Reducing Greenhouse Gases from the Transportation Sector

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Why we care about transportation

- Transportation accounts for over 30 percent of greenhouse gas (GHG) emissions within the US and 60 percent of US oil use
- Despite this and our desire to reduce our oil demand, the US has done little to incentivize reductions in oil use (or GHG) from this sector over the past 30 years
  - CAFE standards for passenger cars haven't changed since 1990
  - For light trucks, they have increased by only only 10 percent since 1990
    - Substantial increase from 1978 to 1985 (followed by reductions from 1986 thru 1989)
  - This makes them seem more stringent
    - Because SUVs are treated as trucks and truck sales have increased from 20% in 1980 to over 60% by 2004

The three-legged stool

- Greenhouse gas emission reductions can come from three sources within transportation
  - 1. Increases in fuel efficiency
  - 2. Lower carbon fuels
  - 3. Reductions in vehicle miles travelled (VMT)

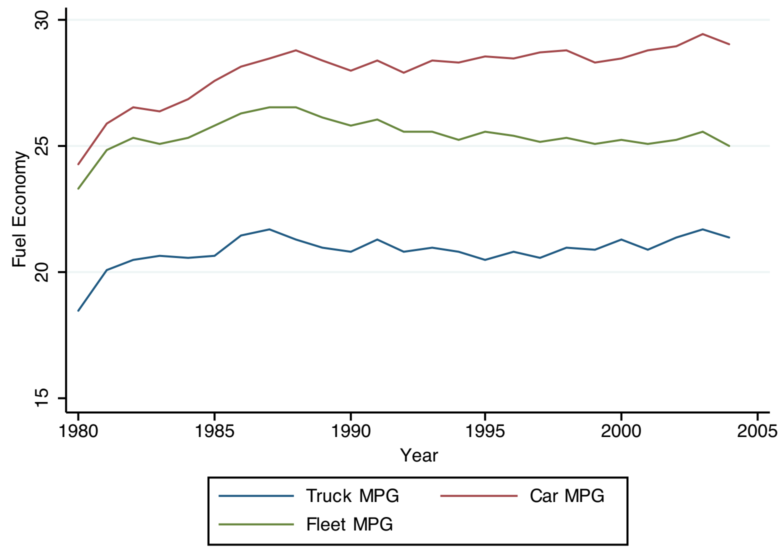
- My discussion:
  - What are some specific sources?
  - What are national and state policy makers doing?
    - How do these stack up in terms of efficiency?
  - What are alternative policy measures?

The first leg -- Fuel economy

- 1. Increases in fuel economy for new and existing vehicles
  - This can come either ***within*** the internal combustion engine or thru ***shifts*** to alternative technologies
  - Shifts to alternative technologies can have larger effects
    - Thermal efficiency of the ICE is limited: diesel (marginally) and electric motors more efficient
      - How to power those electric motors? electricity+batteries or hydrogen+fuel cell
      - At current gas prices and zero subsidies, batteries are still too expensive
      - Some feel hydrogen vehicles are the ultimate technology (time wise), but hydrogen prices are still much higher than gasoline in "gallon of gas equivalent" terms
        - Loss with batteries v. losses with hydrogen production

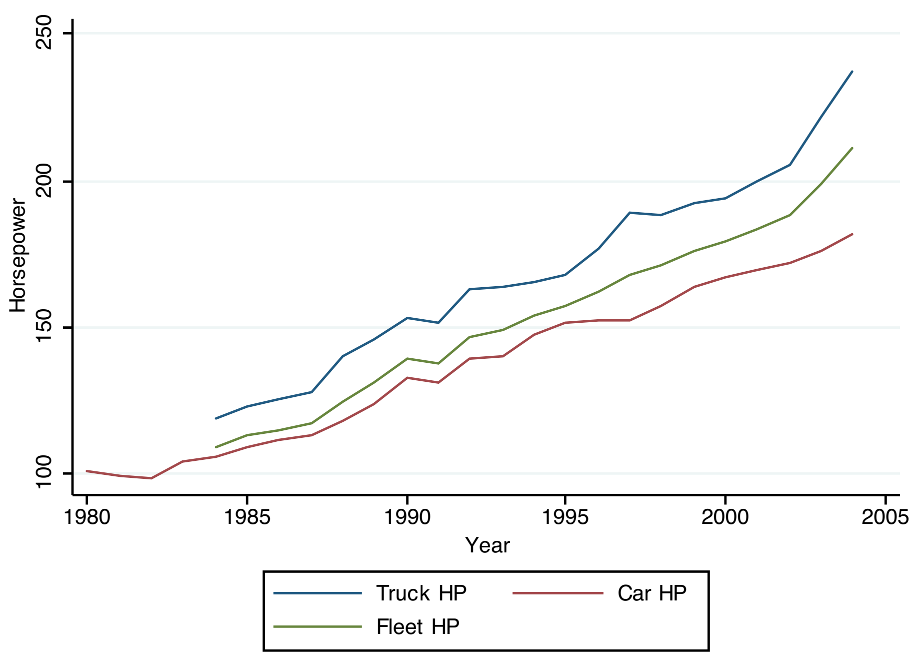
Can traditional technologies play a role?

