The Future of Transportation

Technology, policy, and transitions

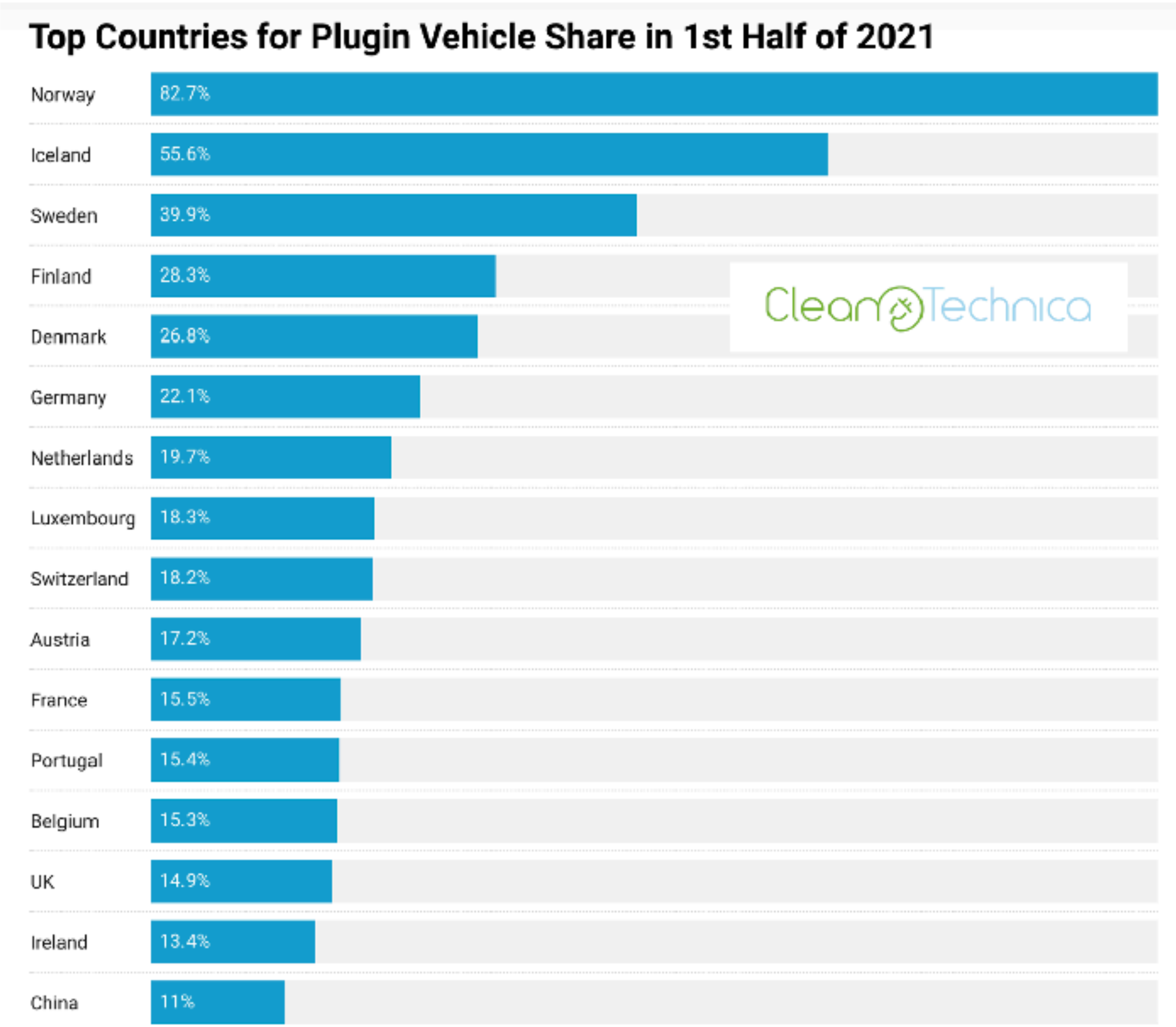
Mark Jacobsen UC San Diego Economics Roundtable November 16, 2021

Electric

- All signs point toward battery-electric
- Pace of transition "depends as much on politics as it does on markets" (John Graham, May 2021)

car Magazine, November 2021

Market Share (Sales)



- U.S. (first half 2021): 2.3%
- Most states: <1%
- California: 10.7%

Wuling Hongguang Mini EV

Best-selling EV in China (by a factor of 3 over Tesla this year)

- $4,500
- Cooperation with GM (44%)
- 1,400 pounds, 75 mile range

- ~$900 in upstream subsidies
- Large registration advantages

2022 MotorTrend Car of the Year

Lucid Air

- First units shipped October 2021
- 520/406 mile range, 933/480 HP dream/base
- High-end EV market has been dominant in the U.S.

