Fundamentals of an Economic Perspective

Recorded Session #2

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The Perspective of this Course

- The fundamental basis for concern about climate change is *scientific*.
  - Hence, we build on basic *scientific understanding*.
- That's our point of departure to examine the *economics and politics*.
  - But *why* focus on economics and politics of climate change?
- For politics, it's probably obvious that the *venue* and *nature* of *key decision-making* is fundamentally *political*.
- But it may be *less clear* why an emphasis on *economics* is warranted.

“What business are you in?”

“I’m an environmental economist.”

Environmental economics is *not* oxymoronic

1. The *causes* of environmental problems (in a market economy) are economic – unintended side-effects of market activity ("externalities").

2. The *consequences* of environmental problems have important economic dimensions.

- Therefore, an economic perspective is *helpful* for …

  - A *full understanding* environmental problems

  - And therefore can be *very helpful* for the design of *solutions* that will be *effective, economically sensible, and (perhaps) politically feasible*.

- Economic thinking is particularly important for the formulation of effective, sensible, and politically feasible **climate policies** …

Science → Economics → Geopolitics of Climate Change

- **Greenhouse gases *mix in the atmosphere*, so the location of emissions has *no effect* on impacts – in economic terms, climate change is a *global commons problem***
  - Any jurisdiction taking action incurs the *costs* of its actions
  - But climate benefits are *distributed globally*
  - Therefore, for virtually any jurisdiction, the climate benefits it reaps from its actions will be *less* than the costs it incurs ….
    - ➢ despite the fact that the global benefits may be *greater* – possibly *much* greater – than the global costs
- **This presents a classic free-rider problem, ….**
  - which is why *international*, if not global, cooperation is essential, and why the highest levels of effective governance (typically countries) are key.
- **There's also a temporal dimension that takes us from science to economics to politics and policy …**

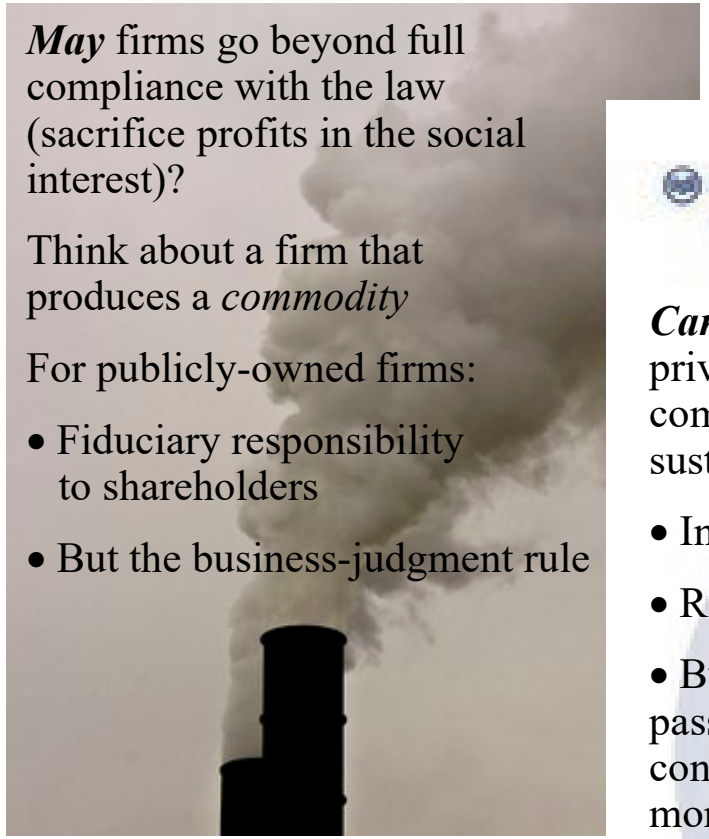
More Science → Economics → Geopolitics of Climate Change

- **Greenhouse gases accumulate in the atmosphere (100+ years for CO_2)**
  - Damages are a function of the *stock*, not the flow
  - If CO_2 emissions begin falling tomorrow by 5%/year, the rate of warming won't begin to change in a detectable way until after 20 years *(Nature* 2020)
  - So, greatest benefits of climate policies will be in the *long term*, but climate change *policies* and the attendant *costs of mitigation* will be *up front*

- **This combination of *up-front costs* and *delayed benefits* presents a great political challenge**
  - Political incentive in democracies is to give benefits (to voters) today, and place costs on future generations
  - The climate problem asks politicians to do precisely the opposite!