- Might not have to give up on the internal combustion engine so fast
  - It's true fuel economy in the US has changed little over the past three decades

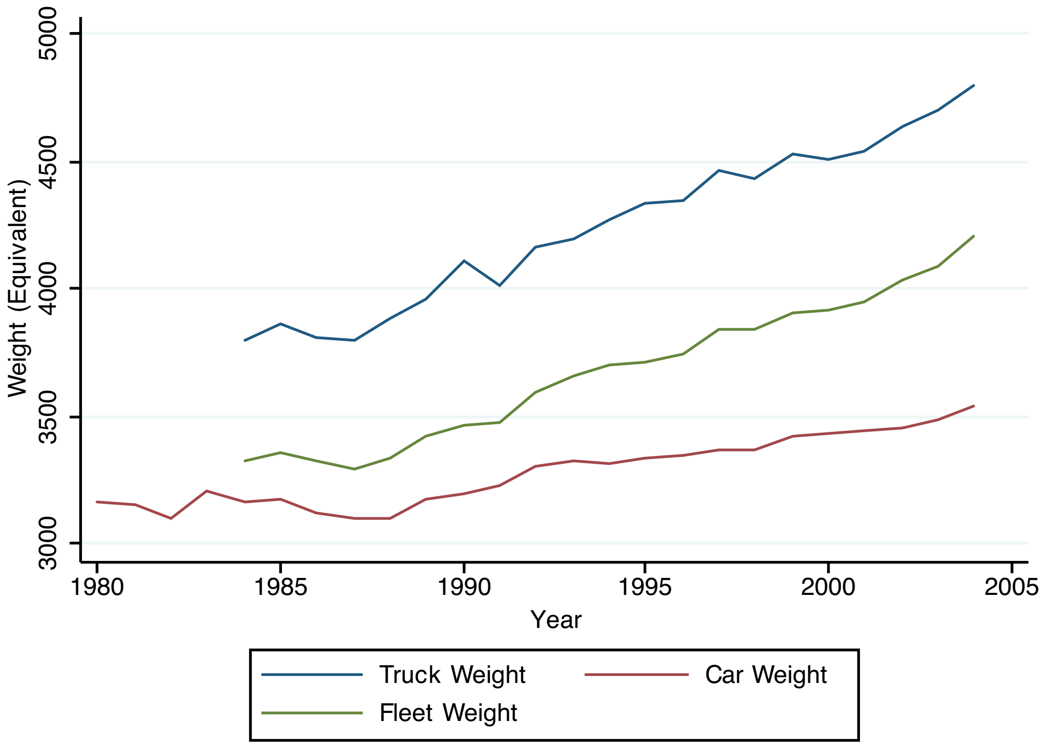


Flat MPGs = stagnant technology?

- No. We've simply put our technological progress towards other things



America is getting fatter (their cars at least)



What could have been?

- Downsizing can have large effects

- Some of my recent work looks at the trade-off between fuel economy and weight and horsepower (amongst other things)
  - I then look at how this relationship has shifted out over time, measure technological progress

- *Had we kept weight and horsepower constant and directed all technological progress towards fuel economy, fuel economy would have increased by 50%*
  - There was simply no incentive to do so
  - Real gas prices ***fell*** by 30 percent from 1980 to 2004

The second leg -- Lower carbon fuels

- 2. Low Carbon Fuels
  - Many fuel du jours
    - First hydrogen
      - Wow, this is expensive!
    - Then ethanol/biofuels
      - ...indirect land use effects make ethanol dirtier than gasoline...indirect land use may not be as bad as thought...corn ethanol isn't too bad afterall, but only marginally better...second generation ethanol is key, but too expensive...
    - Electricity?
      - Where are the batteries?

