



Perspectives on Public Administration: Applying Economics and Statistics to Climate Policy

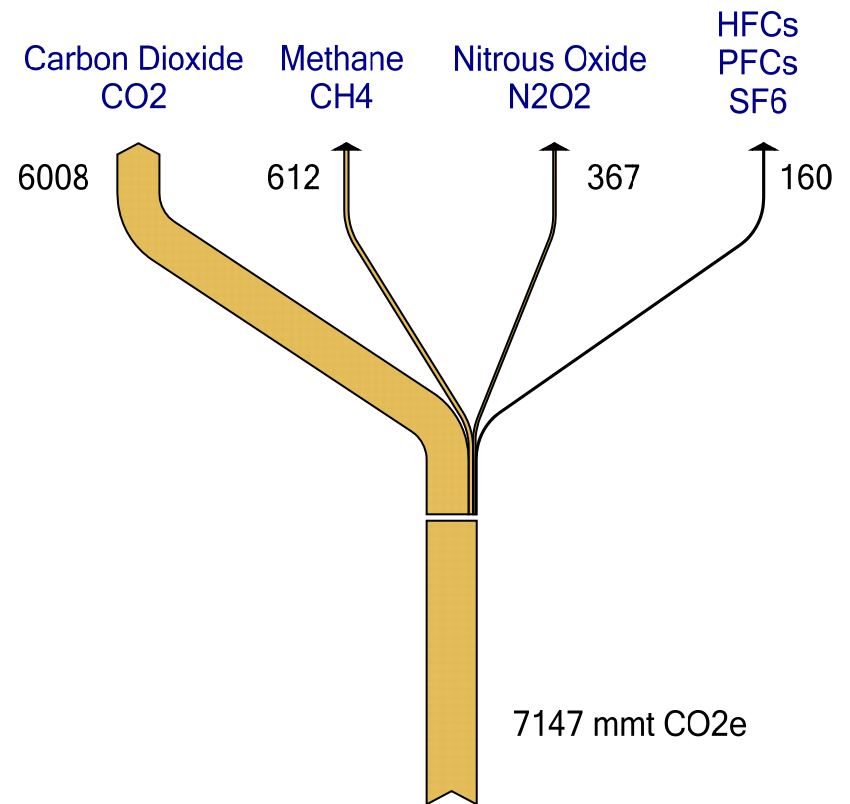
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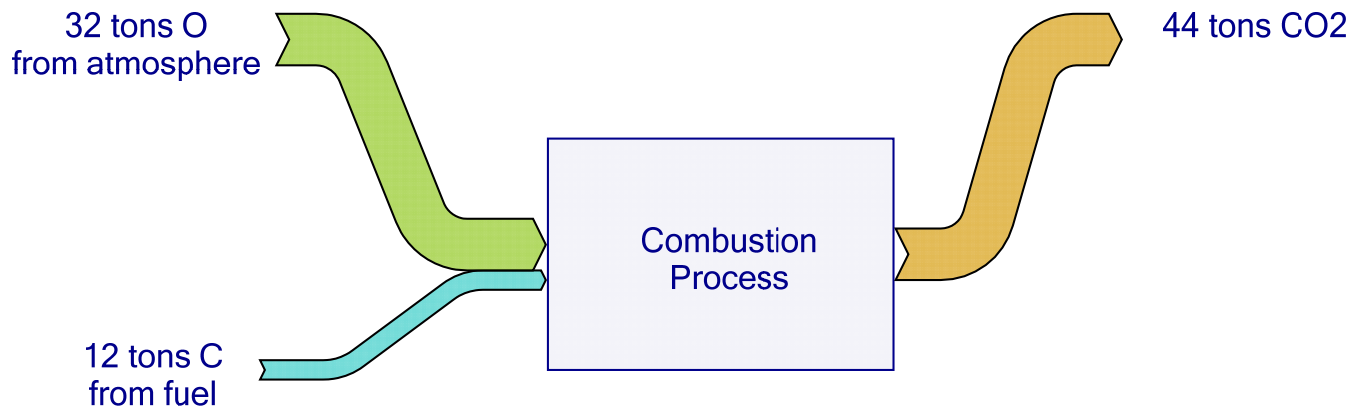
US greenhouse gas emissions in 2005

Weighted by effect on climate:

- 84% CO₂
- 9% methane
- 5% nitrous oxide
- 2% other



CO2 originates from combustion



- Problem is fossil fuels
 - Net addition of carbon to the biosphere
- Fossil fuels vary in CO2 produced per unit of heat
 - Natural gas is lowest (best)
 - Petroleum is next
 - Coal is highest (worst)

Fuel use and energy units

- National fuel use is measured in quads
 - 1 quad = 1 quadrillion BTU (10^{15})
- How large is a quad?
 - Coal “unit trains”: 100 cars, about 1 mile long
 - 1 train fuels a 300 MW power plant for about 3 days
 - 1 quad = 4,500 unit trains



How much energy is used?