- **Together, the global commons nature of the problem plus its intertemporal asymmetry make climate change a very tough political challenge.**

The Causes of Environmental Pollution are Economic



May firms go beyond full compliance with the law (sacrifice profits in the social interest)?

Think about a firm that produces a *commodity*

For publicly-owned firms:

- Fiduciary responsibility to shareholders
- But the business-judgment rule

Can firms – public or private – go beyond full compliance on a sustainable basis?

- Increase prices?
- Reduce profits?
- But some firms can pass on price increase to consumers – namely, monopolies

United States Steel Corporation

	12/31/95	12/31/96	12/31/97	12/31/98	12/31/99	12/31/00
SALES						
5 Self Service Bays	0	72,000	96,000	108,000	120,000	132,000
1 Automatic Bay	0	18,000	24,000	30,000	36,000	42,000
7 Vacuums	0	16,800	25,200	33,600	33,600	33,600
Total Annual Revenue	0	106,800	136,800	171,600	189,600	206,700
OPERATING EXPENSES						
Chemical and Vending	0	5,300	6,800	8,600	9,500	10,400
Gas and Electric	0	6,400	8,200	10,300	11,400	12,500
EDU Fees	24,000	0	0	0	0	0
Water & Sewer	0	3,200	4,100	5,200	5,700	6,300
Utility Connections/Permits	5,000	0	0	0	0	0
Telephone	0	250	250	300	350	400
Trash Removal	0	1,100	1,400	1,700	1,900	2,100
Insurance	0	3,200	4,100	5,200	5,700	6,200
Real Estate Taxes	0	5,000	5,500	6,000	6,500	7,000
Accounting & Legal	500	300	500	600	700	800
Repairs & Maintenance	0	2,100	2,700	3,400	5,700	6,200
Labor	0	8,000	9,400	10,700	12,100	13,500
Depreciation	0	39,800	39,800	39,800	39,800	39,800
Bank Charges	0	250	250	300	350	400
Bank Loan Costs	8,200	0	0	0	0	0
Advertising and Promotion	2,000	2,300	2,500	2,500	2,500	2,500
Total Operating Expenses	39,700	72,400	85,500	94,600	102,200	108,100
Operating Profit/Loss	(39,700)	29,400	51,300	77,000	87,400	99,500
Interest Expense	0	35,100	33,300	31,300	29,100	26,800
Pre-Tax Loss/Income	(39,700)	(5,700)	18,000	45,700	58,300	72,700
Taxes	0	0	7,200	18,300	23,300	29,100
NET INCOME(LOSS)	(39,700)	(5,700)	10,800	27,400	35,000	43,600

Where does the pollution go?

- Commercial laundry next door
- Does cost (to laundry) show up in annual report of steel producer?

Pollution is an *externality*.

The Consequences of Environmental Pollution have important Economic Dimensions

Externality = actions of a firm or individual have a direct (unintentional) and uncompensated effect on the well-being (utility) of other individuals or the profits of other firms

1. Producer → Producer

   (steel production & laundry services – $)

2. Producer → Consumer

   (paper production & recreational fishing)

3. Consumer → Consumer

   (secondary exposure to cigarette smoke)

4. Consumer → Producer

   (littering in a movie theatre – $)

- Economic consequences ≥ financial consequences
  - Economics is *not* the same as accounting

- Aspects that are easiest to analyze may *not* be most important quantitatively

Economic Valuation of the Impacts of Pollution

- You drink dirty water: feel sick for two days, stay home from work, go see the doctor
- How should we economically value the damages of your exposure to this pollution?

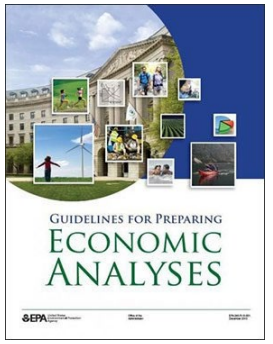
1. Lost wages (reduced productivity)?
2. Medical costs (whether paid, insured, or "free")? [Opportunity Cost]
3. "Pain-and-suffering"?

