Cost and Benefit Concepts and the Social Cost of Carbon

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Section 3
ECON 1661 / API-135: Spring 2021

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Outline

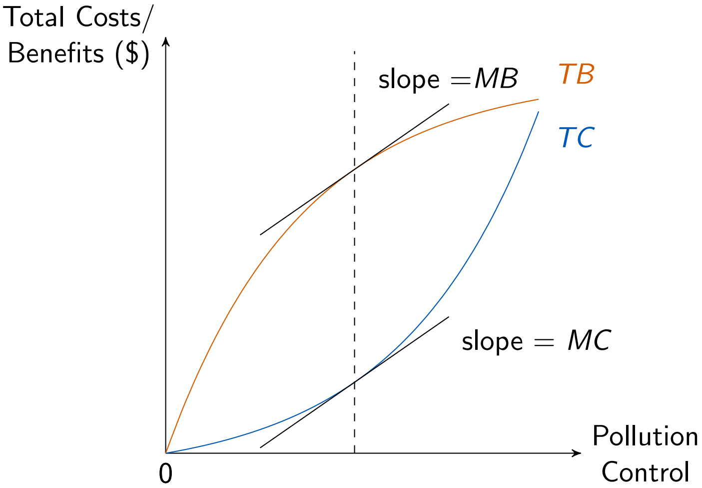
Basic Cost Concepts

Basic Benefit Concepts

The Social Cost of Carbon

Outline

Our basic definition of efficiency



- Static efficiency: maximizing net benefits
- Dynamic efficiency: maximizing NPV
- In both cases, need to know benefits and costs!

Review of *economic* cost

- When it comes to economics, we focus on opportunity cost
  - $\rightarrow$ The value of whatever must be sacrificed in order to obtain something
- Distinction: aggregate cost vs. distribution of costs
- Distinction: real cost vs. transfers

Taxonomy of compliance costs

1. Resource compliance costs
2. Government regulatory costs
3. Social welfare costs
4. Transitional costs
5. Indirect costs

Example: CO_2 emissions regulation

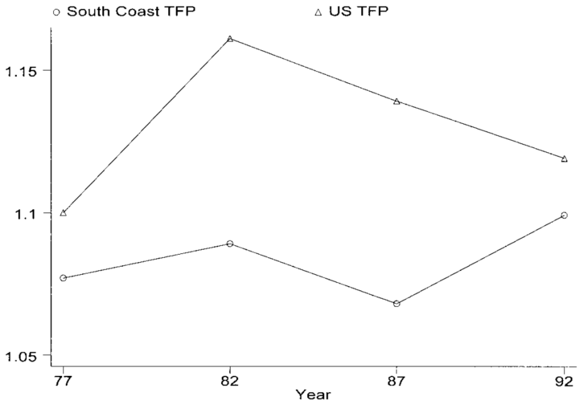
Estimating compliance costs

- Three types of methods:
  1. Direct compliance cost method
  2. Partial equilibrium analysis
  3. General equilibrium analysis

$\Rightarrow$ The appropriate method depends on the relative importance of the five types of costs

Estimating compliance costs in practice: Berman and Bui (2001)[1]

FIGURE 4.—SOUTH COAST AND U.S. TFP



- Examine the effect of air quality regulation on productivity in oil refining market
- Use data on southern California (CA) refiners from 1979-1992
- Find that southern CA refiners increased productivity during period of high local regulation

$\Longrightarrow$ resource compliance cost *may* overstate overall economic costs

[1] Berman, E. and L.T.M. Bui. "Environmental Regulation and Productivity: Evidence from Oil Refineries." *Rev Econ Stat*, 83(3): 498-510.

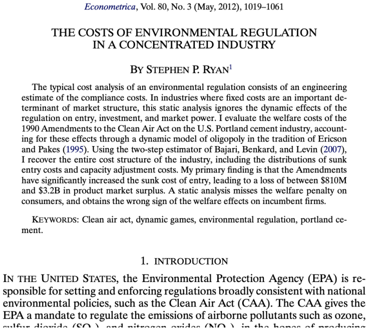
Estimating compliance costs in practice: Ryan (2012)[2]

- Evaluates the welfare costs of the 1990 Clean Air Act Ammendments on U.S. cement industry

- Theoretical model of the cement industry $\rightarrow$ models firm decisions over entry, exit, production, and investment

- 1990 CAAA significantly increased cost of entry in cement industry, increasing market concentration, which leads to welfare costs beyond just the real resource cost of compliance

