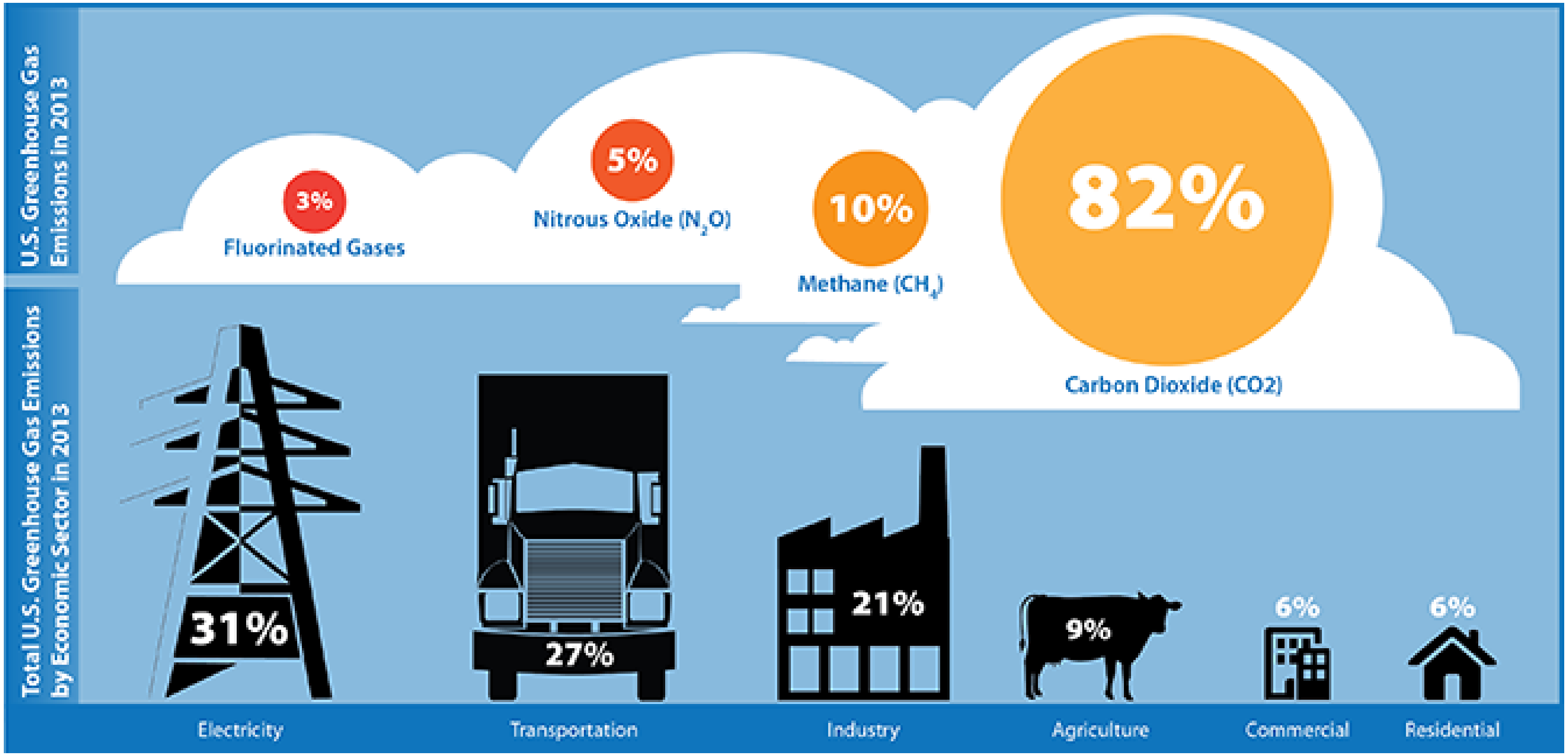
# UNINTENDED CONSEQUENCES OF FUEL-ECONOMY POLICIES

ARTHUR VAN BENTHEM

Wharton
UNIVERSITY of PENNSYLVANIA

# Why Regulate Transport?

Greenhouse gas emissions, United States




Source: U.S. Environmental Protection Agency

# Oil Demand for Transportation Keeps Growing…

**Table 3.3 ▷ World oil demand by sector in the New Policies Scenario** (mb/d)

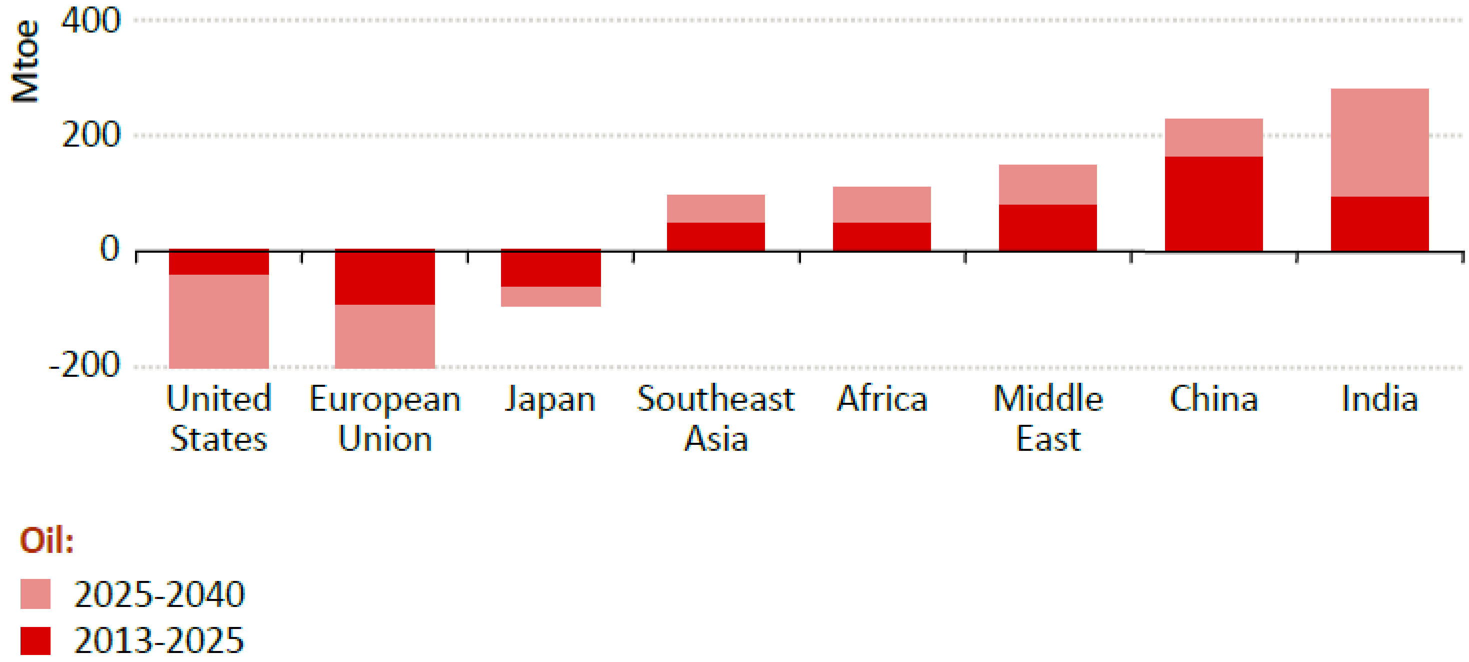
| | 2000 | 2014 | 2020 | 2025 | 2030 | 2035 | 2040 | 2014-2040 Change | 2014-2040 CAAGR* |
|---|---|---|---|---|---|---|---|---|---|
| Power generation | 5.8 | 5.3 | 4.4 | 3.7 | 3.2 | 3.0 | 2.8 | -2.5 | -2.4% |
| Transport | 38.8 | 49.5 | 53.2 | 55.4 | 57.3 | 58.9 | 60.4 | 10.9 | 0.8% |
| Petrochemicals | 9.5 | 11.5 | 14.1 | 14.9 | 15.8 | 16.6 | 17.2 | 5.6 | 1.5% |
| Feedstocks | 8.1 | 10.1 | 12.5 | 13.3 | 14.1 | 14.9 | 15.5 | 5.4 | 1.7% |
| Other industry | 4.9 | 4.9 | 5.1 | 5.1 | 5.1 | 5.1 | 5.2 | 0.3 | 0.2% |
| Buildings | 7.9 | 7.6 | 7.2 | 6.6 | 6.2 | 5.9 | 5.8 | -1.8 | -1.1% |
| Other** | 9.9 | 11.7 | 11.9 | 12.1 | 12.2 | 12.3 | 12.2 | 0.5 | 0.2% |
| Total | 76.9 | 90.6 | 95.9 | 97.9 | 99.9 | 101.7 | 103.5 | 12.9 | 0.5% |