The second leg -- Should NG play a bigger role?

- Shifts to natural gas are rarely discussed
  - The EPA has estimated the following environmental benefits:
    - ***Reduces carbon dioxide emissions 25%***
    - Reduces carbon monoxide emissions 90%-97%
    - Reduces nitrogen oxide emissions 35%-60%
    - Potentially reduces non-methane hydrocarbon emissions 50%-75%
    - Still others.
  - The refueling retrofit issues are similar to electricity
  - Higher upfront costs, but on a "per unit of energy content" basis, natural gas roughly 1/3 the cost of oil (at current prices)

The third stool -- Reducing how much we drive

- Decreases in vehicle miles travelled (VMT)
  - The third leg of the transportation stool that doesn't receive enough attention
    - Land use patterns can have large effects
    - Availability of public transportation can have large effects
    - Cutting out marginal trips can have large effects
  - The first two are expensive, the last one may not be
    - These are trips from which consumers get little "net utility"

Choice of policies

- "Performance Standards"
  - Corporate Average Fuel Economy (CAFE) Standards
    - New CAFE Standards call for new fleet fuel economy to be 35.5 MPGs by 2022
  - Low Carbon Fuel Standards (LCFS) at the state level
    - Like a CAFE standard, regulates a fuel producer's average carbon intensity
  - Renewable Fuel Standard (RFS) at the national level
    - Requires minimum amounts of advanced biofuels
    - Recently relaxed when it appeared as though we wouldn't meet the target
- Subsidies
  - Both on the vehicle and biofuel side

Where is carbon pricing?

- Transportation is often left out of cap and trade programs, at least initially
  - e.g., Waxman/Markey, CA's AB32
- Why?
  - I often hear things like "Transportation is just different"
  - "The demand for gasoline is too inelastic for anything to happen, just go read Hughes, Knittel, and Sperling"
    - Long run elasticity is the important parameter
    - If reductions come elsewhere that is the efficient outcome

Carbon pricing: A one-price-fits-all policy...

- Change the relative demand for automobiles
  - Push out the demand for fuel-efficient vehicles and push in the demand for fuel-inefficient vehicles
    - My recent work suggests that these are large effects
- Change how many miles people will choose to drive
  - It is this channel that pricing carbon has the largest advantage over CAFE standards
    - Current work suggests that if gas prices stay high for two years, the VMT effect is large
- Change how long existing vehicles will stay on the road
  - Fuel inefficient vehicles will be scrapped sooner
  - Fuel efficient vehicles may stay on the road longer
    - Recent work by me and other suggest that efficient vehicles stay on the road longer, inefficient vehicles exit faster

Economics of "performance standards"

- Our choice has been to rely on "performance standards" -- policies that regulate the average emissions of firms, not the total emissions as in cap&trade program
- Work dating back to the 1980s has show that performance standards are simply **implicit** tax and subsidy programs
  - Products (cars or fuels) better than the standard are subsidized, products worse than the standard are taxed
  - We typically layer these onto explicit subsidy programs
- Should we be subsidizing GHG emitting behavior?
- How large are the inefficiencies, relative to carbon pricing?
  - Are there more risks associated with subsidies?

Vehicle choice and CAFE

- Under CAFE, small vehicles are implicitly subsidized, while large vehicles are implicitly taxed
  - Multiple inefficiencies:
    - Insofar as the demand for vehicles isn't vertical, you get too many vehicles on the road
    - There is also an incentive to keep existing inefficient vehicles on the road longer
    - *Finally, because you have pushed people into more efficient vehicles without increasing the price of fuel, the cost of driving has fallen --- people will drive more (the so-called rebound effect)*
- CAFE has also been subject to inefficient rulemaking to please certain manufacturers
  - First wave: SUVs were treated as trucks
  - Newest CAFE: "footprint based"