$\Longrightarrow$ resource compliance cost *may* understate overall economic costs



Econometrica, Vol. 80, No. 3 (May, 2012), 1019–1061

THE COSTS OF ENVIRONMENTAL REGULATION IN A CONCENTRATED INDUSTRY

BY STEPHEN P. RYAN[1]

The typical cost analysis of an environmental regulation consists of an engineering estimate of the compliance costs. In industries where fixed costs are an important determinant of market structure, this static analysis ignores the dynamic effects of the regulation on entry, investment, and market power. I evaluate the welfare costs of the 1990 Amendments to the Clean Air Act on the U.S. Portland cement industry, accounting for these effects through a dynamic model of oligopoly in the tradition of Ericson and Pakes (1995). Using the two-step estimator of Bajari, Benkard, and Levin (2007), I recover the entire cost structure of the industry, including the distributions of sunk entry costs and capacity adjustment costs. My primary finding is that the Amendments have significantly increased the sunk cost of entry, leading to a loss of between \$810M and \$3.2B in product market surplus. A static analysis misses the welfare penalty on consumers, and obtains the wrong sign of the welfare effects on incumbent firms.

KEYWORDS: Clean air act, dynamic games, environmental regulation, portland cement.

1. INTRODUCTION

IN THE UNITED STATES, the Environmental Protection Agency (EPA) is responsible for setting and enforcing regulations broadly consistent with national environmental policies, such as the Clean Air Act (CAA). The CAA gives the EPA a mandate to regulate the emissions of airborne pollutants such as ozone,

[2]Ryan, S.P. 2012. "The Costs of Environmental Regulation in a Concentrated Industry." *Econometrica*, 80(3): 1019-61.

Outline

Valuing environmental goods and services

- Imagine you are a policymaker. You know that the optimal amount of pollution control requires $MC = MB$
- The direct costs of compliance can be large
  - $\rightarrow$ The direct costs of implementing the Clean Air Act from 1970-1990 were $523B
- How do we know if this expenditure is worth it? Need to know the benefits $\Longrightarrow$ what is the value of clean air?

Valuing environmental goods and services

- Problem: environmental goods and services are particularly difficult to value — why?
- Typically no markets for environmental quality
- Unlike typical consumer goods, we cannot observe a market price and quantity sold for coral reefs or wetlands

What are environmental benefits?

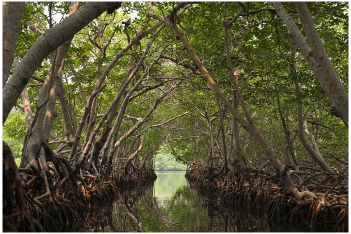
Three broad categories:

1. Use value
   - Benefits of direct use of the good/service
   - Example: rafting the Colorado river in the Grand Canyon
2. Option value
   - Benefits people receive now from having the option to use the good/service in the future
   - Example: the benefits to people living now of preserving the Grand Canyon so they can see it in the future
3. Existence value
   - Benefits people receive from the knowledge of the existence of a good/service (that they never intend to use)
   - Example: the benefits people obtain from knowing that the Grand Canyon exists

Examples

The policy that cleaned up the Cuyahoga river?

The creation of Rocky Mountain National Park?



Protection of Thai mangrove swamps?

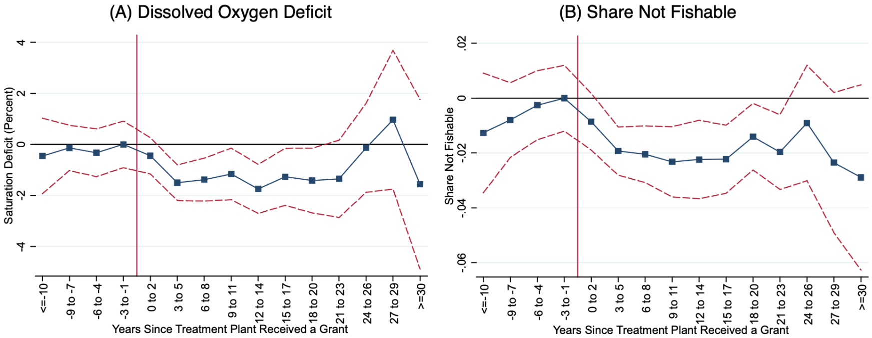
Preview of next week: estimating benefits

- To estimate benefits, need to know willingness-to-pay $\rightarrow$ why?
  - Aggregate of WTP is total benefit!