- World energy consumption
 - 400 quads per year
 - 1 quad every 22 hours
- US consumption
 - 100 quads
 - 86 quads from fossil fuels
 - 14 quads nuclear and renewables
 - 25% of world total
- US emissions
 - 6 billion tons of CO₂ or 1.7 billion tons of C
- In the long term, must make emissions 0
 - Reduce consumption or capture emissions

Reducing carbon dioxide emissions:

- Requires substantial investment by the private sector
 - More efficient vehicles
 - Better insulation and windows
 - Renewable energy
 - Additional nuclear plants
 - Carbon sequestration
- Policies must provide **credible long-term incentives** for investment

Key incentive: higher fossil fuel prices

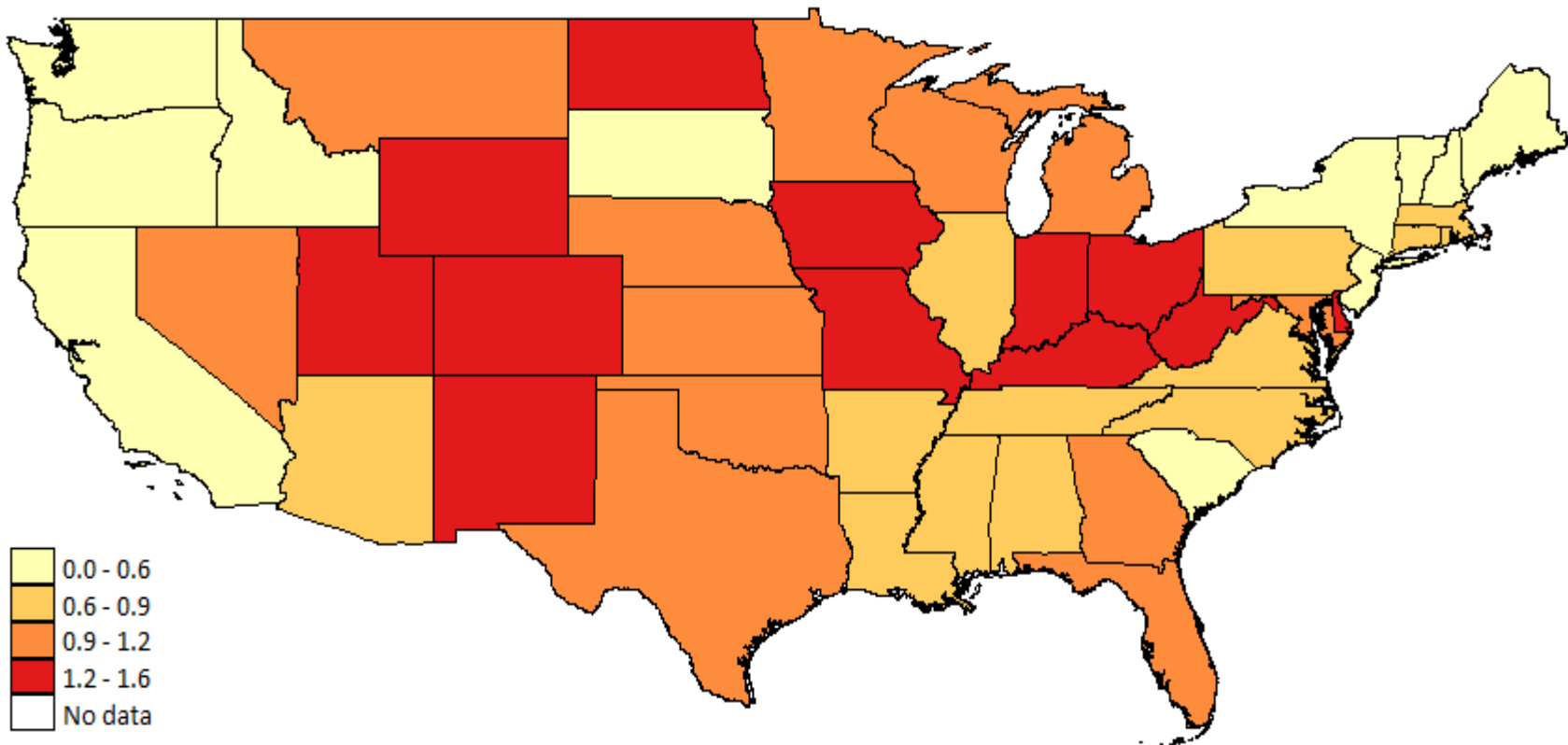
- Shifts the fuel mix toward nuclear and renewables
 - Investments in power plants and vehicles
 - Give credits for sequestration
- Improves energy efficiency
 - Use less fuel to get equivalent outcomes
 - E.g., same thermostat setting but less fuel
- Reduced demand for fuel-intensive activities
 - Choosing different outcomes
 - E.g., different thermostat settings

One option: a carbon tax

- Tax fossil fuels based on the CO₂ emitted
 - Example: \$20 per ton of CO₂
- Raises prices of gasoline, natural gas and electricity
 - Gasoline: 17 cents per gallon
 - Natural gas: 110 cents per 1000 cubic feet
 - Electricity: 0 to 2 cents per kWh