* Compound average annual growth rate. ** Other includes agriculture, transformation and other non-energy use (mainly bitumen and lubricants).

Source: IEA World Energy Outlook

# … But Mostly in Emerging Economies

Oil demand projection by region, 2013-2040




Source: IEA World Energy Outlook

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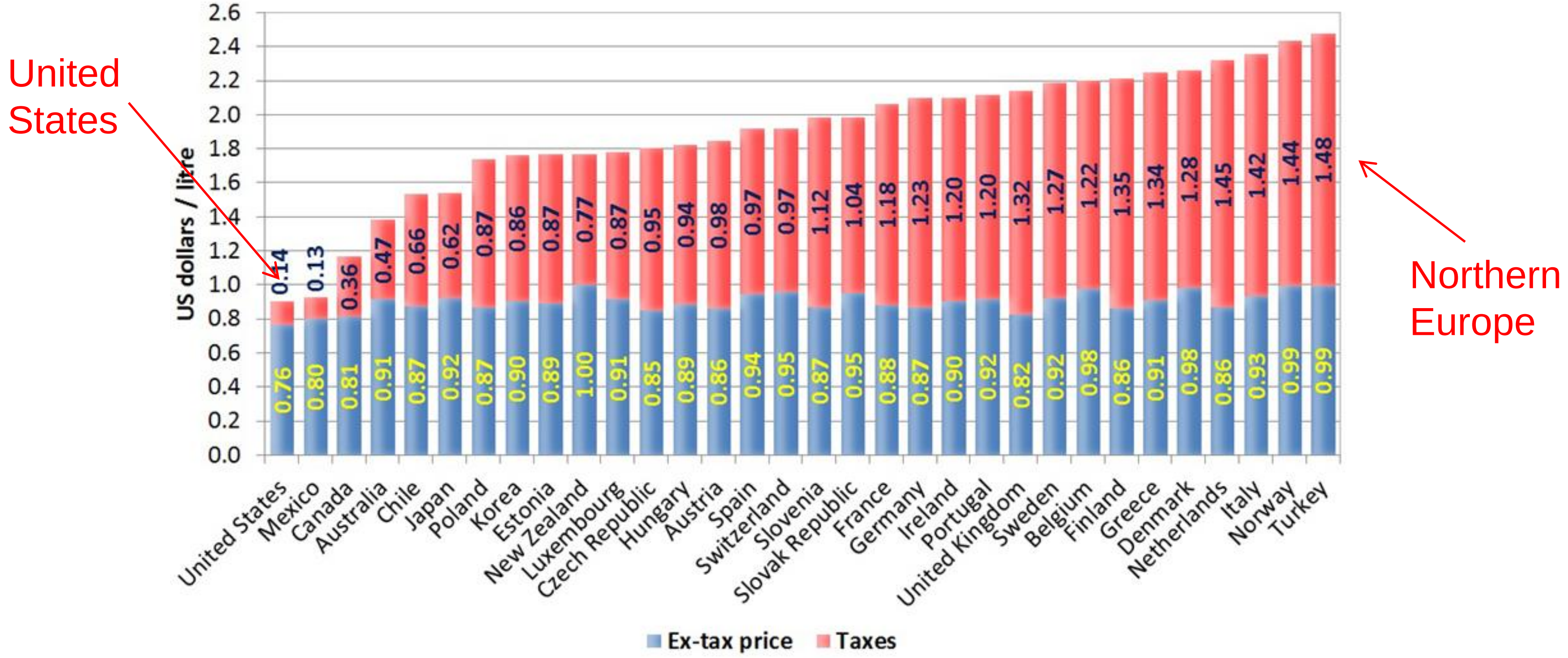
# How to Regulate GHG Emissions from Transport?

- Option 1: Gasoline tax
- Option 2: Fuel-economy standard
- Plus many others, but these are the most important ones

# Taxing Gas Has Proven Possible in the EU…

Fuel taxes by country




The United States has one of the lowest gasoline taxes in the OECD

Today's gas price in the Netherlands is $6.20/gallon

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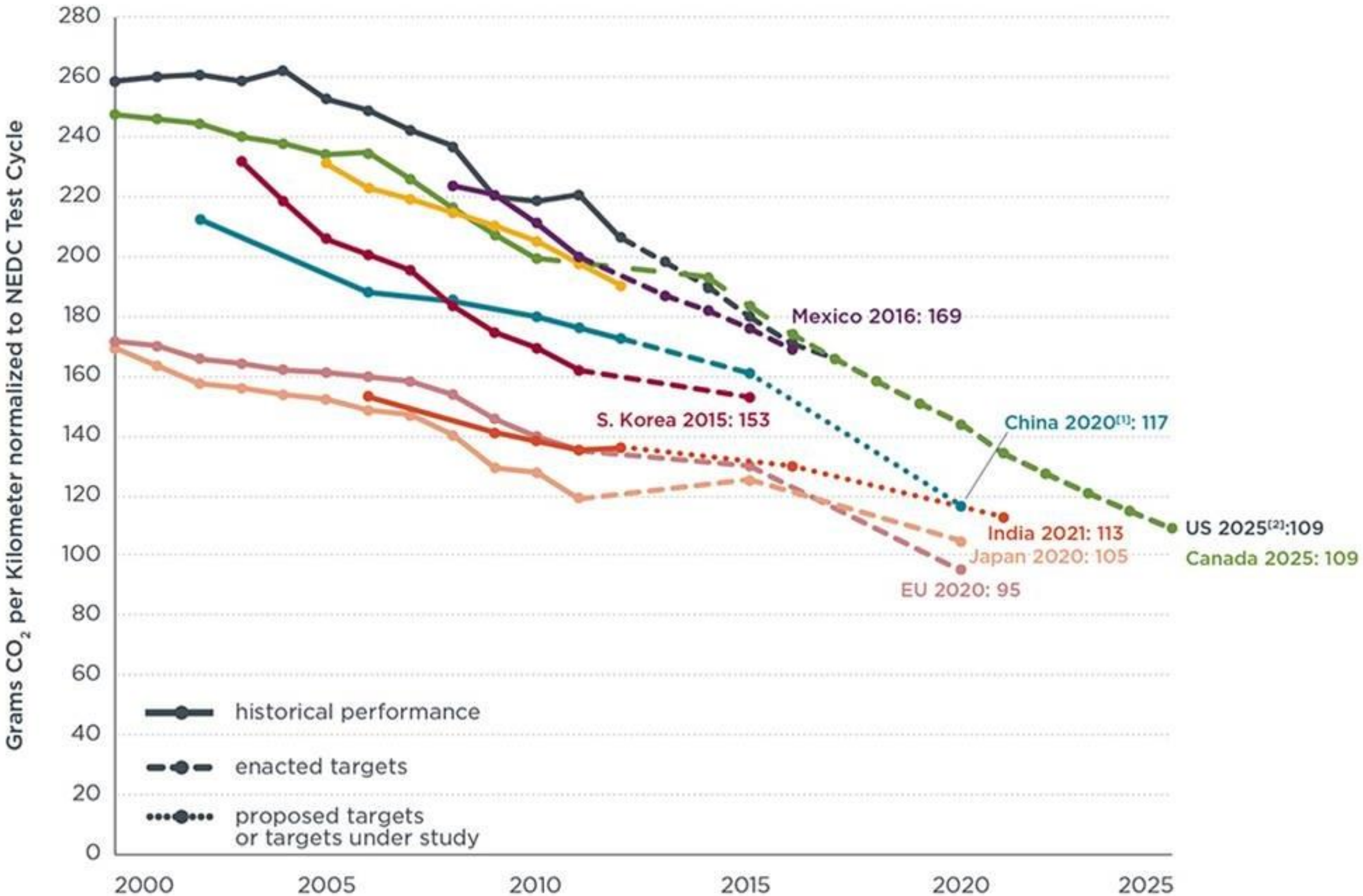
# … But Other Countries Prefer Fuel Economy Standards