Policy Landscape

- California and New York 100% electric (light-duty) by 2035
  - Together 31% of the U.S. market, other states likely to follow
- Structured mostly as a mandate
  - Mix-shifting creates a hidden tax on gasoline and subsidy to electric?
- Role of federal targets and overlaps
  - Will federal targets (e.g. 50% by 2030) change if more states aim for 100% on their own?

Federal Policy History

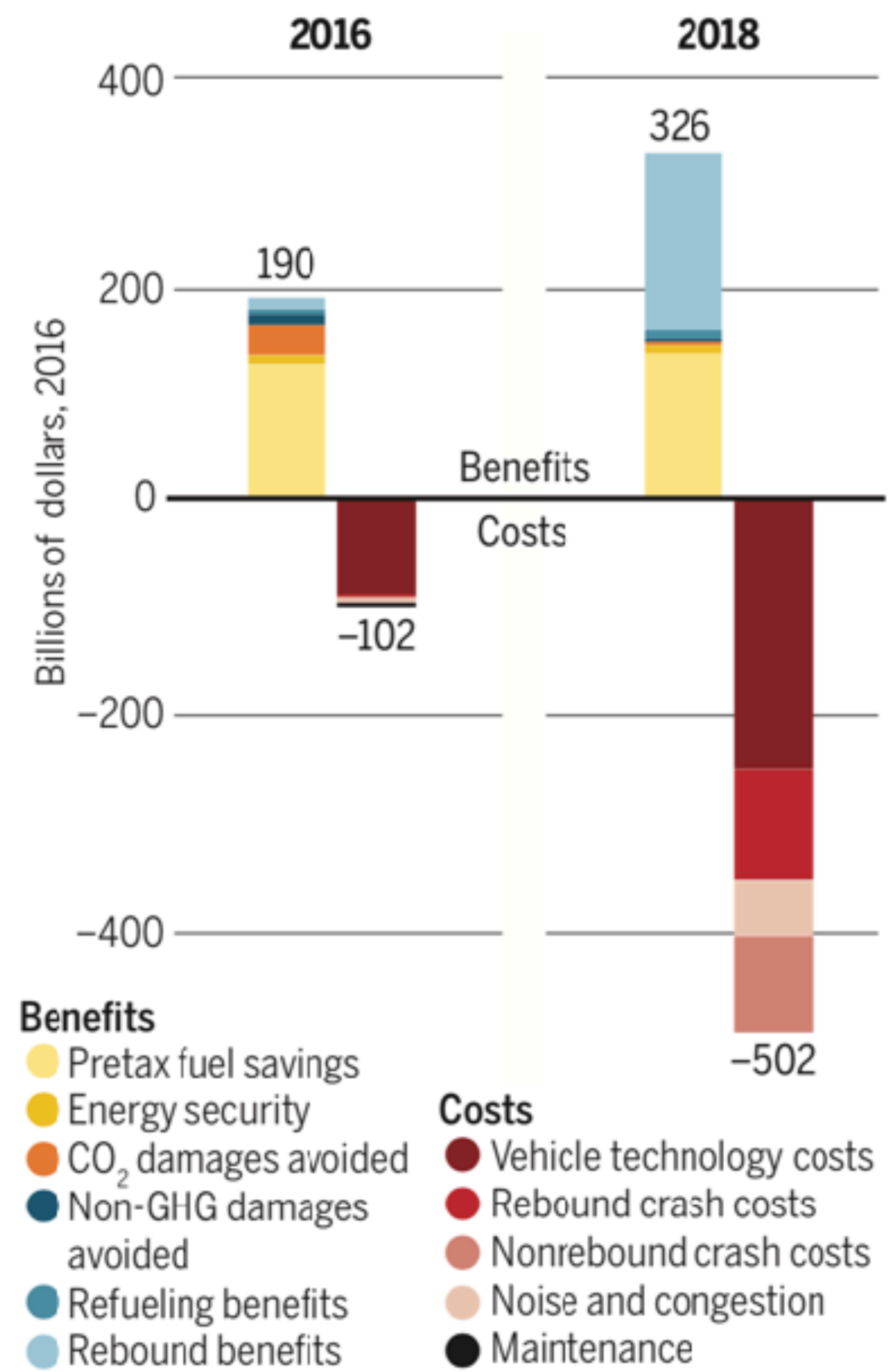
- U.S. federal fuel economy standards (which incorporate EVs) have been in use for 40 years:
  - 2010: 25.5 MPG
  - 2020: 37 MPG
  - 2025: 54.5 MPG (2016)
  - 2025: 37 MPG (2018)
  - 2025: 43 MPG (2021)
- Most U.S. auto producers came out against the 2018 revision, but it polled well among voters