 - In general, about an 8% increase

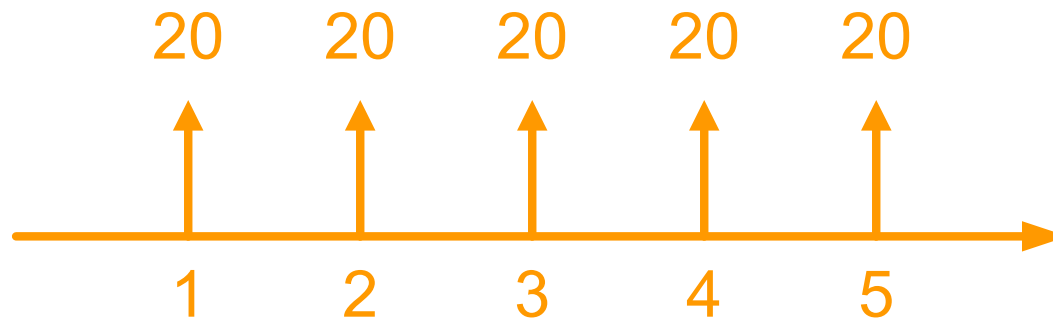
Cents per kWh due to a \$15 CO2 fee



National average price is now about 9 cents per kWh

Emissions taxes and investment

- Example investment in new equipment
 - More efficient electric motor
 - One-time \$300 payment
 - Eliminates 1 ton of carbon emissions every year
 - Saves \$20 of emissions taxes per ton per year
- Cash flows:



Would be profitable:

- Payments without it
 - \$20/year
- At a 5% interest rate ...
 - Present value of savings is \$400
- Cost of motor
 - \$300
- Gain from investment
 - $\$400 - \$300 = \$100$

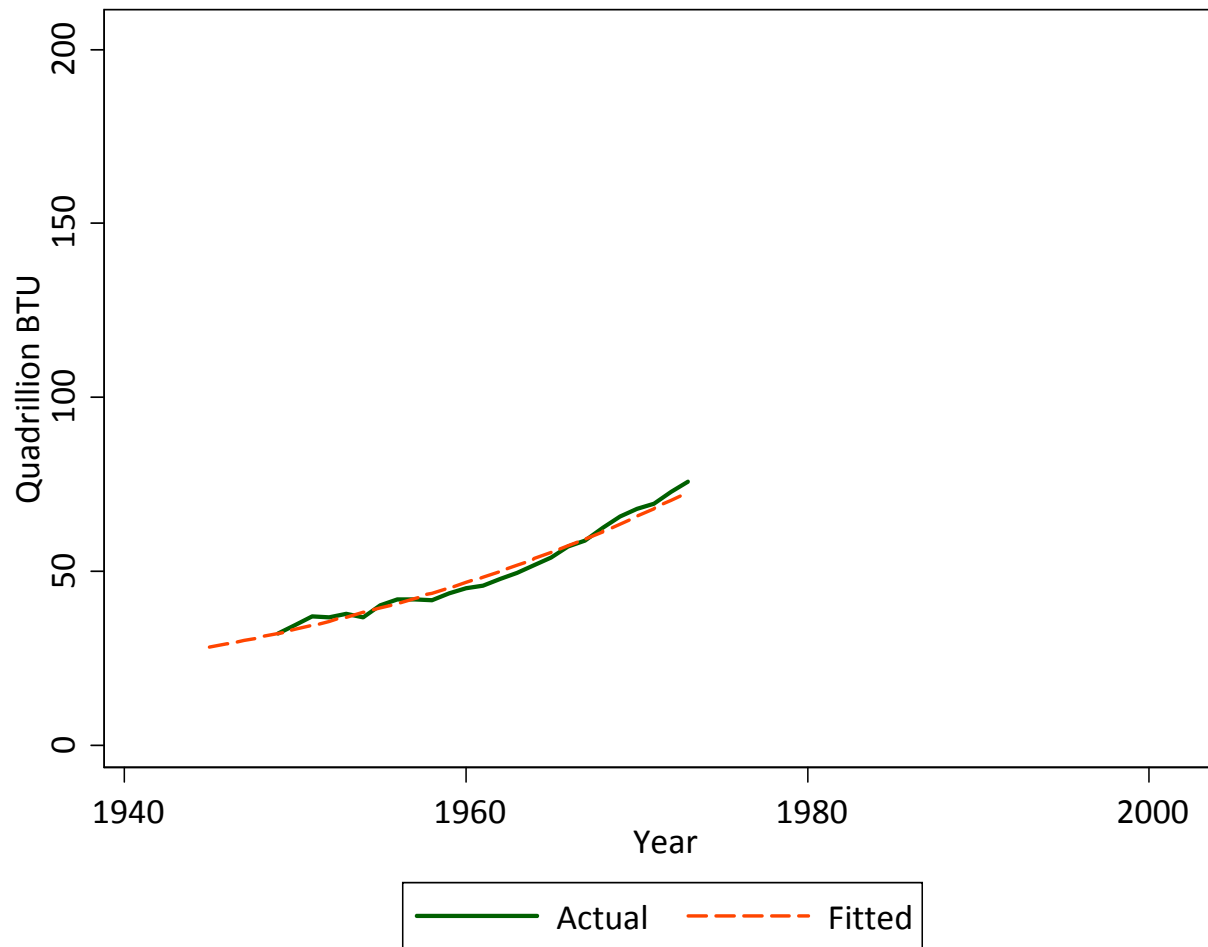
Importance of credibility

- Investors need to be confident policy won't be weakened
- If policy may be repealed:
 - Won't have to pay \$20 per year for emissions
 - Expected savings < \$20 per year
 - Expected value of savings < \$400
- Example:
 - Suppose chance of repeal is 10% in each year
 - Value of investment drops to \$133
 - Cost is still \$300
 - Expected gain is now $\$133 - \$300 = -\$167$
 - Loses money -- no incentive to invest