- So to estimate benefits, need to estimate the relevant demand function

- Primary tools:
  1. Revealed preference methods
  2. Stated preference methods
  3. Other: experimental methods, official referenda

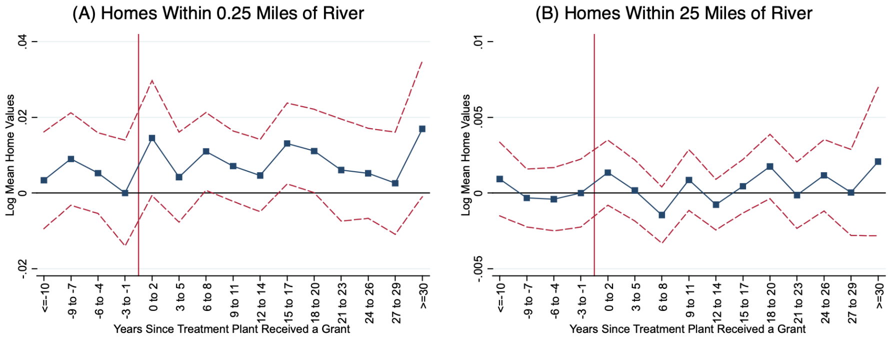
Preview of next week: Keiser and Shapiro (2019)[3]



- Effect of Clean Water Act grants to municipal wastewater treatment plants (1962-2001)
- Find substantial improvements in water quality from grants
- Limited effects on house prices (see figures)

[3] Keiser, D.A. and J.S. Shapiro. 2019. "Consequences of the Clean Water Act and the Demand for Water Quality." *Q J Econ*, 134(1): 349-96.

Preview of next week: Keiser and Shapiro (2019)[4]



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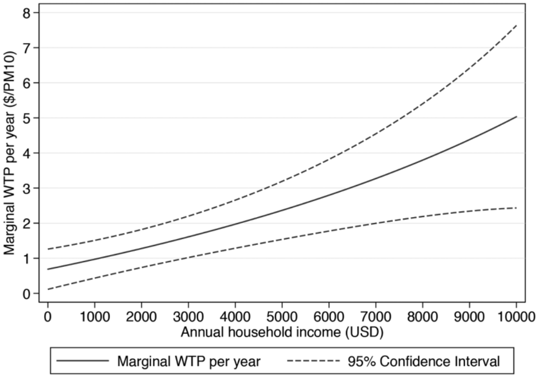
Preview of next week: Ito and Zhang (2020)[5]



- Use data on sales of air purifiers in China to estimate household WTP for clean air
- Substantial heterogeneity in WTP by income
- Implications for equity when thinking about BCA analysis of clean air policies?

[5] Ito, K. and S. Zhang. 2020. "Willingness to Pay for Clean Air: Evidence from Air Purifier Markets in China." *J Polit Econ*, 128(5): 1627-72.

Outline

Efficient climate policy?

- An efficient policy sets the price faced by CO_2 emission sources at the value of marginal damages (will discuss how to do this in the coming weeks)

- Same question as before: what are the benefits (costs) of climate mitigation (inaction)?

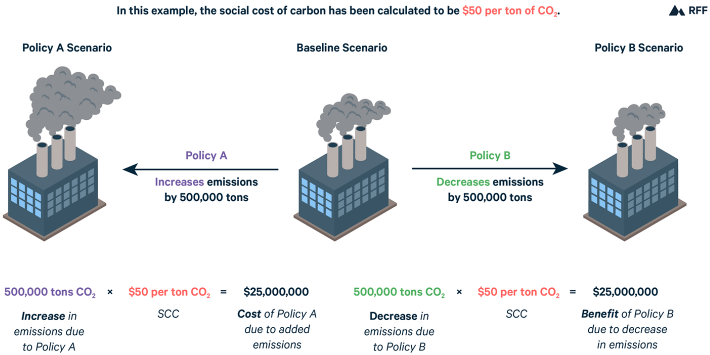
- Helpful concept: Social Cost of Carbon (SCC)
  → The dollar value of all of the future damages associated with the change in climate due to the release of an additional ton of CO_2

Brief history of the SCC

- 2007: Supreme Court decision in *U.S. EPA vs. Massachusetts*
  → required federal regulation to reduce greenhouse gases under Clean Air Act
- 2009: Obama admin issues temporary SCC and forms Inter-agency Working Group (IWG)
- 2010: IWG releases first estimate of SCC equal to \$21/ton CO_2
- 2013: First update to the SCC estimate, going to \$42/ton CO_2
- 2017: Final Obama admin estimate equal to \$52/ton CO_2
- 2017: Trump admin E.O. 13783 disbanded IWG, modified SCC by (1) only considering domestic damages and (2) using discount rates of 3% and 7%
- 2021: Biden E.O. re-establishes IWG; asks IWG to publish interim SCC within 30 days

SCC: what's the point?