Source: International Council on Clean Transportation

# What Is A Fuel-Economy Standard Exactly?

Target stated in terms of the harmonic mean of the miles per gallon (MPG)

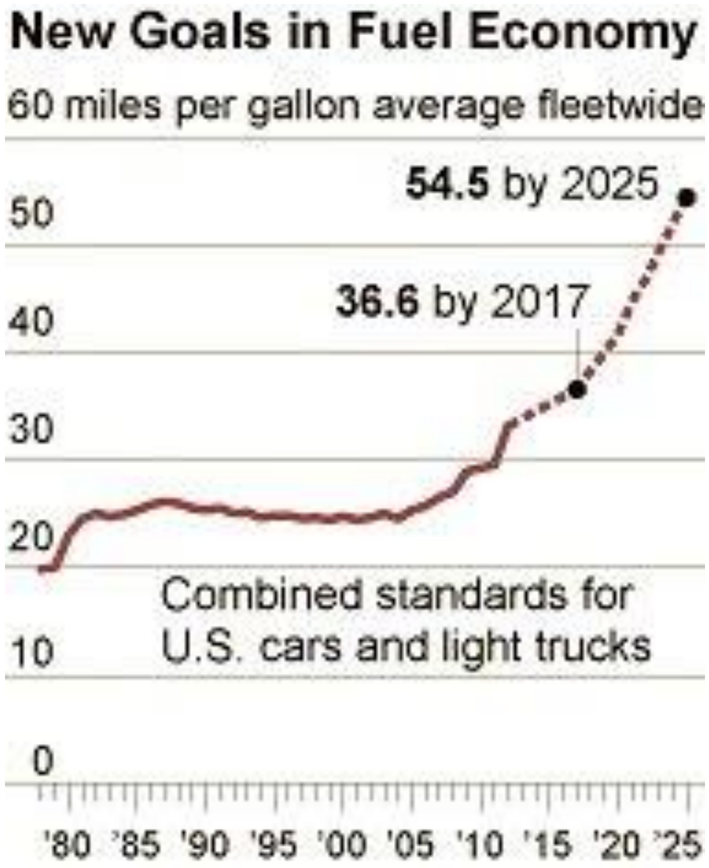
Sales for each model →

$$\frac{q_1 + q_2 + q_3 + q_4}{\frac{q_1}{mpg_1} + \frac{q_2}{mpg_2} + \frac{q_3}{mpg_3} + \frac{q_4}{mpg_4}}$$

Inefficient cars get more weight, since we care about emissions per mile

$$\frac{4}{\frac{1}{15} + \frac{1}{13} + \frac{1}{17} + \frac{1}{100}} = 18.83$$

$$< \frac{15 + 13 + 17 + 100}{4} = 36.25$$




Source: National Highway Traffic Safety Administration

# Fuel-Economy Standards in the US

- Corporate Average Fuel-Economy (CAFE) standards aim to achieve a fleetwide average of 54.5 MPG by 2025
  - Negotiated in 2010-2011 between government and automakers, supported by environmentalists and labor unions
- Foreign automakers complained
  - GM, Ford and Chrysler benefit since light trucks facer laxer standards
- Non-compliance penalty: $55 per MPG per vehicle
  - Historically, European manufacturers simply pay fines
- Based on CAFE MPG << window sticker MPG
  - Edmunds: "54.5 CAFE MPG = 36 window sticker MPG"!

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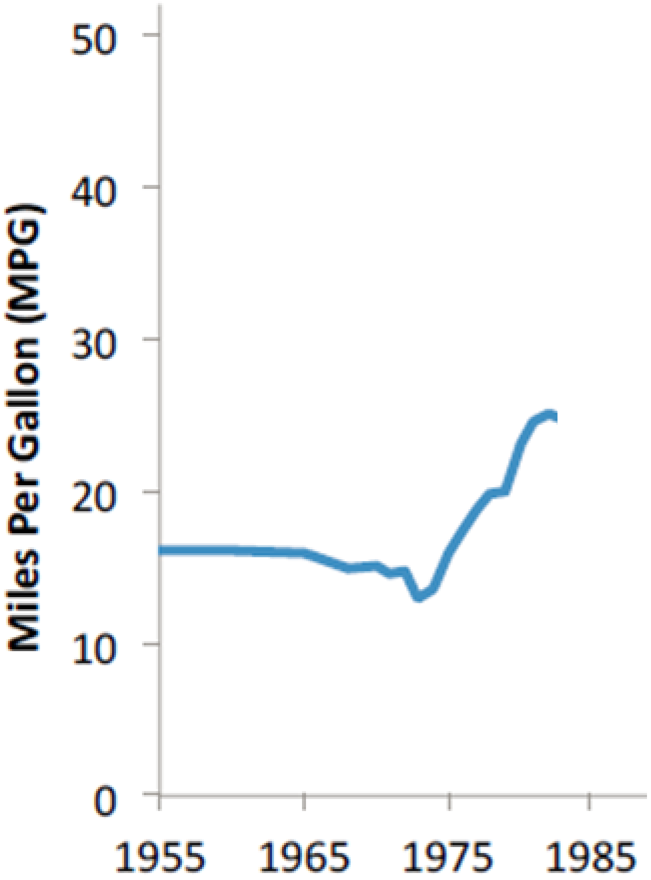
# Early Implementation Was a Great Success…