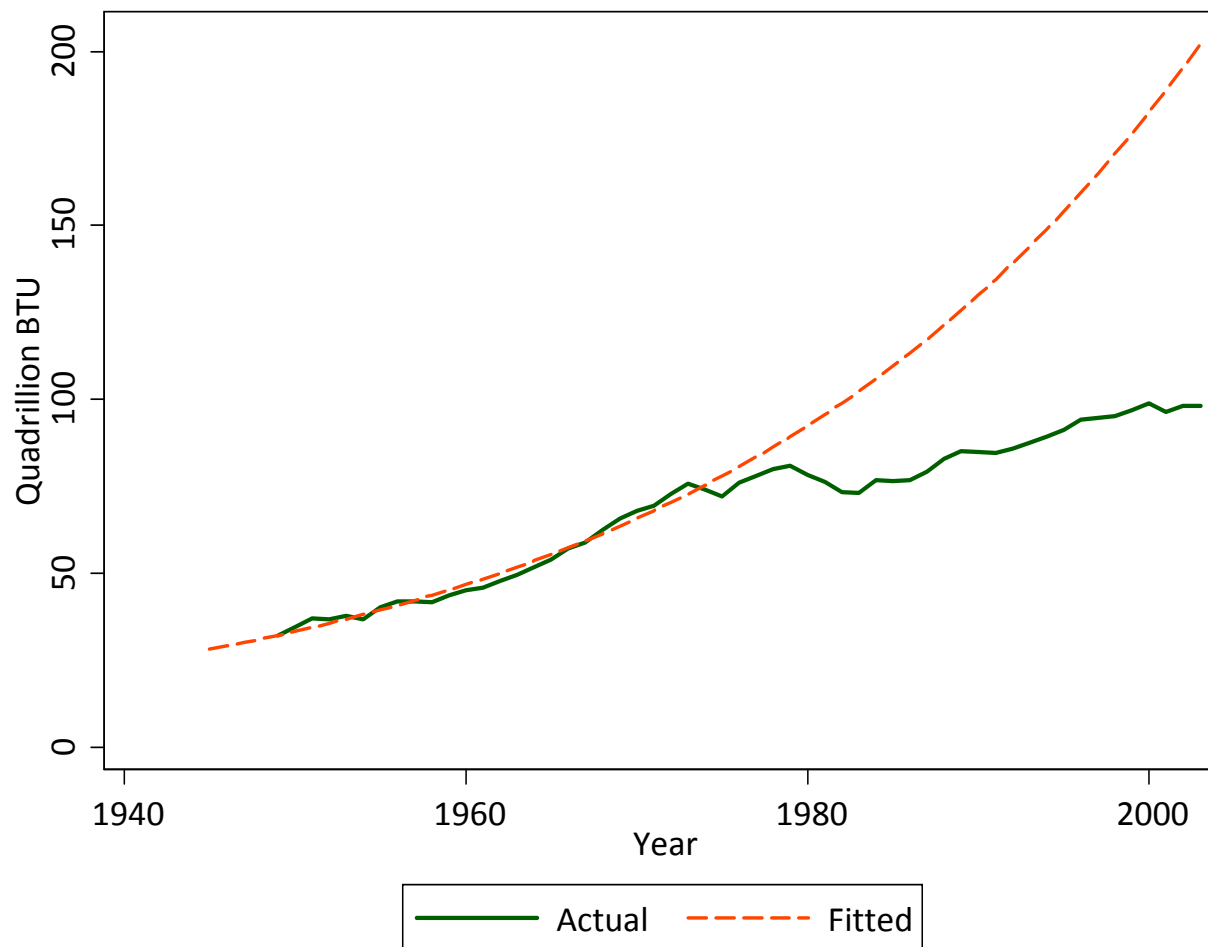
Are prices effective?

- What do we know from history about fuel use?

US fuel consumption after the war: 3.4% annual growth



Sharp change after the energy shocks!



Energy prices matter!

- Stabilized US energy consumption
 - Flat for about 20 years
- GDP growth was a little slower
 - About 0.2% per year: from 3.2% to 3.0%

Potential problems with a carbon tax

- Large energy taxes may not be politically viable
 - Not possible to discuss seriously
- Are large energy taxes credible?
 - Future governments could reduce or repeal them