- Economics takes a *holistic* view, because #3 cannot be observed
  - The *economic value of the damages* are whatever you *truly* feel (believe) that they are!
  - *Not* what you my *say* the damages are, but what you *really feel* they are: what you reveal through your *behavior*.

Can Meaningful Numbers be Put on These Concepts?

- Over the past 50 years, economists have developed rigorous methods for *reliably estimating* people's valuation of a wide range of environmental threats and damages
  - If you want to learn about these, please take my course at Harvard on "Economics of Climate Change and Environmental Policy" – 25 lectures of 75 minutes each

- Are these methods just the province of academics?
  - No, the concepts and specific methods are *validated*, even *required* by:
    - *Executive Orders* by Reagan, Bush, Clinton, Bush, Obama, Trump, Biden
    - *Federal statutes*, including Clean Air Act, Clean Water Act, CERCLA, and others; *and laws and regulations in many other countries*
    - *Best analytic methods* laid out by Guidelines of U.S. Office of Management and Budget, and U.S. EPA



- **Important Tautology**: *benefits* of environmental protection are equal to the *damages* that are thereby *avoided*
  - So, if we have concepts and methods for valuing *damages* of environmental pollution, then we have methods for valuing ***benefits*** of public policies.

What About the Costs of Environmental Policies?

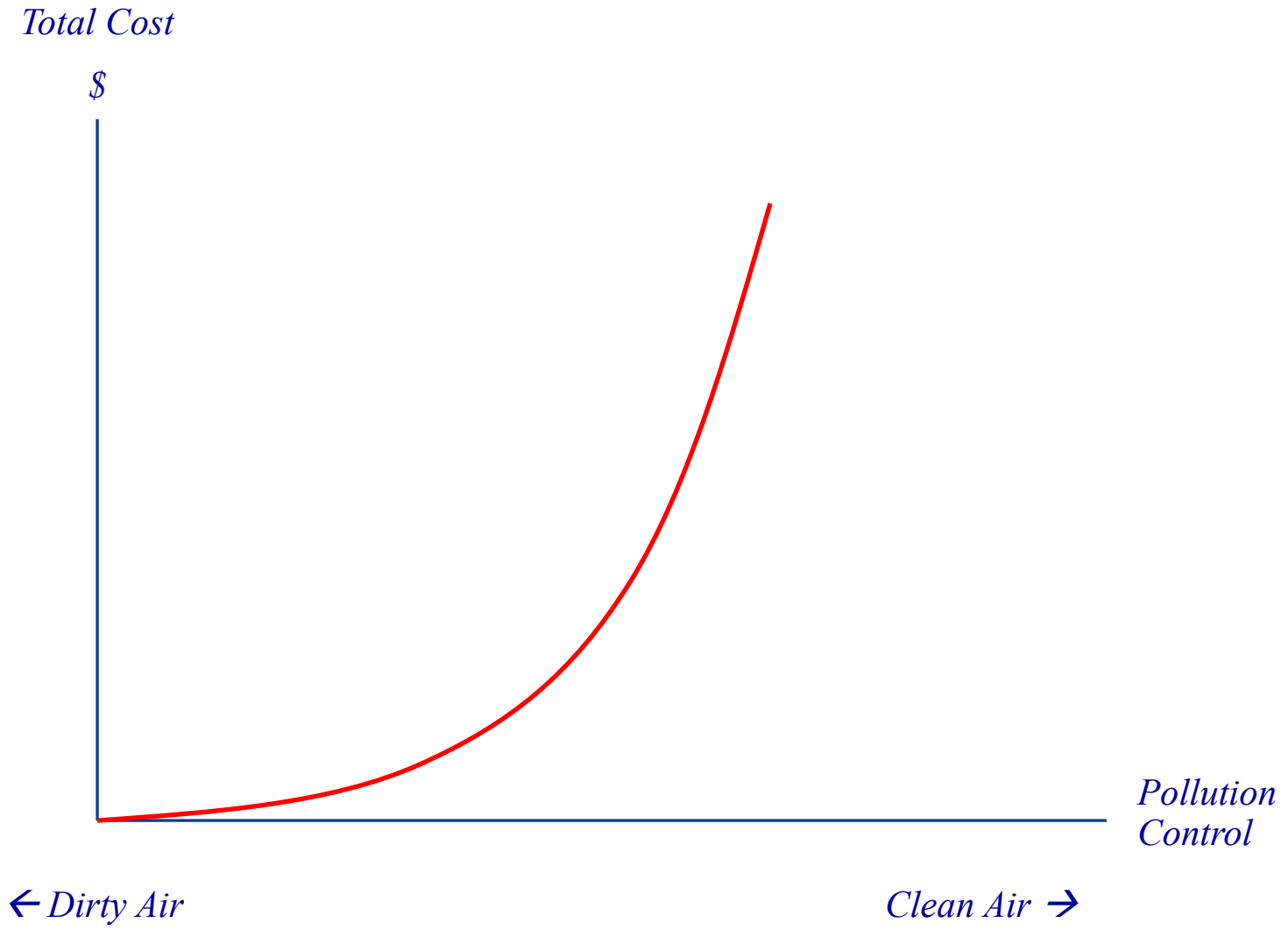
- How much does it cost to reduce a ton of emissions?
- Total costs increase at an increasing rate.
- In other words, incremental or *marginal costs increase*.