Fuel-economy of cars went up fast from 1975-1983

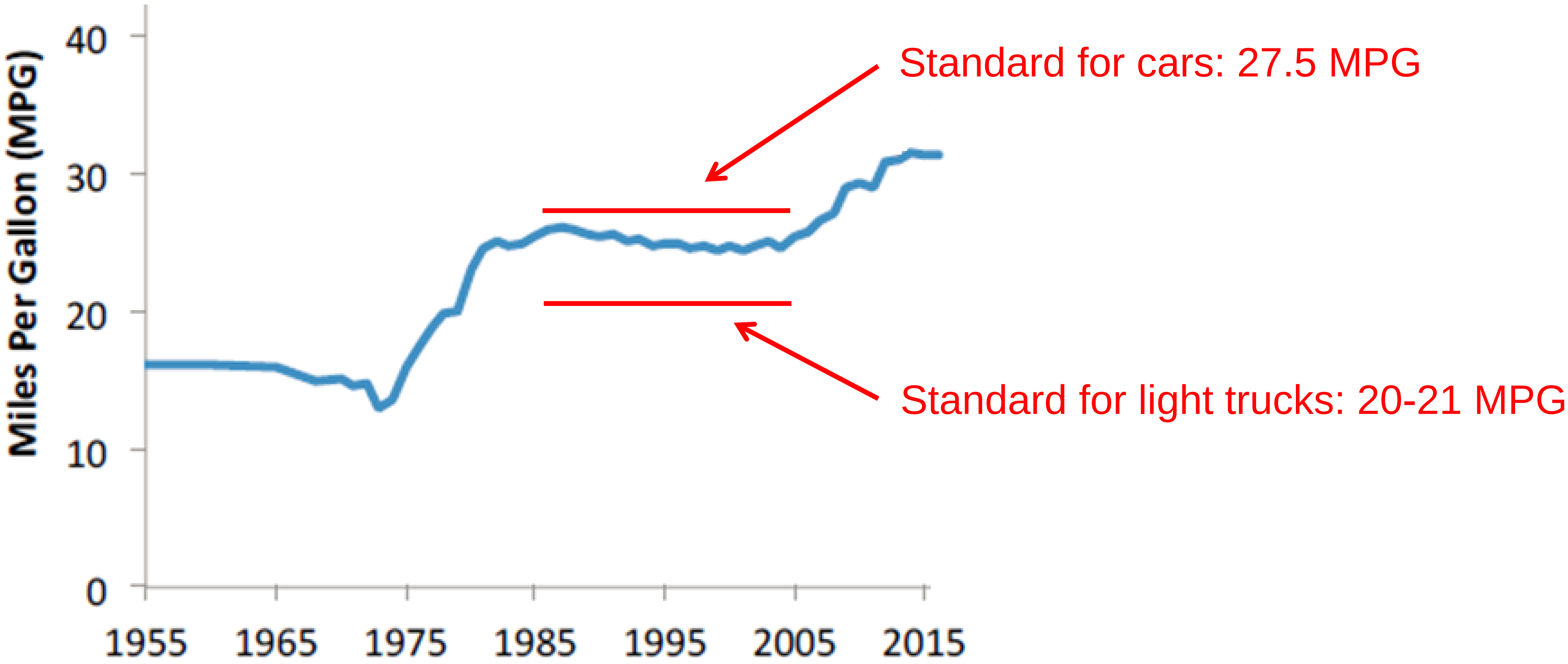



1988 Honda Civic

2004 Honda Civic

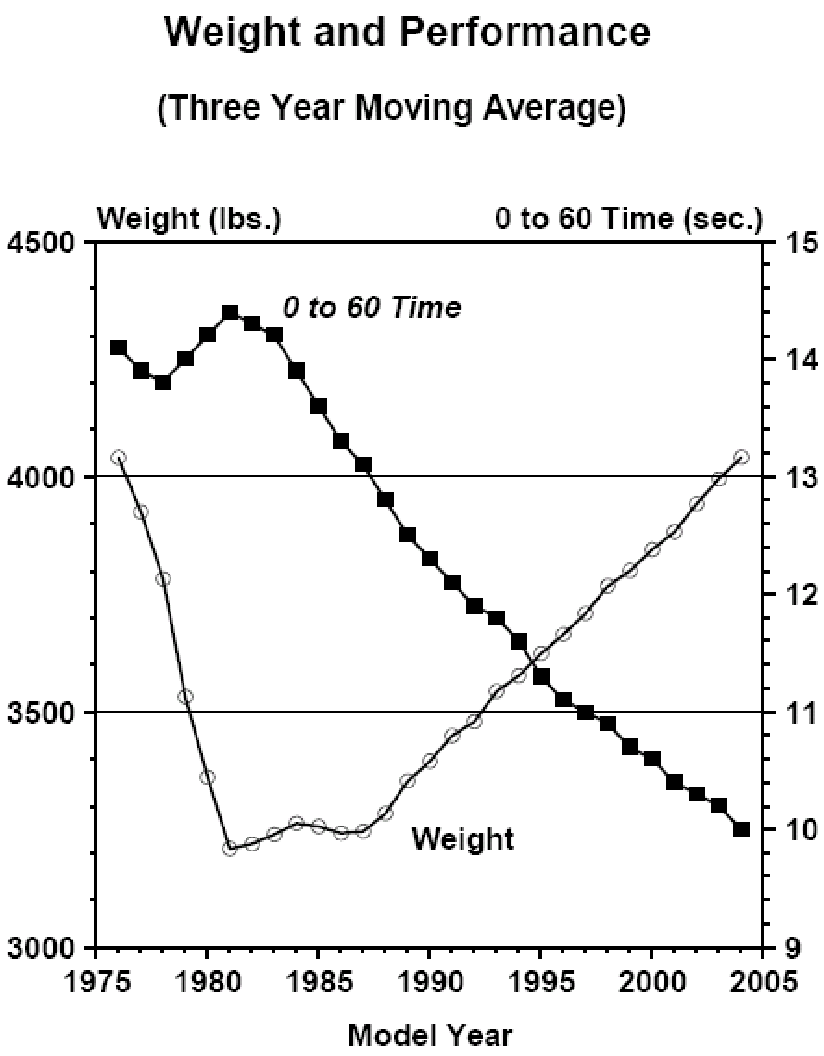
# … But the Standard Did Not Change Until Recently

It proved politically infeasible to raise the standard (“U.S. manufacturers would go bankrupt”)