Federal Policy History

CAFE Cost-Benefit

2016 (Obama EPA) vs 2018 (Trump EPA) economic analyses of 2025 CAFE rules:

- Key changes:
  - Safety and size of used car fleet
  - Technology costs
  - Value of CO_2



Federal Policy Future

Build Back Better Bill

- November 8th version, rapidly evolving
  - $12,500 credit for EVs ($8,000 if not union-made)
- GM and Tesla have both exceeded their cap (200,000 vehicles) under the current subsidy
  - Build Back Better would re-open subsidies for 10 years (5 years for imports)
- Limits
  - $80,000 vehicle price cap
  - $500,000 AGI cap (joint filers, recently reduced from $800,000)
  - Back and forth on refundable provision

The Missing Policy: Scrappage

- Vehicle stock in the U.S. has been stable (about 270 million)
  - Scrappage $\approx$ sales
- Many reasons to think scrappage is beneficial
  - Air quality
  - Safety
  - Stimulus
  - And now, pace of electrification

Scrap Elasticity

What determines if this (gasoline) vehicle will be scrapped, or repaired and driven another 100,000 miles?

- Answer: mostly, its value
- Elasticity about -0.7 (Jacobsen and Van Benthem, 2015)
- Used and new vehicle prices tend to move together

Changing The Used Fleet

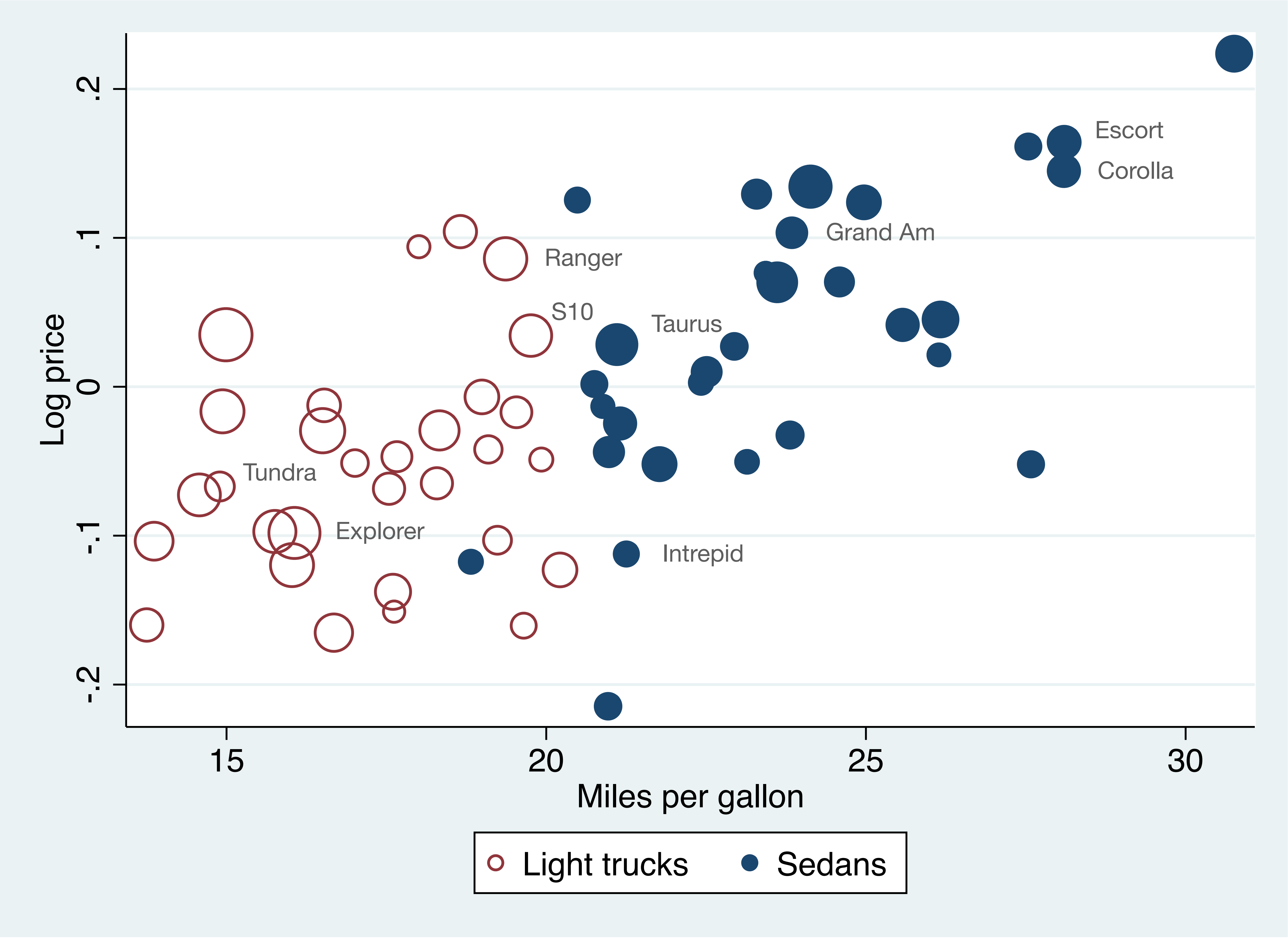
- Because cars last so long, changes in the used fleet are important for policy

- Understudied in economics: many policy analyses assume a fixed profile of scrappage

- Literature: “Cash-for-clunkers” evaluations (e.g. Mian & Sufi, 2012), “Scrap bounty” evaluations (e.g. Hahn (1995), Alberini, Harrington & McConnell (1998))

- Less work on the long term ability of policy to alter turnover

Effect of a $1 Gasoline Price Increase on Used Vehicle Prices



Link to Scrappage ($1 change in fuel price)

Fuel Economy	Used vehicle value	Annual scrap rate
15 MPG	-$786	+1.6
20 MPG (average vehicle)	-$227	+0.3
35 MPG	+$611	-1.5

(For a typical used vehicle valued at $7,000 with scrap rate of 3% per year)