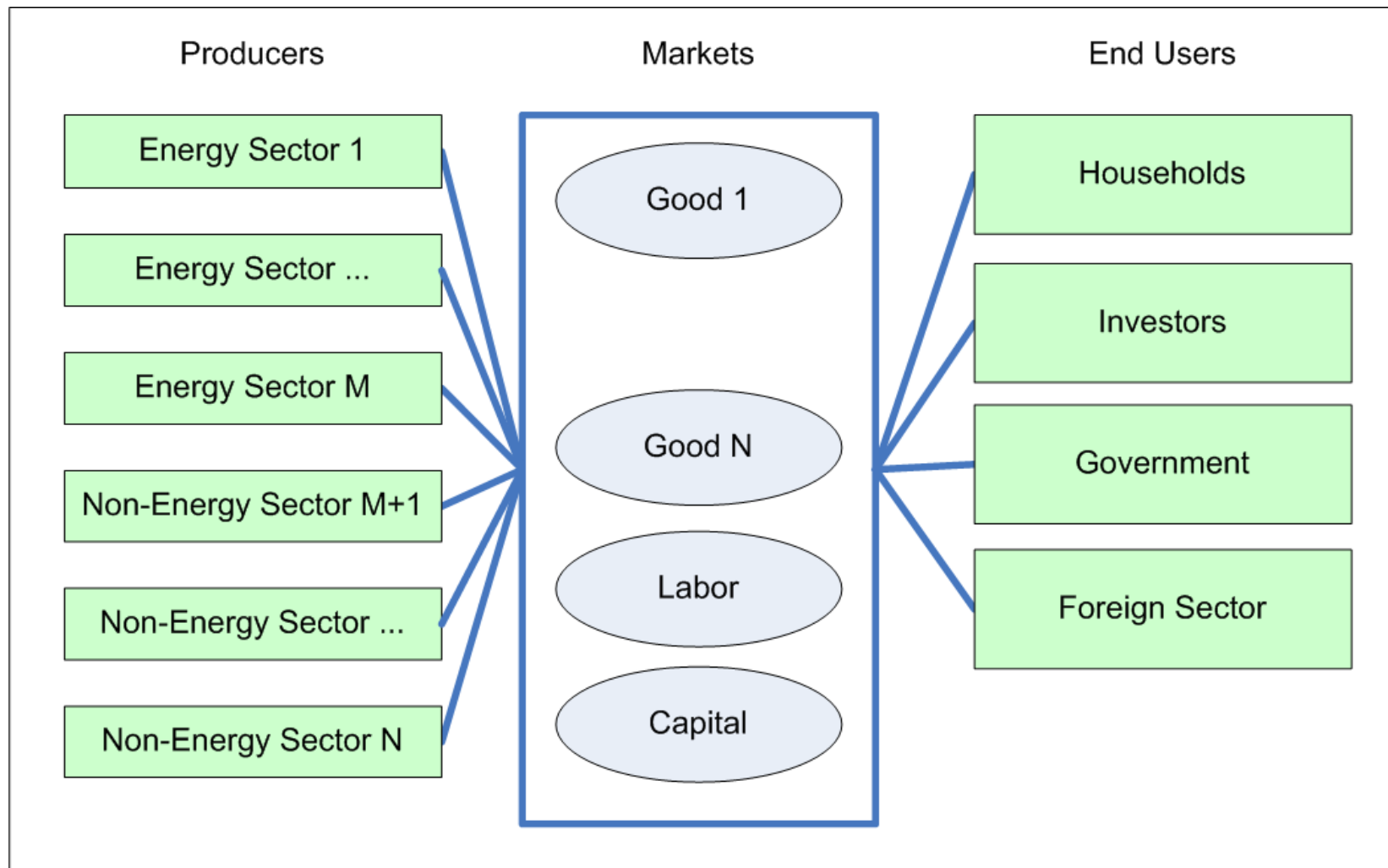
Looking forward, typical questions from policy makers

- How much would emissions fall for a given tax?
- How costly would it be in GDP?
- What would happen to energy producers?
 - Electric power producers? Oil and coal companies?
- What happens to energy users?
 - Aluminum producers? Airlines? Households?
- What about government finance?
 - Tax revenue? Government expenditures? The deficit?
- What does the policy do to investment and growth?
- What about exchange rates and international competition?
- ...