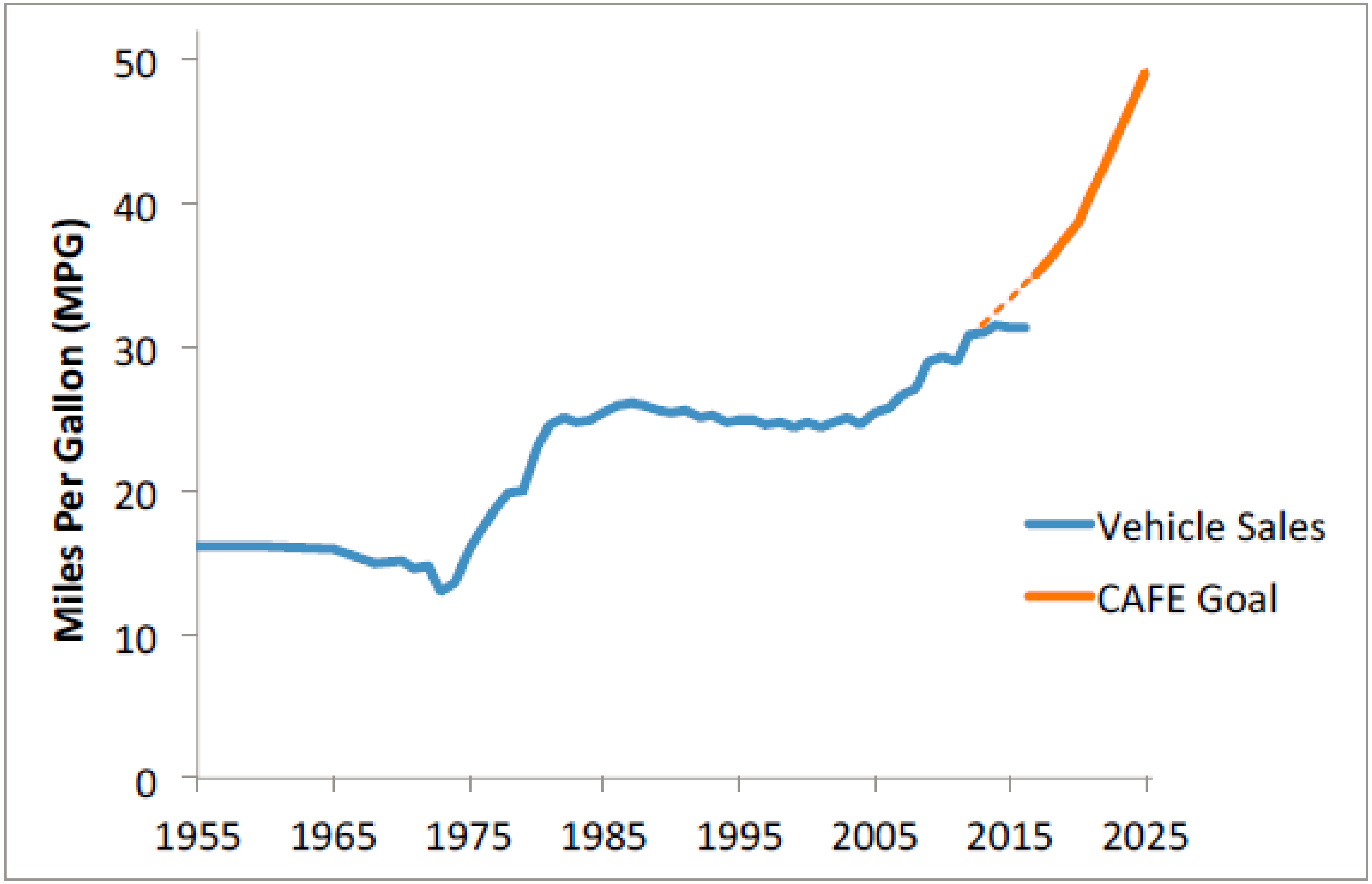


# Technology Was Used for Performance, Not MPG

- New technology was used to increase weight, luxury and horsepower…
- …but not for increased fuel-efficiency
- Also, more SUVs and light trucks were sold
  - Truck fleet in 1987: 28%
  - Truck fleet in 2004: 53%
  - Truck fleet in 2015: 57%