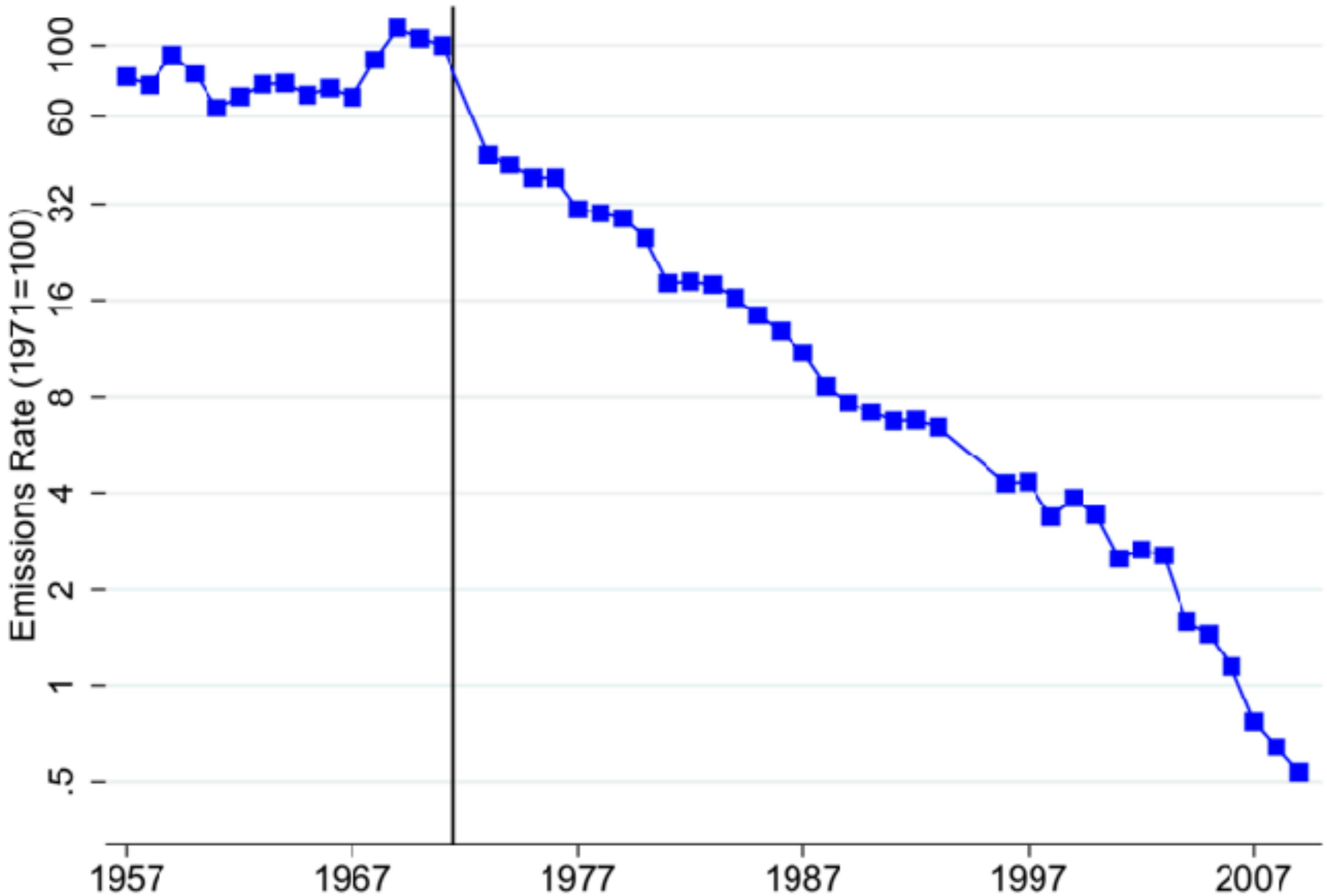
Translates to the elasticity of approximately -0.7