- *U.S. EPA vs. Massachusetts* $\Longrightarrow$ legal imperative to regulate CO_2 emissions
- E.O. 12291 (1981): agencies must prepare regulatory impact analyses of new regulations
- SCC helps us determine efficient policy, but it is also helpful in conducting benefit-cost analysis of proposed regulations



Example of the SCC in action

Source: Carleton, T. and M. Greenstone. 2021. "Updated the United States Government's Social Cost of Carbon." BFI Working Paper 2021-04.

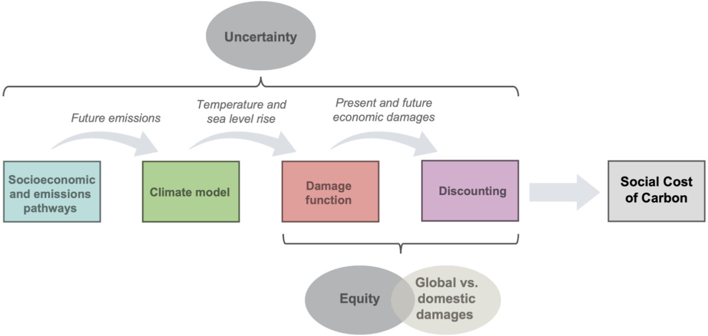
- Example regulatory BCA using two different SCCs (note: costs include others beyond emission-related climate damages)
- 2017 EPA and NHTSA rollback of fuel economy standards for 2021-2026 model-year vehicles
- Takeaway: the assumptions used to calculate SCC have very real implications for policymaking

How is the SCC calculated?

- Integrated Assessment Models (IAMs): combine climate processes, economic growth, and climate-economy feedbacks into single modeling framework
  - $\rightarrow$ IWG used three IAMs: DICE (Yale), PAGE (Cambridge), FUND (Sussex)

- General approach:
  1. Create baseline scenario:
     - 1.1 Predict future emissions based on population, economic growth, etc.
     - 1.2 Model future climate responses such as tempaerature increases and SLR
     - 1.3 Assess the economic impact that these responses will have
     - 1.4 Convert future damages into their present-day value and add them up
  2. Repeat modeling process with a small, incremental increase in emissions to determine change in total estimated cost of damages

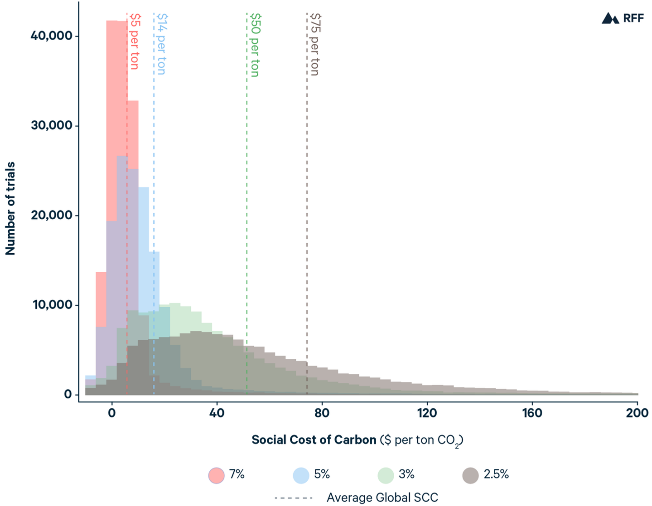
How is the SCC calculated?



Source: Carleton, T. and M. Greenstone. 2021. "Updated the United States Government's Social Cost of Carbon." BFI Working Paper 2021-04.