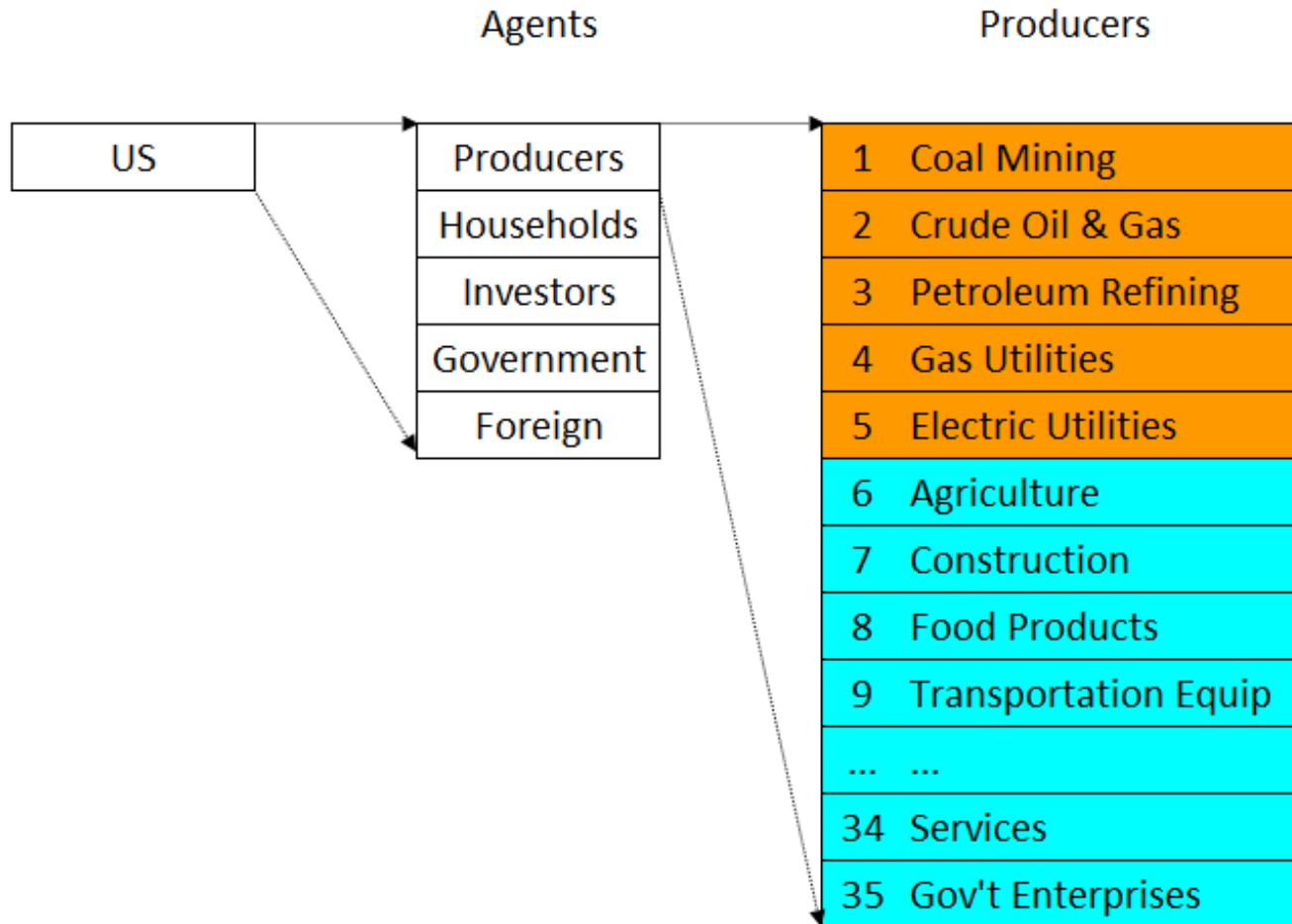
Answer using economic models

- Divide world into regions
- Divide regions into economic actors
 - Households
 - Manufacturing and service sector firms
 - Energy suppliers
 - Governments

Schematic view



Example: IGEM (used by the US EPA)