Air Quality Benefits

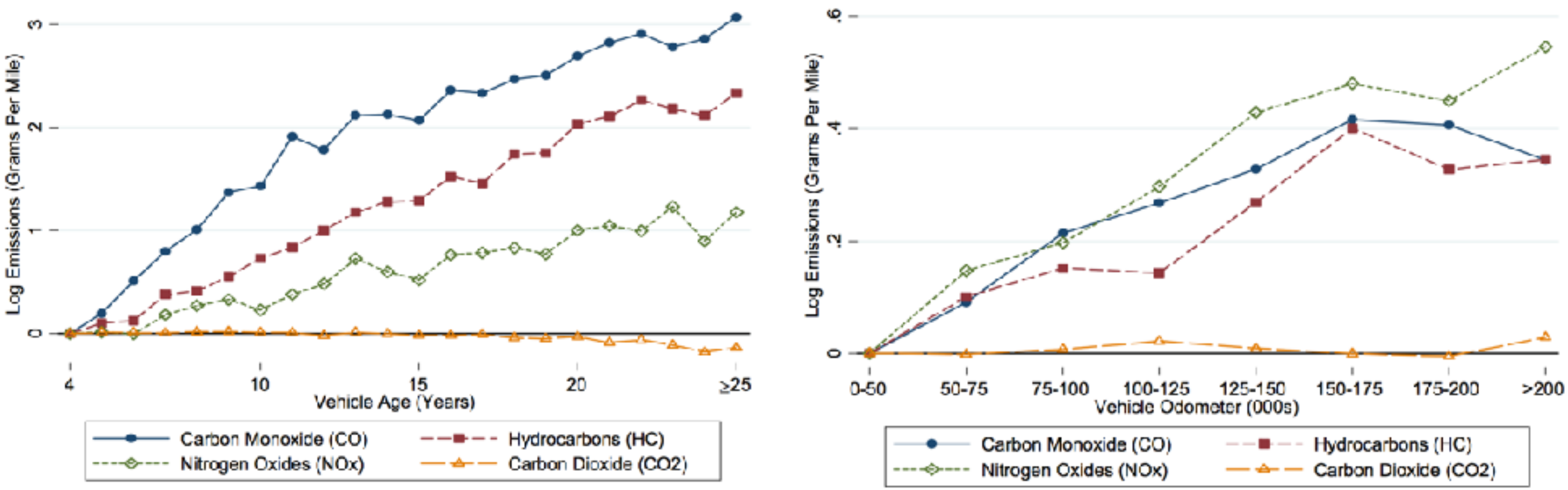
- Preliminary findings from Jacobsen, Sallee, Shapiro, and van Benthem (2021 working paper)
- Large scale health damages occur due to pollution from older used cars
- Key existing regulations are “tailpipe” standards, mandating specific control equipment on new cars, and "smog check," removing gross polluters
- We document the remarkable effectiveness of new-vehicle tailpipe standards and show how further dramatic gains are possible using scrappage policy

Emissions Across Vintages: Nitrogen Oxides

- First regulated in 1972
- Log scale
- Other (local) air pollutants similar reductions



Within Vehicle, Over Time



- Graphs hold the VIN stub fixed (year, make, model, trim)
- Age and odometer both increase local air pollutants (but not CO_2)

Results

- Compounding effects from vintage and age create large changes in health damage:
  - New $200/year
  - Age 20 $2000/year
- Typical values of 15-20 year old vehicles mean that relatively small fees can have a large influence on scrappage
  - Scrap/repair decisions take account of cumulated future fees, not just one year
- Scrap effects earlier in the age distribution (around 10 years) also turn out to be economically important

Influencing Scrappage

- Pulling cars into retirement: scrap subsidy
  - Pros: opt-in, possibility that subsidy goes to lower-income groups
  - Cons: most payments don't create additional scrappage, very expensive program, decreases average cost of driving (worsens congestion, other externalities)