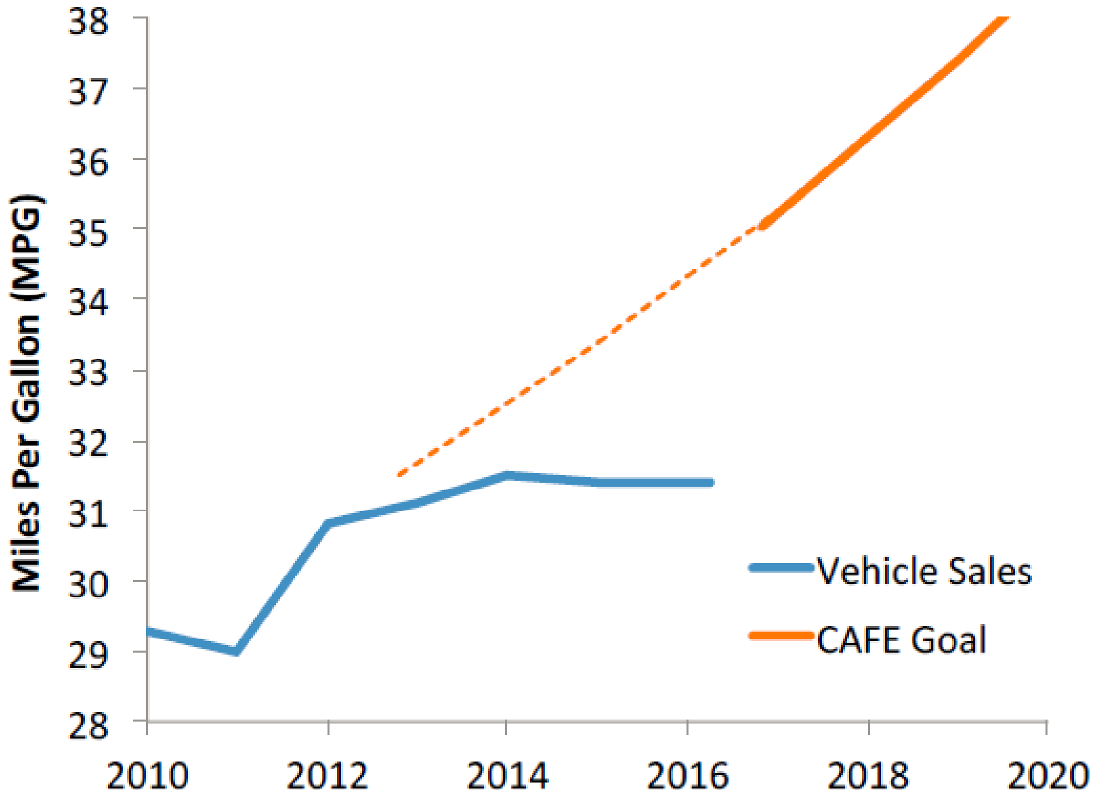


# Standard Is Rising Again, But Are We Meeting It?




Source: Mark Jacobsen

# Different Standard for Every Size Vehicle…



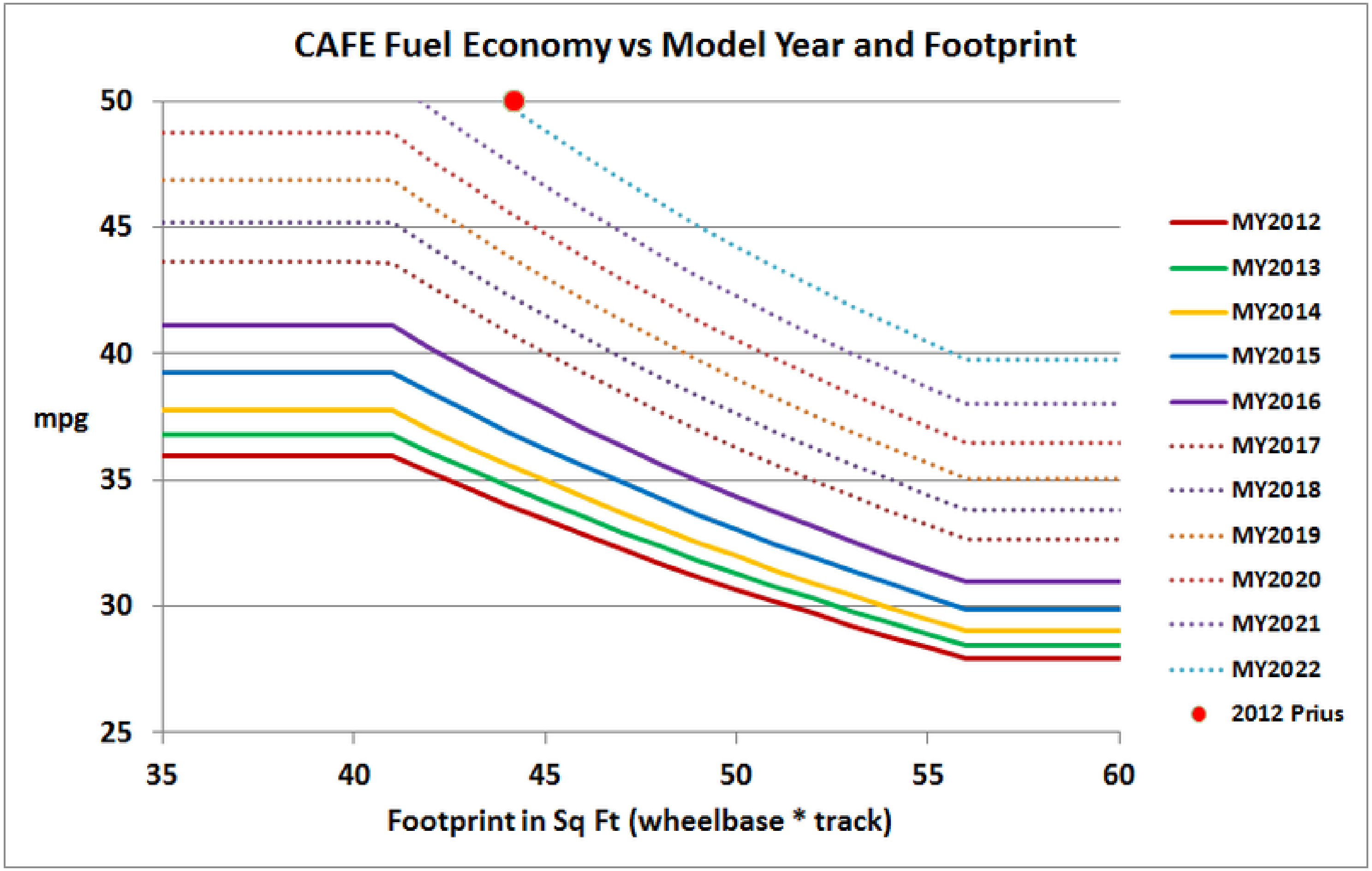

**2016 rules:**

40 sq.ft. car
→ 41 MPG

65 sq.ft. light truck
→ 24 MPG

Composition of sales determines actual MPG

# … Based on "Footprint Curves"



# Taxes vs. Fuel-Economy Standards

| Gasoline tax | **Performance standard** |
|---|---|
| Gets purchase decision right | Gets purchase decision roughly right |
| Gets utilization decision right | "Rebound effect" |
| | Subject to loopholes and exemptions |
| | Does not apply to used vehicles |

Fuel-economy standards are **much** more expensive per gallon of gasoline saved than gasoline taxes…

…but are often the best politically feasible policy option

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# CAFE Standards Have a History of Loopholes…

Europe's high gasoline taxes create incentives to sell small cars

Fuel-economy standards in the US create interesting incentives for firms…

# … Which Reduce Their Effectiveness

| Rule | Response |
| --- | --- |
| Vehicles above 8500 lbs. were previously exempt from rules | Make big fuel-inefficient trucks heavier |
| Different rules for cars and light trucks | Call SUVs “light trucks” (e.g., PT Cruiser) |
| Flex-fuel vehicles get a bonus in computing CAFE | Produce flex fuel vehicles, sell them even where biofuels are not available |
| Gas guzzler tax for specific vehicles with low MPG | Corvette gained a fuel-efficient feature that also reduced performance; car’s manual showed how to disable it |
| “Supercredits” and zero emissions ratings for electric vehicles | Every EV sold leads to lots of *extra* carbon emissions |

Regulation creates incentives; it is important to understand the supply response!

## Key Takeaways

- Fuel-economy standards achieve emissions savings at higher cost to society than a gasoline tax
- Eliminating seemingly innocuous loopholes and cutoffs in fuel-economy standards can make them much more efficient…
- …although fuel-economy standards will never beat gas taxes on efficiency grounds, since they leave the driving externality untaxed and they cause trouble in the used market (next slides)
- Gas taxes are an uphill battle in the short run, so a pragmatic approach calls for optimizing the design of new standards

KNOWLEDGE FOR ACTION

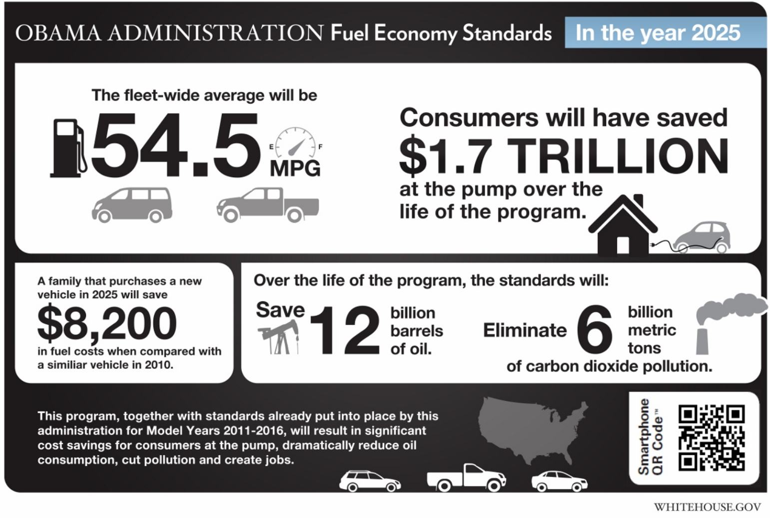
# Vehicle Scrappage and Gasoline Policy

Mark Jacobsen
UC San Diego

Arthur van Benthem
The Wharton School
University of Pennsylvania

EnerFront - December 16th, 2016

# Many Gasoline Policies Target New Cars . . .



# . . . But Also Cause Changes in the Used Market

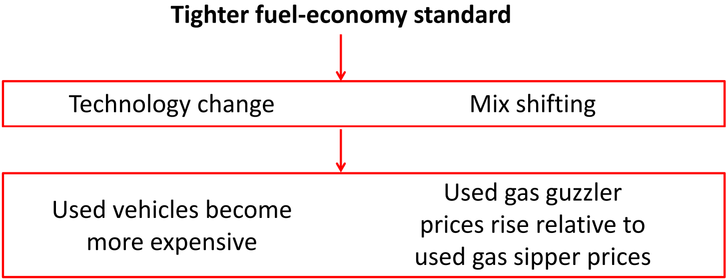
# The Result: Emissions Leakage

**Tighter fuel-economy standard**

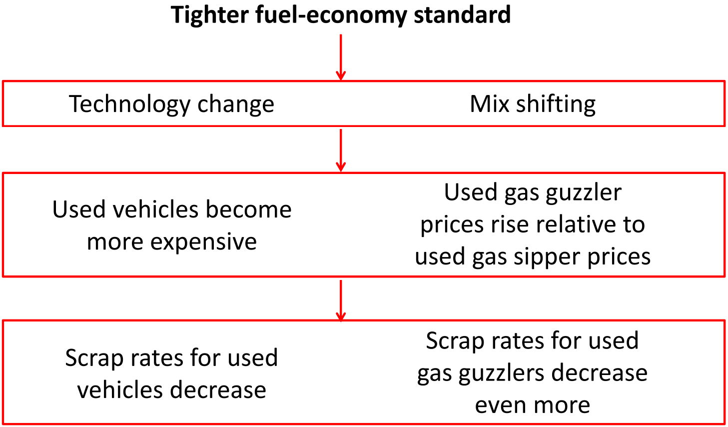
↓

Technology change | Mix shifting

# The Result: Emissions Leakage



# The Result: Emissions Leakage



# Motivation

- The efficiency of gasoline policy depends on the size and direction of changes in the used fleet: **vehicle scrappage**
  - Gasoline (or carbon) taxes
  - Policies directly targeting used vehicles
  - Fuel economy standards
    - "Leakage" through *incomplete regulation*
    - Degree of loss depends on the scrap elasticity