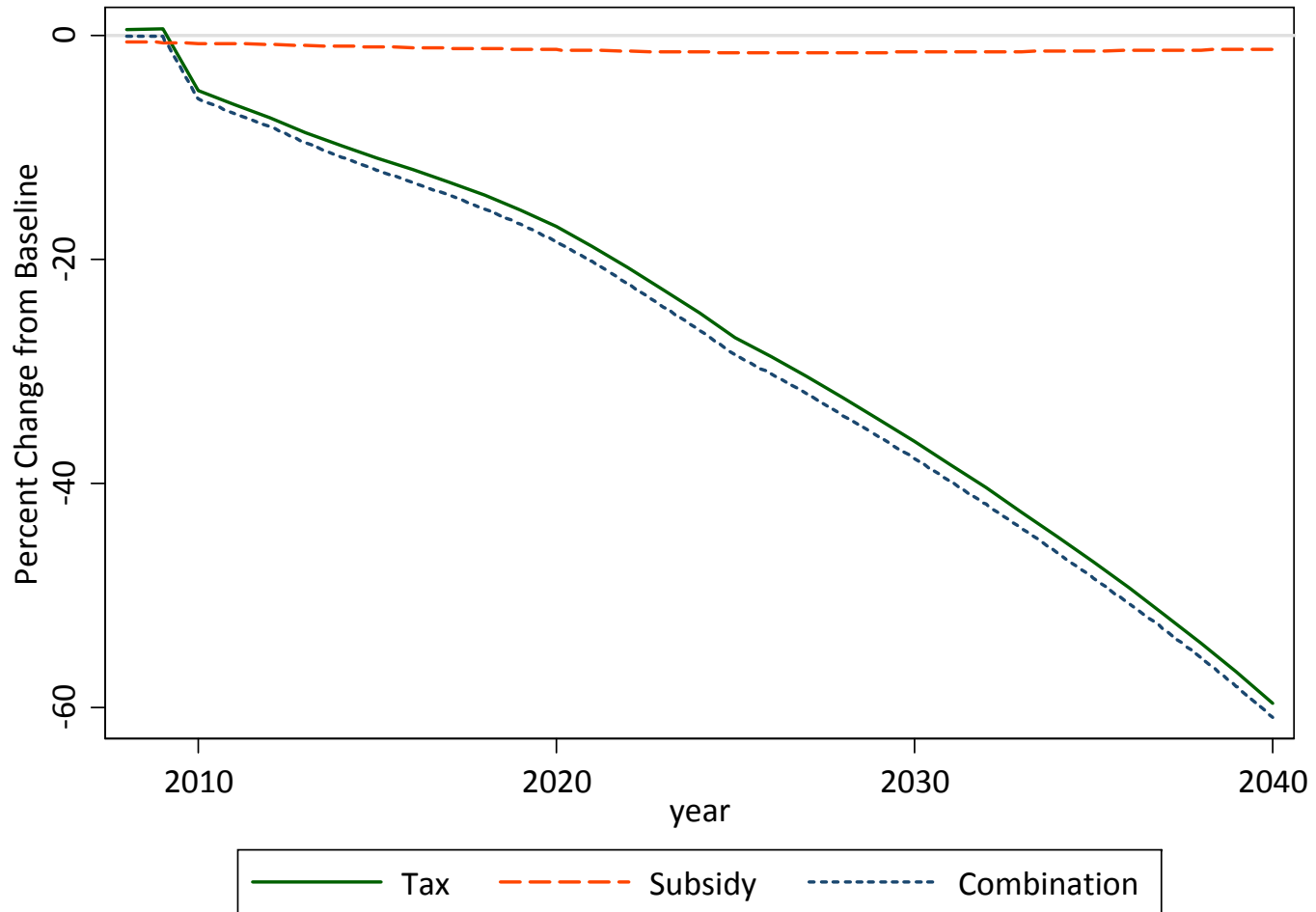
Component models of agents

- Households
 - Based on utility maximization
 - Demand equations for goods
 - Supply equations for labor and savings
- Firms
 - Based on profit maximization
 - Demand equations for fuels and inputs
 - Supply equations for goods and services
- Design of models
 - Straightforward extensions of those used in economics classes
- Estimation of parameters
 - Use techniques from statistics and quantitative classes

Example analysis

- Policy 1: carbon tax on fossil fuels
 - \$30 per ton and rising at 5% per year
 - Raises considerable revenue
- Policy 2: investment tax credit for household energy efficiency
 - 10% credit for capital that is 20% more efficient than usual
 - Reduces revenue by an amount similar to policy 1
- Policy 3: policies 1 and 2 combined
 - Approximately neutral in revenue

