of fertilizers, etc.):
  - $MC_g = 2$
  - $MC_e = 2 + q_e/2$

What is the equilibrium price of RINs, aka λ?

RFS Numerical Example

What's wrong with "feebates"?

- We haven't equated prices with MSC.
- Prices will remain too low on the fuel side
  - Ethanol effectively receives a subsidy
  - Makes gasoline cheaper than with a tax
- For car standards, prices for high MPG cars will be too low.
  - Subsidy to **purchasing cars**.

- More broadly, ethanol policies have been a disaster for agricultural practices/land use changes.

… but it might be the only feasible option (in this case, unclear if better than nothing!)

So, why do we have these policies?

- **Frequent reasons**:
  - Americans like cheap gas, renewable fuel standards or CAFE standards either not taxing full externality or no direct effect on gas prices
  - Distrust with what will be done with tax revenue, and this policies are self-funded
- **Political economy** reasons?
  - Performance standards can create large winners (for cars, domestic manufacturers get good treatment; for gasoline, agricultural production benefits)
  - It creates an obvious group of supporters, while taxes tend to make everyone worse off compared to the status quo

Studying the political economy of climate policies

- Empirical studies characterize the winners and losers of certain climate policies along a given vector: demographic (e.g., income), geographic, political.
- **Key**:
  - Understand which policies/coalitions can be successfully implemented.
  - Understand how policies can be modified/optimized while still maintaining a viable coalition.

Note: There is also a separate theoretical literature on climate agreements and how to best design them (e.g., climate clubs or international agreements). The paper today is focused on more “micro” policies.

Policies with winners more likely to pass

- Holland, Hughes, Knittel and Parker (2015) considers **support/opposition** to Waxman-Markey (attempt to pass cap-and-trade program in 2009) vs. more inefficient RFS policies.
- They show that states are more likely to vote against cap-and-trade if they benefit more from RFS.
  - Preference for those policies that generate **benefits in the region.**

- Note other example looking at French feebate for new cars (Durrmeyer, 2022)
- Other times, easier to focus on other attributes such as size (Ito and Sallee, 2021)

Key comparisons

Policy portfolio:

- Business-as-usual (BAU)
- Cap-and-trade (analogous to carbon tax in their model)
- Subsidy to ethanol production
- Renewable Fuel Standard: require a certain share of production of gasoline to come from renewable sources
- Low Carbon Fuel Standard (quite similar to RFS, but with different standards)