Arguments for CAFE

- Proponents of CAFE will argue that there are two "market failures" at work here: GHGs and some other market failure that causes consumers to care too little about the future
  - This leads consumers to underinvest in fuel economy
  - Implicitly subsidizing fuel economy is a round-about way to undue this second market failure
    - Note, however, this is not the efficient way
- Two counterpoints:
  - First, the evidence on this is mixed
  - Second, those papers that account for this often find CAFE does more harm than good
    - That is, the social cost of reducing GHGs is greater than what we typically believe the damages of GHGs are

Costs of Low Carbon Fuel Standards and Renewable Fuel Standards

- A recent paper of mine (and coauthors) simulates the social cost of GHG reductions from a national transportation-only cap&trade program and a national LCFS
  - On social-cost-per-ton-of-CO2 abated the LCFS is 5-10 times more expensive than a cap&trade program yielding equivalent reductions
    - But, the LCFS does a better job at hiding these costs, as fuel prices are lower
  - There are also huge transfers under the LCFS (from oil to ethanol)
    - Ethanol production tends to be 4-10 times greater under the LCFS compared to the cap&trade system
  - More fundamentally, if you believe the social cost of CO2e is $50 per ton, a LCFS that reduces the carbon intensity by only 5% does more damage than good for a broad range of parameter values

Why so expensive?

- By subsidizing some fuels, fuel prices are artificially low leading to too much VMT
- In addition, the heavy subsidy on ethanol means we have too much ethanol production given its carbon content
  - We move up the ethanol cost curve too much

Greater risk under an LCFS/RFS

- One of the difficulties of regulating/pricing fuels is that comparing fuel is not a trivial exercise
  - This is true for Low Carbon Fuel Standard/Renewable Fuel Standard
  - The relevant carbon content of a fuel is its ***lifecycle*** carbon content
    - For oil-based fuels (conventional or unconventional) this is the carbon released when the fuel is burned + the carbon released through the production process
    - For biofuels this is the carbon released when the fuel is burned + the carbon released through the production process -- the carbon sequestered when the plant was growing + the extra carbon released because of crop shifting (Indirect Land Use Changes -- iLUC)
    - For electricity/hydrogen this is the carbon released during generation/ production
  - For any upstream emission that isn't taxed or within the cap, these issues also exist for carbon taxes and cap & trade

What's the right number? I mean, numbers?

- Calculating the upstream emissions is difficult for all fuels, especially for the non-traditional ones (unconventional oil and biofuels)
  - Lots of heterogeneity

Table C. GHG Emissions Summary for the Various Corn Ethanol Scenarios

Scenarios	Technology	Regional Electricity		CA-GREET (gCO_2e/MJ)	
		Corn Farming	Ethanol Prod.	Anhydrous	Denaturant + Comb. adjusted
Ave Mid-West Dry Mill, Dry DGS	80% dry and 20% wet mill	Ave. US	Ave. Mid Western	67.60	68.40
Ave Mid-West Wet Mill	60% NG and 40% Coal	Ave. US	Ave. Mid Western	74.30	75.10
Ave Mid-West Dry Mill, Wet DGS	NG	Ave. US	Ave. Mid Western	59.30	60.10
Mid-West Dry Mill, Dry DGS	80% NG, 20% biomass	Ave. US	Ave. Mid Western	62.80	63.60
Mid-West Dry Mill, Wet DGS	80% NG, 20% biomass	Ave. US	Ave. Mid Western	56.0	56.80
Mid-West Average	**Mix (80% dry mill and 20% wet mill) (for dry mill, uses 95% Dry DGS and 5% Wet DGS)**	**n/a**	**n/a**	**68.60**	**69.40**
CA Dry Mill, Dry DGS	NG	Ave. US	CA Marginal	58.10	58.90
CA Dry Mill, Wet DGS	NG	Ave. US	CA Marginal	49.90	50.70
CA Dry Mill, Dry DGS	80% NG, 20% biomass	Ave. US	CA Marginal	53.40	54.20
CA Dry Mill, Wet DGS	80% NG, 20% biomass	Ave. US	CA Marginal	46.60	47.44
CA-Weighted Average	**80% Mid-West Average and 20% CA Dry Mill Wet DGS**	**n/a**	**n/a**	**64.86**	**65.66**