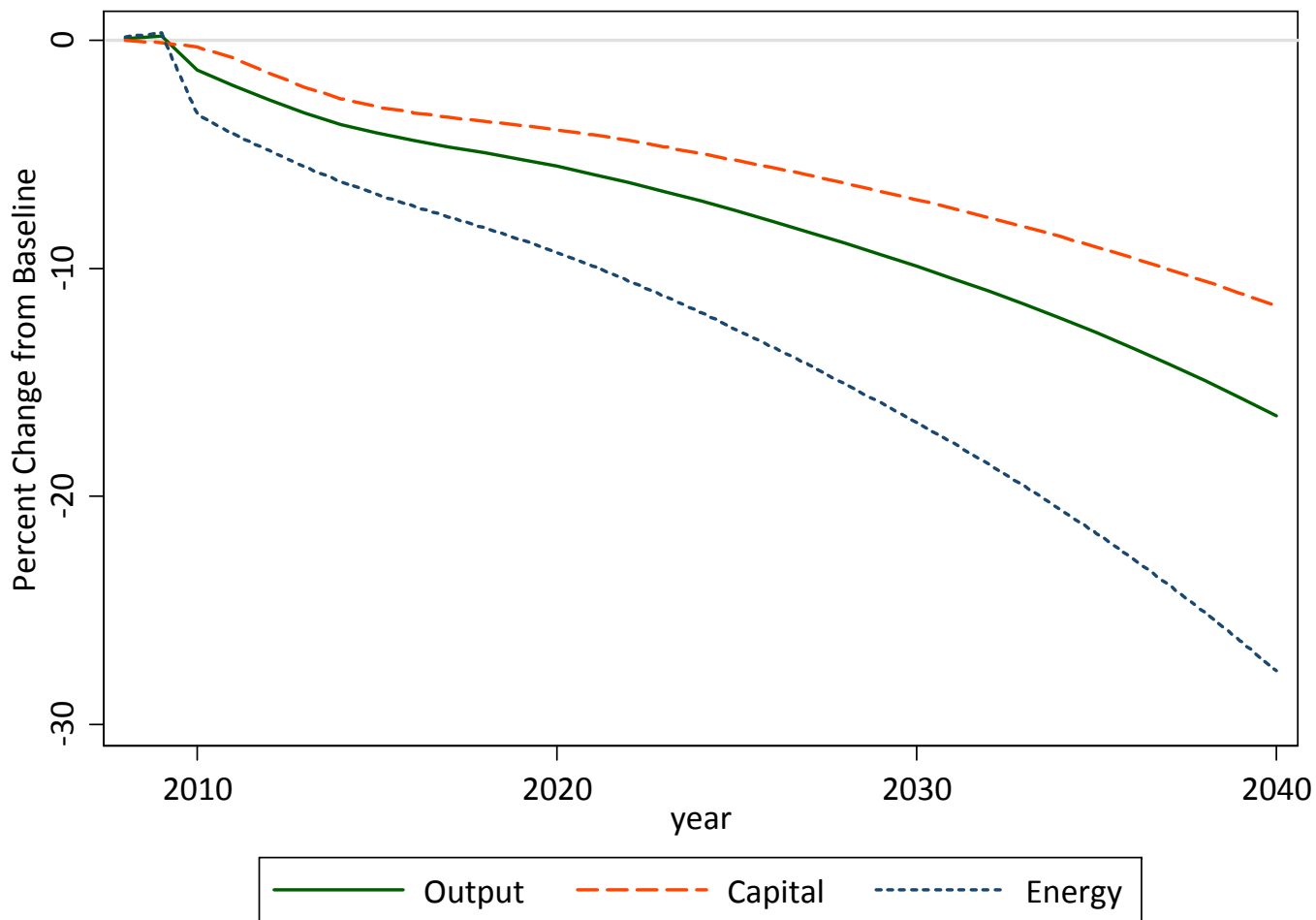
Effect on annual US CO2 emissions



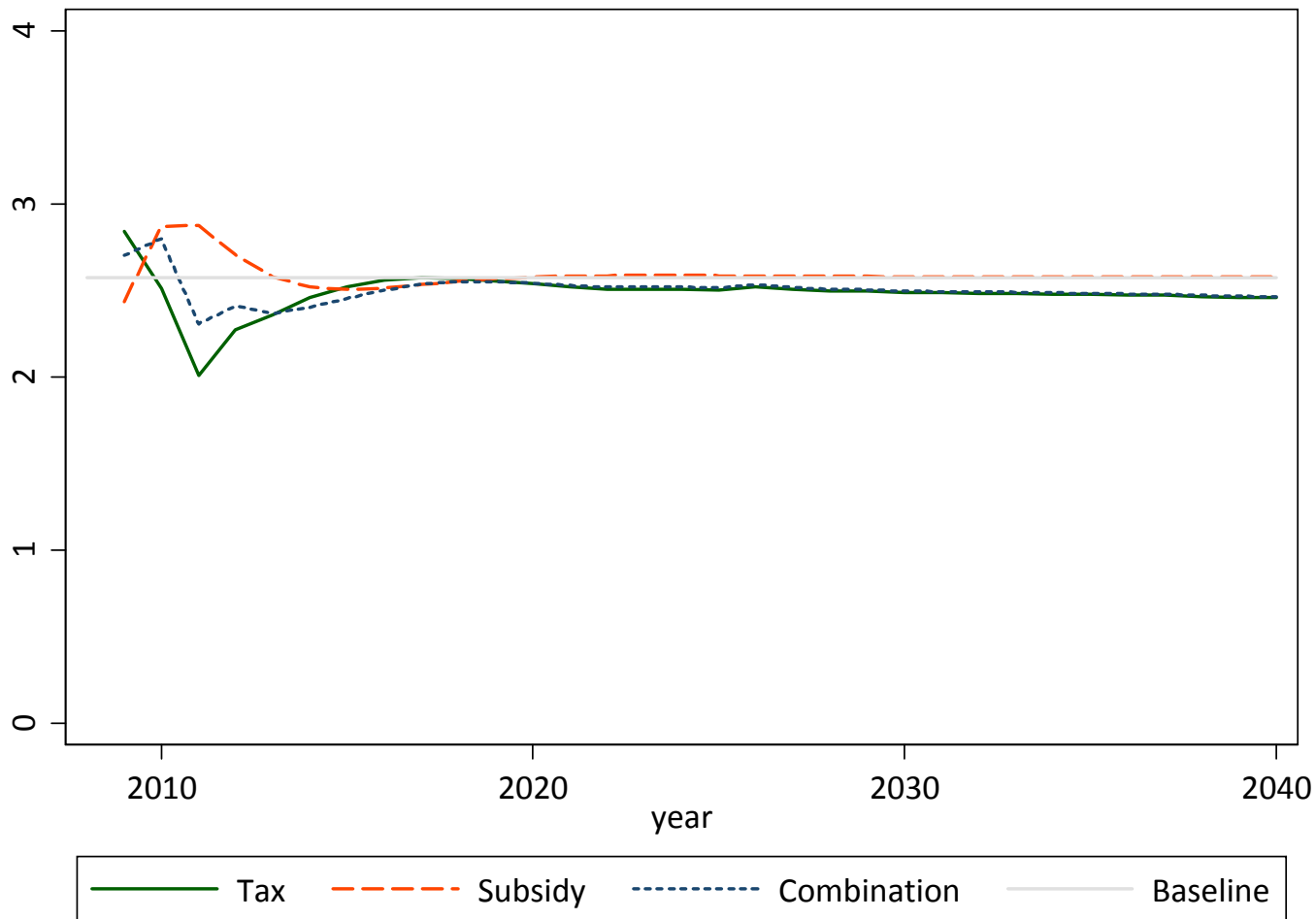
Effect on industry output in 2030

Num	Sector	Carbon Tax	Tax Credit	Combination
1	Electric Utilities	-9.9%	-0.9%	-10.8%
2	Gas Utilities	-4.5%	-1.0%	-5.5%
3	Oil Refining	-26.0%	-1.5%	-27.5%
4	Coal	-31.2%	-0.8%	-32.0%
5	Crude Oil and Gas	-31.8%	-1.5%	-33.4%
6	Other Mining	-3.0%	0.5%	-2.5%
7	Agriculture	-0.9%	0.0%	-1.0%
8	Forestry	-2.2%	0.4%	-1.8%
9	Durables	-3.3%	0.7%	-2.6%
10	Nondurables	-0.8%	-0.1%	-0.9%
11	Transportation	-1.1%	0.0%	-1.2%
12	Services	0.6%	-0.2%	0.5%

Effect of a carbon tax on inputs and outputs of utilities



Effect on the growth rate of real GDP



Summary

- Controlling climate change
 - Challenging: 86 quads to reduce
 - Possible: prices are very effective
 - Big effects on some industries and regions, not a big effect on GDP
- Tools from the core classes
 - Used directly and daily in major real-world policy analysis!