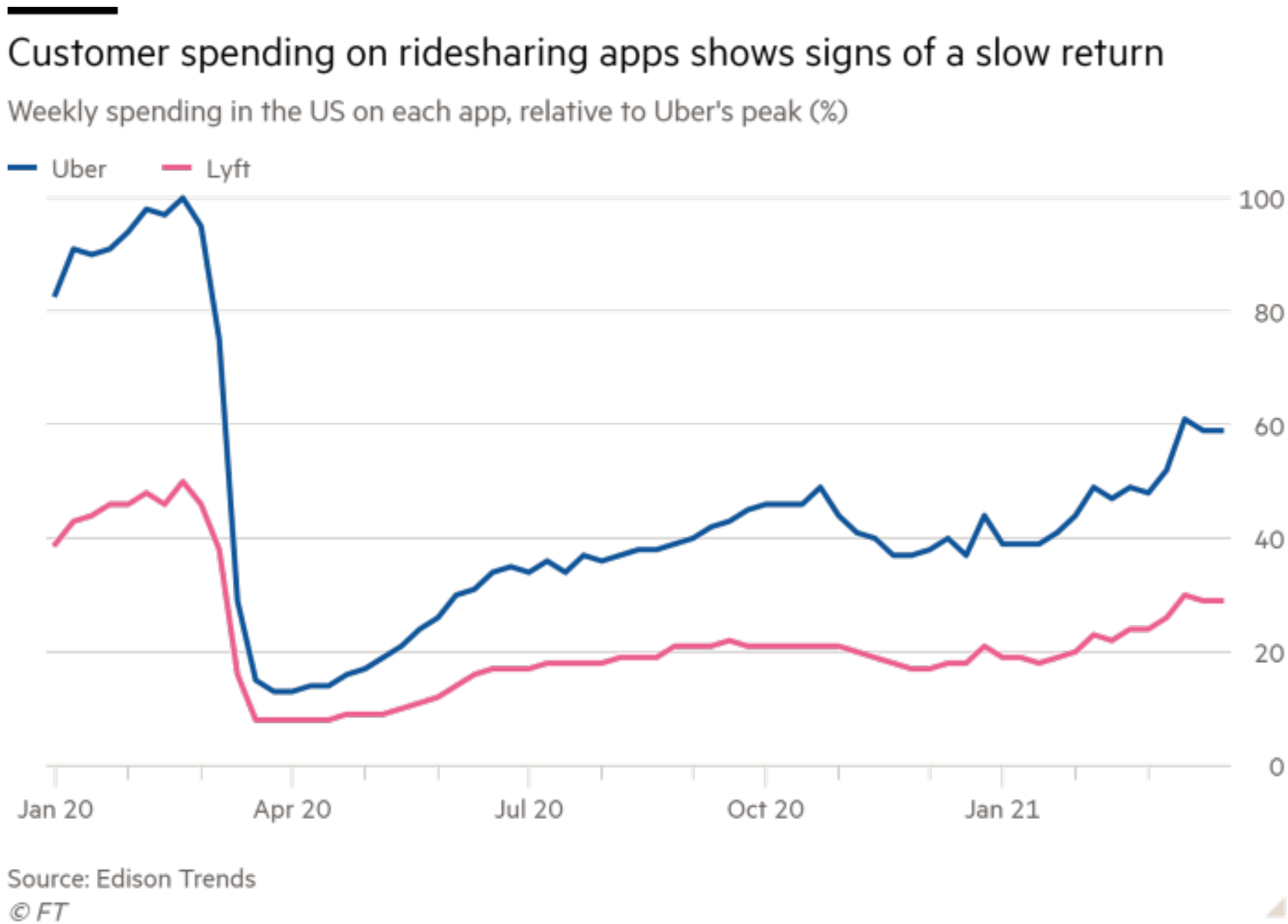
- Pushing cars into retirement: registration fees
  - Pros: increases the average cost of driving
  - Cons: increases the average cost of driving

Scrap Policy

- Scrappage is part of an economically efficient strategy to transform the fleet
  - It is also very difficult to incentivize
- Equity
  - Large EV subsidies may go mostly to high-income groups (new car buyers, multi-car households)
  - Flatter registration fees would fall more on low-income groups
  - There is also a significant urban/rural divide on vehicle age