# Main Questions

1. What is the effect of **gasoline price** changes on used car prices and scrap rates?

2. What is the **scrap elasticity** with respect to **used vehicle prices**?

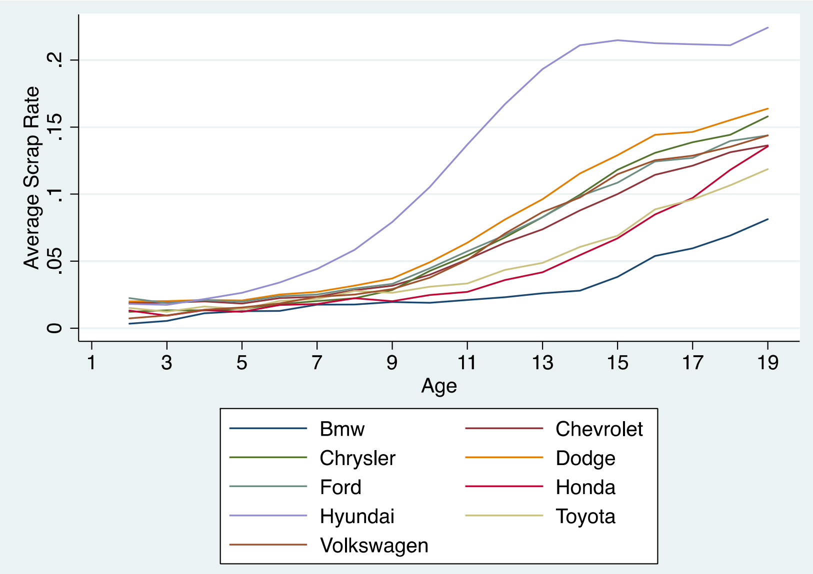
$$scrap\ elasticity = \frac{\%\ change\ in\ scrappage}{\%\ change\ in\ vehicle\ price}$$

3. How large is the corresponding **emissions leakage** (*Gruenspecht effect*) in fuel economy policy?

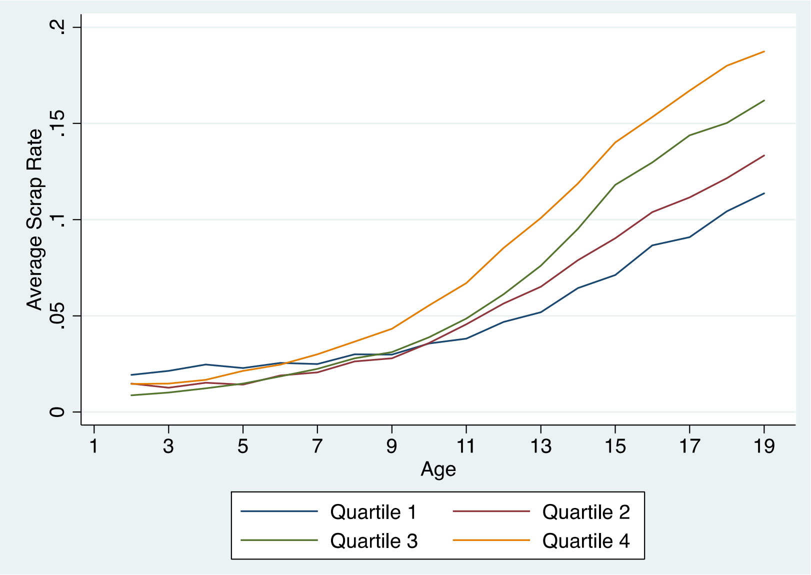
# Data

- VIN prefix-level data on US prices and registrations
  - Sub-model level, back to the 1980 vintage
  - Registration counts for 1999-2009
  - Example: VIN prefix 1HGCB765*N (1992 Honda Accord LX, 4-door, 2.2L I4)
- Matched to characteristics and fuel economy

# Scrap Rates by Age and Make



# Scrap Rates by Age and Fuel Economy



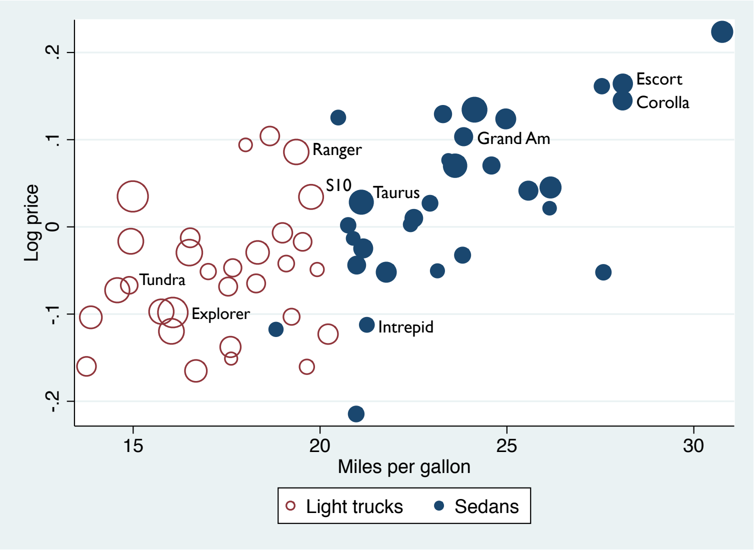
# Effect of Gas Price on Used Car Prices

| | All ages | By age category | | |
|---|---|---|---|---|
| | | Age 2-5 | Age 6-9 | Age 10-19 |
| | (1) | (2) | (3) | (4) |
| Gasoline price * MPG quartile 2 | 101 | 89 | 43 | 264** |
| | (90) | (227) | (188) | (73) |
| Gasoline price * MPG quartile 3 | 710** | 873** | 1,068** | 517** |
| | (94) | (231) | (206) | (62) |
| Gasoline price * MPG quartile 4 | 1,401** | 2,121** | 1,760** | 790** |
| | (86) | (201) | (196) | (62) |
| $R^2$ | 0.402 | 0.497 | 0.374 | 0.166 |
| Observations | 35,107 | 9,452 | 9,100 | 16,555 |

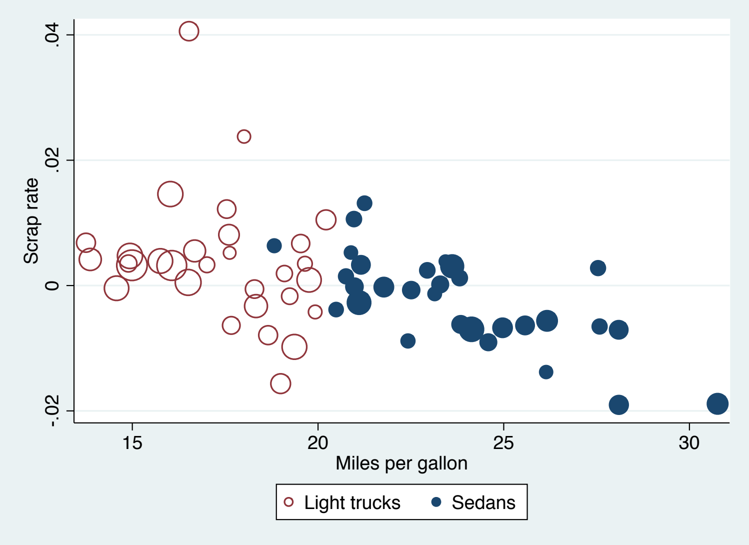
*Notes:* Standard errors clustered by make-model-age. *,** indicate significance at the 5% and 1% level, respectively.