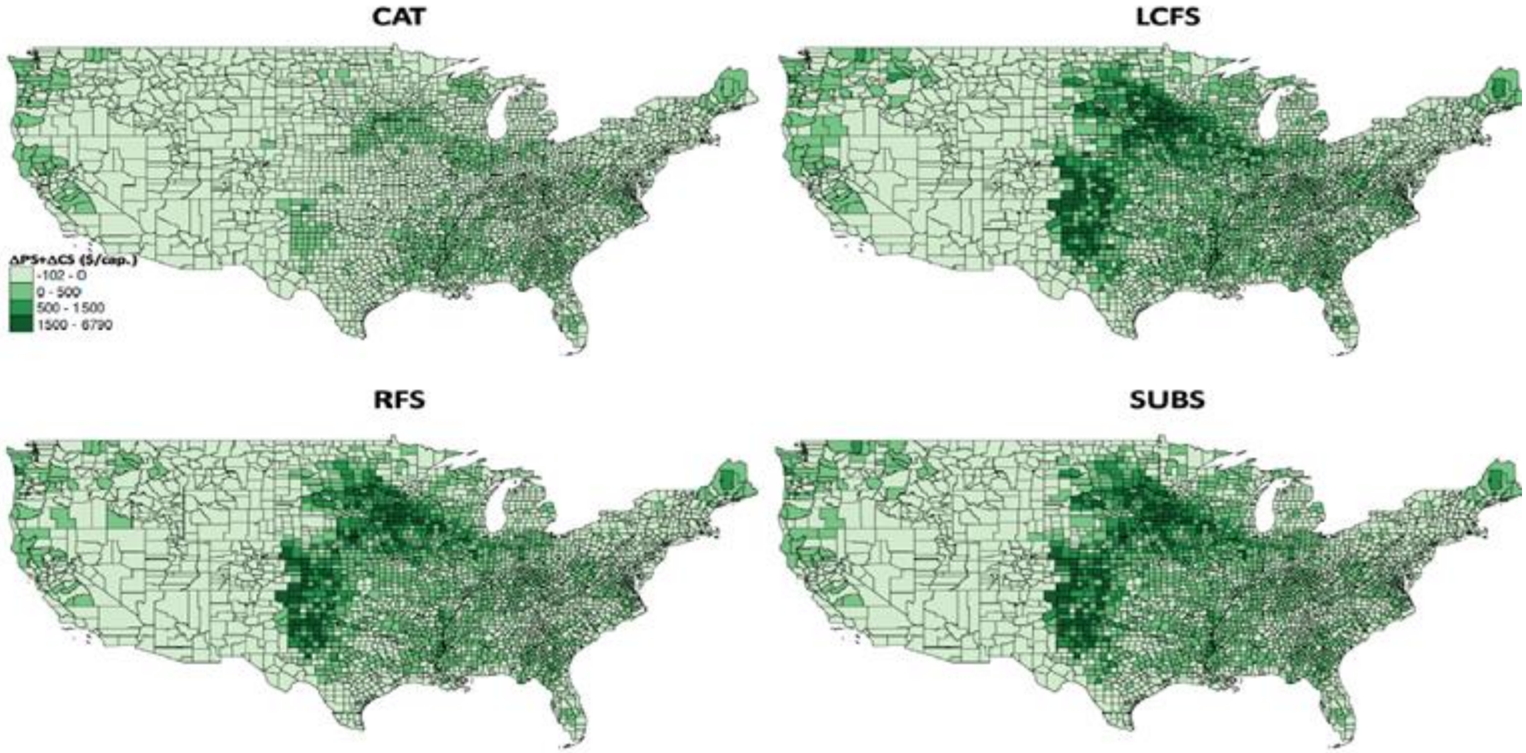
Politics meets economics

- First, what are the relative costs of the RFS v. cap & trade?

	BAU	RFS	LCFS	CAT	SUBS
ΔCS ($ bn.)		-$26.69	-$28.59	-$65.07	$0.00
ΔPS ($ bn.)		$17.12	$20.56	$2.49	$18.89
ΔPS Corn Ethanol ($ bn.)		$3.19	$0.91	$0.09	$2.50
Carbon Market Revenue ($ bn.)				$59.35	
Subsidy Payments ($ bn.)					$28.05
Carbon Permit Price ($/MTCO2e)			$189.70	$40.83	
Abatement Cost ($ bn.)		-$9.57	-$8.03	-$3.23	-$9.16
Avg. Abatement Cost ($/MTCO$_2$e)		$57.90	$48.58	$19.52	$82.30

Source: Holland, Hughes, Knittel and Parker (2015)

Are there winners?



Source: Holland, Hughes, Knittel and Parker (2015)

Taking stock of the policy

On the broader evaluation of RFS

- While RFS have been **relatively popular in policymaking**, its climate benefits have been very limited or not positive (see an early assessment by Hahn and Cecot, 2009, for an early critical assessment and Lark et al, 2022).
- Initial regulation treated ethanol as emissions-free, but the overall carbon footprint is much more unfavorable.
- It also requires many hectares of agricultural land that could be used for **food production**.
  - Biofuels produced from crops require a large amount of land for fuel production. Today, 60 million acres of U.S. farmland — almost 25% of the total area planted in the United States — is being used to produce fuel!
- It has had *ripple effects* in other areas of the world (e.g., deforestation in Brazil).

The overall assessment is negative

- Even in new mandates, concerns about the **design of the policy**.
- Assumptions about the source of alternative fuels (agriculture-based vs. synthetic fuels or other alternatives) have dramatic effects on **the implied impacts on land use**.
- **Partial** or domestic analysis also misses substantial global implications.
- Political economy still made it a *policy choice*.

EPA's New Renewable Fuel Standard Will Increase Carbon Emissions — Not Lower Them

July 3, 2023 By **Dan Lashof** Cover Image by: adamkaz/iStock

Commentary *Topic* Climate *Region* North America

More on
U.S. Climate
biofuels
transportation
climate policy
GHG emissions

When it comes to clean fuel for transportation, the EPA has taken a wrong turn.

On June 21, 2023, the U.S. Environmental Protection Agency established new Renewable Fuel Standards (RFS) for 2023-2025. The rule, intended to lower greenhouse gas emissions from transportation while reducing reliance on foreign oil, will require increased use of "renewable fuels" in coming years — specifically, biofuels produced from crops, such as corn ethanol and soy biodiesel.

Note: One can still find positive assessments that do not consider the environment (e.g., jobs in US, low gasoline prices, agricultural output) but not a good *environmental/climate/global* policy.

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