- Calculating the iLUC is even more difficult and contentious
  - Requires simulating how crop, land use, and growing practices change under the policy
  - Searchinger (2009) suggested that these iLUCs make corn ethanol much dirtier than gasoline
    - Follow up papers have suggested that it might not be as dire, but corn ethanol at best a marginal improvement
    - As of a month ago, the EPA has set the iLUC to 28.4 grams of CO2-equivalent/mega joule (g/MJ), the Renewable Fuel Association argues its 10.8 g/MJ using the EPA's models
      - 28.4 represents 35 percent of the 2022 Corn Ethanol emissions

Some observations

- 1. While the true value is uncertain, our best guess is a positive number
  - Think of trying to guess the value of a random number that can only take on positive values, your best guess will not be zero
    - (I haven't heard anyone argue that the iLUC number might be negative)
  - The more uncertain you are, the higher will be your guess
- 2. The risk is likely to be asymmetric
  - That is, we are probably hurt more by picking a number too low than picking a number too high
- 3. The true iLUC number will be policy specific
  - Those policies that rely more heavily on biofuels will have higher iLUC numbers
- 4. The risk will be policy specific
  - The downside risk will be larger, the more a policy relies on biofuels

LCFS/RFS and land use changes

- Some of my recent work uses long run GIS-based biofuel supply curves and simulate land use under the RFS and a C&T program and LCFS that achieve the same CO2e reductions as the RFS (~7%)
  - On a social cost perspective, similar conclusions as in HHK

	Current Tax/Subsidies	**RFS**	**LCFS**	**C&T**
Average Social Cost ($/Metric ton of CO2e)	$96.81	$65.62	$42.76	$16.38
Increase in Acres devoted to Feedstocks				
(1000s of acres)	~37,736	37,736	26,044	672
Percentage Change v. BAU	1219%	1219%	841%	22%
Increase in Acres devoted to Corn				
(1000s of acres)	~28,304	28,304	15,711	0
Percentage Change v. BAU	914%	914%	507%	0%

Note: This assumes that corn-based ethanol is 20% cleaner than gasoline.

Our recent work on RFS/LCFS and land use

- Potentially more worrisome is the very different land use changes associated with an RFS and LCFS, compared to cap&trade
- Why do we care?
  - 1. We might get the iLUC number wrong, so the greater the land use changes associated with the policy, the greater the error
  - 2. There are other "negative externalities"/undesirable consequences associated with land use changes
    - Fertilizer run-off, habitat loss, increases in food prices

Unintended consequences of pricing GHGs

- Pricing GHGs also has unintended consequences
- The difference, however, is that all of the unintended consequences are good in this case
  - Lower criteria pollutants
  - Less congestion
  - Lower traffic externalities
  - Can use the revenues to reduce taxes that distort the economy
  - Etc.

A final benefit from carbon pricing

- Having transportation outside of the cap makes comparing traditional vehicle technologies (internal combustion engines running on gasoline) difficult to compare with alternative technologies and fuels
  - If electricity and natural gas are prices, under a Cap&Trade program and gasoline is not, the incentives to shift to these technologies is distorted
- You now run the risk of leaving low hanging fruit on the tree

Wrapping up

- Reaching our GHG emission goals will require reductions from transportation
  - These will come from three different channels
- While pricing carbon pushes on all three of these "legs" our preference has been for subsidies and performance standards
- While these do a better job at hiding the social cost of the greenhouse gas reductions, they can be up 10 times more costly compared to pricing GHGs
  - So much so, for commonly cited social damages from GHGs, they do more harm than good
- Finally, they can distort the comparison of many of the future technologies that we envision for transportation

Thanks to my co-authors!

- Mentioned work:
- "Pain at the Pump: The Differential Effect of Gasoline Prices on New and Used Automobile Markets," joint with Meghan Busse (Northwestern) and Florian Zettelmeyer (Northwestern).
- "Transportation Carbon Policies Lead to Large Differences in Land Use," joint with Stephen P. Holland (UNC, Greensboro), Jonathan E. Hughes (U of Colorado), and Nathan C. Parker (UC Davis).
- "Greenhouse Gas Reductions under Low Carbon Fuel Standards?," joint with Stephen P. Holland (UNC) and Jonathan E. Hughes (ITS, UC Davis). ***The American Economic Journal: Economic Policy***, 1(1), February 2009, pp. 106-146.
- "Automobiles on Steroids: Product Attribute Trade-offs and Technological Progress in the Automobile Sector," conditionally accepted at ***The American Economic Review.***