- Controls for make-model-age and age-year
- Quartile averages range from 15.4 to 26.7 MPG
- Least efficient vehicles (quartile 1) omitted

# Effect of Gas Price on Used Car Prices, by Model



# Effect of Gas Price on Scrap Rate, by Model



# Scrap Elasticity

- So far, we've looked at the effect of a gas price (tax) increase

- Now, relate **vehicle prices** and scrap rates
- Why? CAFE standards influence used car prices, which causes emissions leakage

# Scrap Elasticity

$$ln(y_{amt}) = \gamma ln(p_{amt}) + \alpha_{am} + \alpha_{at} + \varepsilon_{amt}$$

- Determinants of the scrap function (e.g., parts and labor prices) may be less volatile than demand at the model level
  - But, the data still mix changes of both types over time
- Need exogenous shocks to demand to isolate the slope of the scrap function
  - Instrument for used car price with changes in **relative** fuel costs as gasoline prices move
  - Instruments act as model-specific demand shifters
- Age-by-year effects remove aggregate changes in the market

# Scrap Elasticity Results

| | | By age category | | | |
|---|---|---|---|---|---|
| | All ages | Age 2-5 | Age 6-9 | Age 2-9 | Age 10-19 |
| | (1) | (2) | (3) | (4) | (5) |
| | OLS | | | | |
| Scrap elasticity ($\gamma$) | -0.579** | -1.084** | -0.492** | -0.737** | -0.477** |
| | (0.032) | (0.104) | (0.069) | (0.059) | (0.037) |
| | IV - First stage: DPM by make-model | | | | |
| Scrap elasticity ($\gamma$) | -0.694** | -1.154** | -0.687** | -0.842** | -0.646** |
| | (0.043) | (0.140) | (0.078) | (0.080) | (0.040) |
| First stage $F$-statistic | 66.67 | 21.37 | 25.53 | 34.82 | 31.73 |
| | IV - First stage: DPM by make-model-age | | | | |
| Scrap elasticity ($\gamma$) | -0.711** | -1.210** | -0.710** | -0.909** | -0.589** |
| | (0.035) | (0.128) | (0.072) | (0.069) | (0.035) |
| First stage $F$-statistic | 18.15 | 16.70 | 20.68 | 19.82 | 14.44 |

*Notes:* Fixed effects are for each make-model-age and each age-year combination. Standard errors are clustered by make-model-age. *,** indicate significance at the 5% and 1% level, respectively.

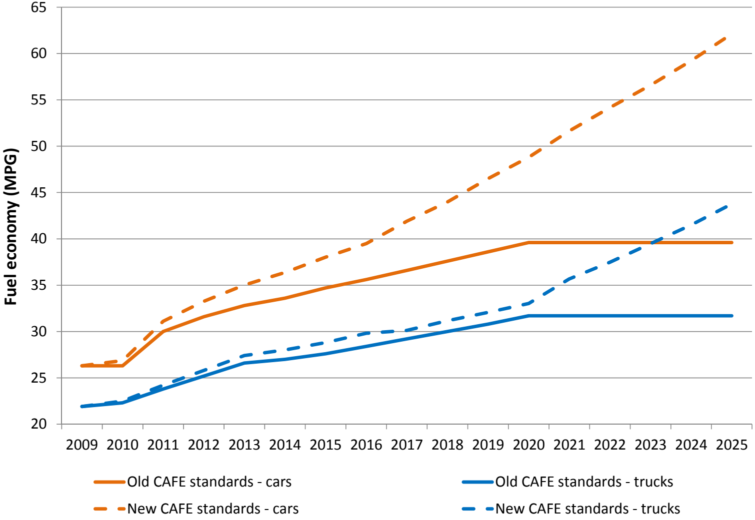
# Additional Tests

- Elasticities are fairly constant across vehicle classes
  - Most elastic scrap behavior is for older SUVs and vans
- Similar elasticities when considering luxury models, vintage effects, and excluding the recession
- (Unobserved) miles driven makes our estimates conservative, but the impact is small

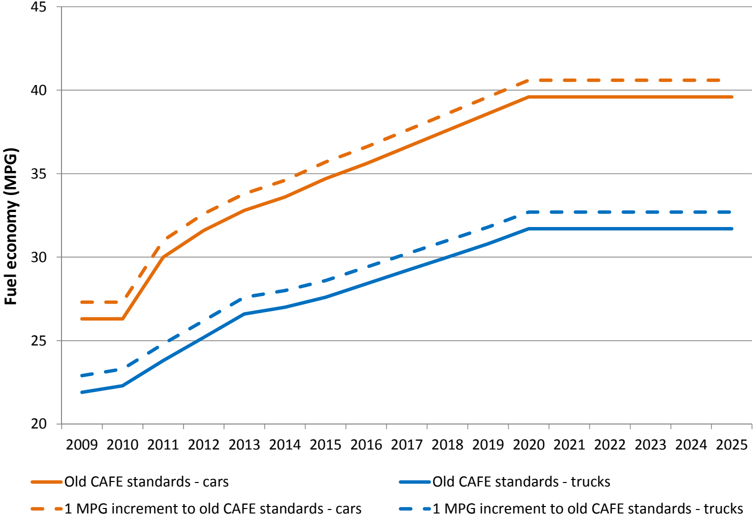
# Policy Implications of the Scrap Elasticity

- Simulate stricter fuel economy rules
  - One version where cars are scrapped at their historical rates each year
  - Another version where changes in car prices are allowed to change scrap rates, **following our estimated elasticity**
- The difference in gasoline savings is leakage via the Gruenspecht effect

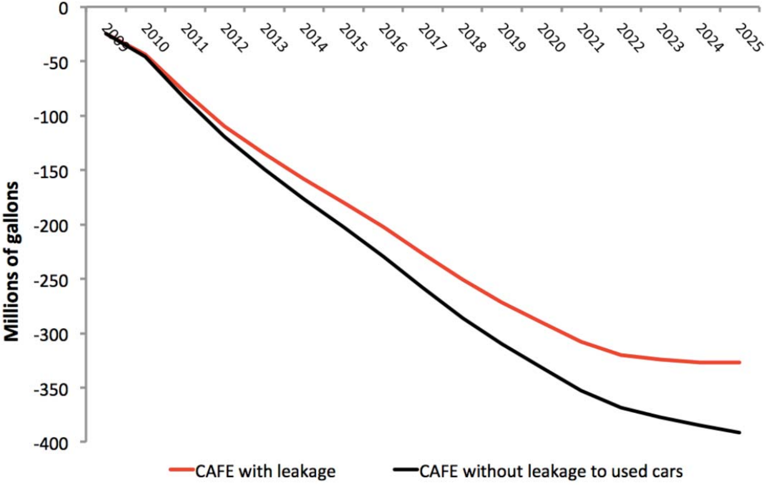
# Policy Experiment 1



# Policy Experiment 2



# Gasoline Savings to 2025




- Cumulative leakage by 2020 for the 1 MPG increment: 16%

# Summary of Leakage Simulation

- Emissions leakage to used vehicles from fuel economy policy is 13-16%
  - Robust to assumptions on engineering cost and rates of technological change
- Leakage through scrappage rivals or exceeds the "mileage rebound effect"
  - Policy analysis often assumes 10% mileage rebound
- Leakage grows in importance as:
  - The scrap elasticity increases
  - The elasticity of substitution between new and used cars increases
  - The new fuel-economy standard becomes more stringent

# Key Points

- A \$1 gas price increase changes used car prices \$1,400 across fuel economy quartiles
- Scrap elasticities of about -0.7
- Used vehicle leakage offsets 13-16% of projected savings
- This matters for cost-benefit analysis of CAFE
- The presence of this leakage favors gasoline taxes or annual registration fees, ideally based on VMT or fuel economy
- Extension: substantial changes in scrappage from CAFE become particularly relevant to local air quality