The Other Two Revolutions

Sharing

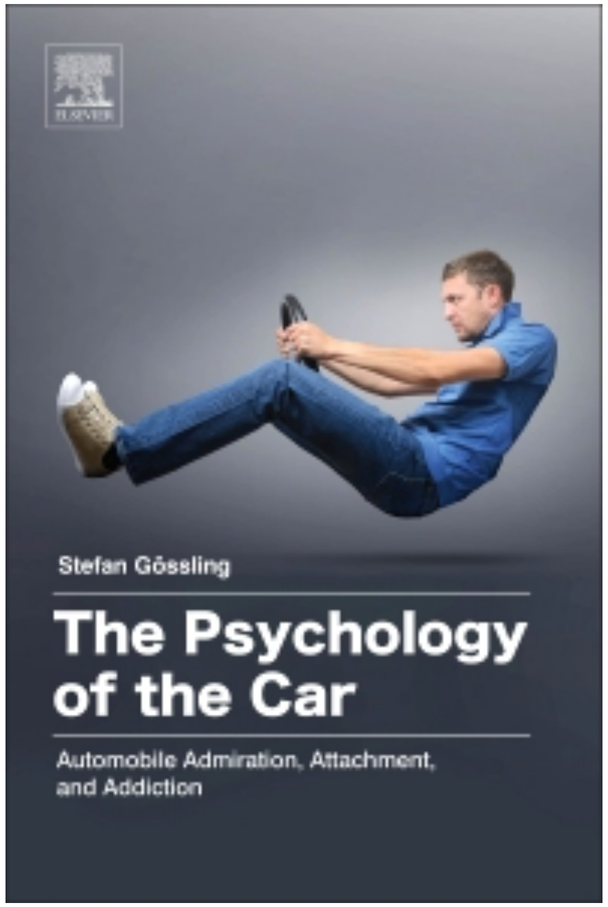


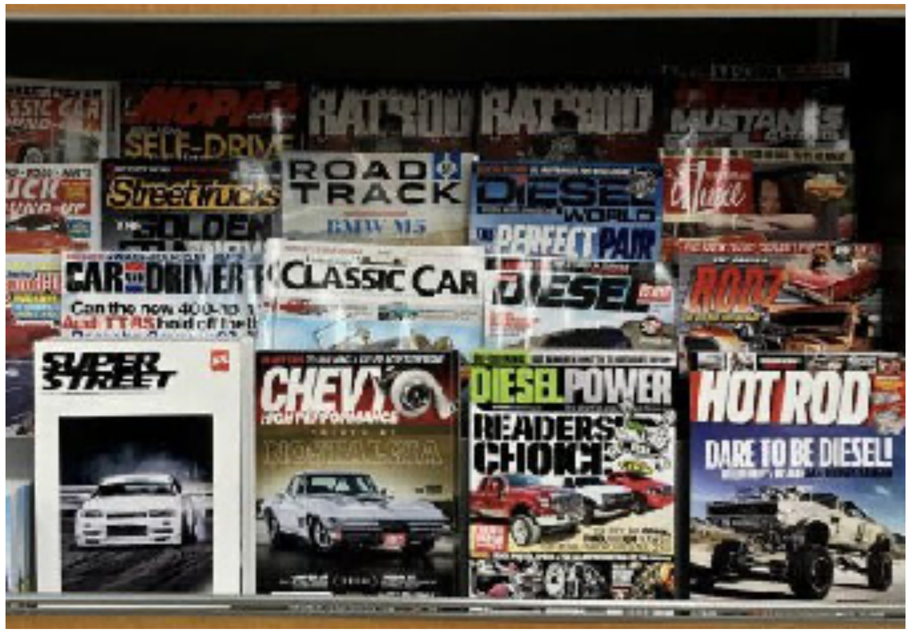
- Slow rebound from Covid due to reduction in capital inflows? Perhaps also policies on wages and benefits?

The Other Two Revolutions

Sharing

- Ride-sharing will likely capture the entire taxi market, and then some
- I'm not as optimistic as many about how big the "and then some" will be
    - Children, safety, cleanliness, shopping trips
    - Cost: 3,500 mile break-even, 5th percentile (McKinsey 2018)
    - Psychology, pride of ownership





The Other Two Revolutions

Automation

- Promises to transform
  - Safety
  - Convenience
- Tesla Autopilot (3 billion miles)
- Waymo (20 million miles)

Time Magazine, October 2015

The Other Two Revolutions

Automation

- When automation comes, I think it will change transportation and society more than anything else I've discussed
- Reduced (time) cost of travel
- Urban form: parking, commutes, real estate
- Health and safety, congestion, law enforcement
- Spatial economic growth, urban infrastructure
- Caveat: Trust? Driverless elevator technology took 50 years to capture the market

Alternative Transportation

- Buses and rail
  - Some technological improvements (e.g. real-time tracking, bus accident safety), but appears quite limited relative to cars
- Vast majority of U.S. population chooses to move by private car
  - New technologies seem poised to increase the preference for cars over bus and rail
  - Simultaneous public transport investment could slow the shift toward cars
- E-Bikes: incredibly rapid technological change, as with cars
- Distant future: something altogether new and transformative?

Local Policy

- Los Angeles, especially aggressive charging station subsidies
  - January 2021: 11,000 public charging stations (226 high speed) and 63,000 EVs (nearly 1% of vehicles)
  - High targets for EV sales (how will it meet them?)
- Electricity
  - San Diego electricity prices are quite high (3-4x national average)
  - Solution: subsidize EV owners' electricity

Local Policy

- Local EV tech hub?
  - Rivian (based in Irvine) startup with 800 HP electric pickup, market cap greater than that of General Motors
  - Large-scale lithium mining as close as the Imperial Valley
  - Nickel, cobalt, and manganese from the deep sea may be landed in San Diego