- Boxes: "modules"; circles: modeling decisions
- To-date most of the focus has been on uncertainty and global vs. domestic damages; equity considerations ignored

Uncertainty



- Assumptions introduce uncertainty
  - → Ex: range of plausible values for future economic growth rates
- To account for uncertainty, models are run hundreds of thousands of times with different values for the uncertain parameters

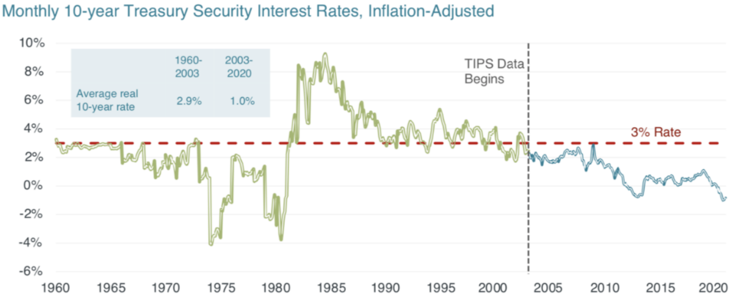
Global vs. domestic damages

Discount rate	Global SCC (\$/ton)	Domestic SCC (\$/ton)
2.5%	75	10
3%	50	7
5%	14	2
7%	5	1

Units 2019 USD; Source: Affordable Clean Energy Rule Regulatory Impact Analysis (2020)

- Clearly the decision over whether to include international damages impacts SCC estimates
- Ignoring international damages appears to place US interests first
- In reality: using global SCC to set domestic climate policy incentivizes other countries to reduce their own emissions
  - $\rightarrow$ $\sim$90% of emissions from outside US
  - $\rightarrow$ Likely to benefit US more than policy set using domestic SCC in the long run!

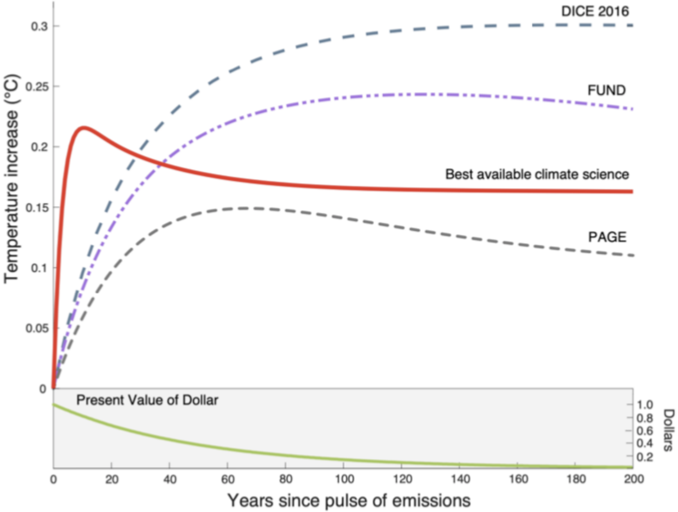
Discounting



Source: Carleton, T. and M. Greenstone. 2021. "Updated the United States Government's Social Cost of Carbon." BFI Working Paper 2021-04.

- IWG: set central discount rate at 3%, consistent with OMB guidance at the time which was informed by existing asset markets
- Recent changes in capital markets suggest 3% may be high
- Review: why do we discount? → (primarily) declining marginal utility of consumption

Looking ahead: updating the SCC



- Recent climate science (red) departs from three IAMs in terms of temperature predictions
- Current science predicts faster initial temperature increase
  - $\rightarrow$ Important implications given that we discount damages

Source: Carleton, T. and M. Greenstone. 2021. "Updated the United States Government's Social Cost of Carbon." BFI Working Paper 2021-04.

Updating the SCC: equity considerations

- Remember why we discount: declining marginal utility of consumption
- "Equity-weighting" of damages may be consistent with the discounting logic
  - → Low income individuals have higher marginal utility of consumption than high income individuals
  - → Equity weighting: given amount of climate damages in poorer areas of US contribute more to the SCC than equal damages in wealthier areas
- Current regulatory framework not in place for this kind of equity weighting
- Practice of equal weighting: akin to a utilitarian criterion
  - → In maximizing (minimizing) overall benefits (costs), maximize total utility

Updating the SCC: final points

- Other greenhouse gases
  - Social cost of methane and social cost of nitrous oxide also estimated by IWG
    - → Estimate for 2020 was $1400/ton methane
  - Concept of CO_2 equivalent: use to compare emissions from various greenhouse gases on the basis of their global-warming potential
    - → CO_2-eq sub-optimal though given differences across GHG's over time

- Adaptation: technically adaptation and technological change are included in the IAMs
  - → Potential for updating: assumptions about adaptation differ across the three IAMs and are not based on recent literatures on adaptation

Questions?

Reminders:

- Office hours: Fridays from 3:00-5:00pm ET; Zoom link on Canvas
  - → Email if these times don't work
- Problem set 1 due on **Wednesday, February 17 at 12:00pm ET**
- All recordings posted to Canvas