SO_2 Emissions Abatement

Emission Reduction (million tons)	Total Cost ($ billion)	Average Cost ($/ton)	Marginal Cost ($/last ton)
8	$2.2	$270	$270
10	$3.6	$360	$720
12	$9.3	$720	$2,775

- This general pattern is *ubiquitous* for virtually all environmental policies, including those that address Greenhouse Gases (GHGs):
  - Increasing marginal costs

The Costs of Pollution Control

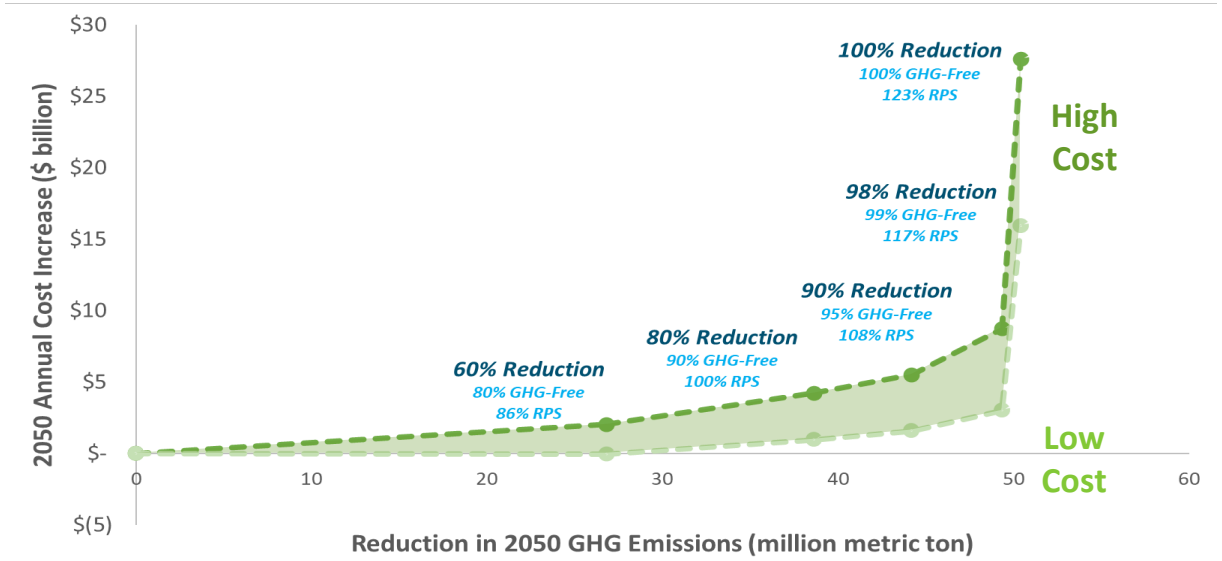


The Costs of GHG Emissions Abatement

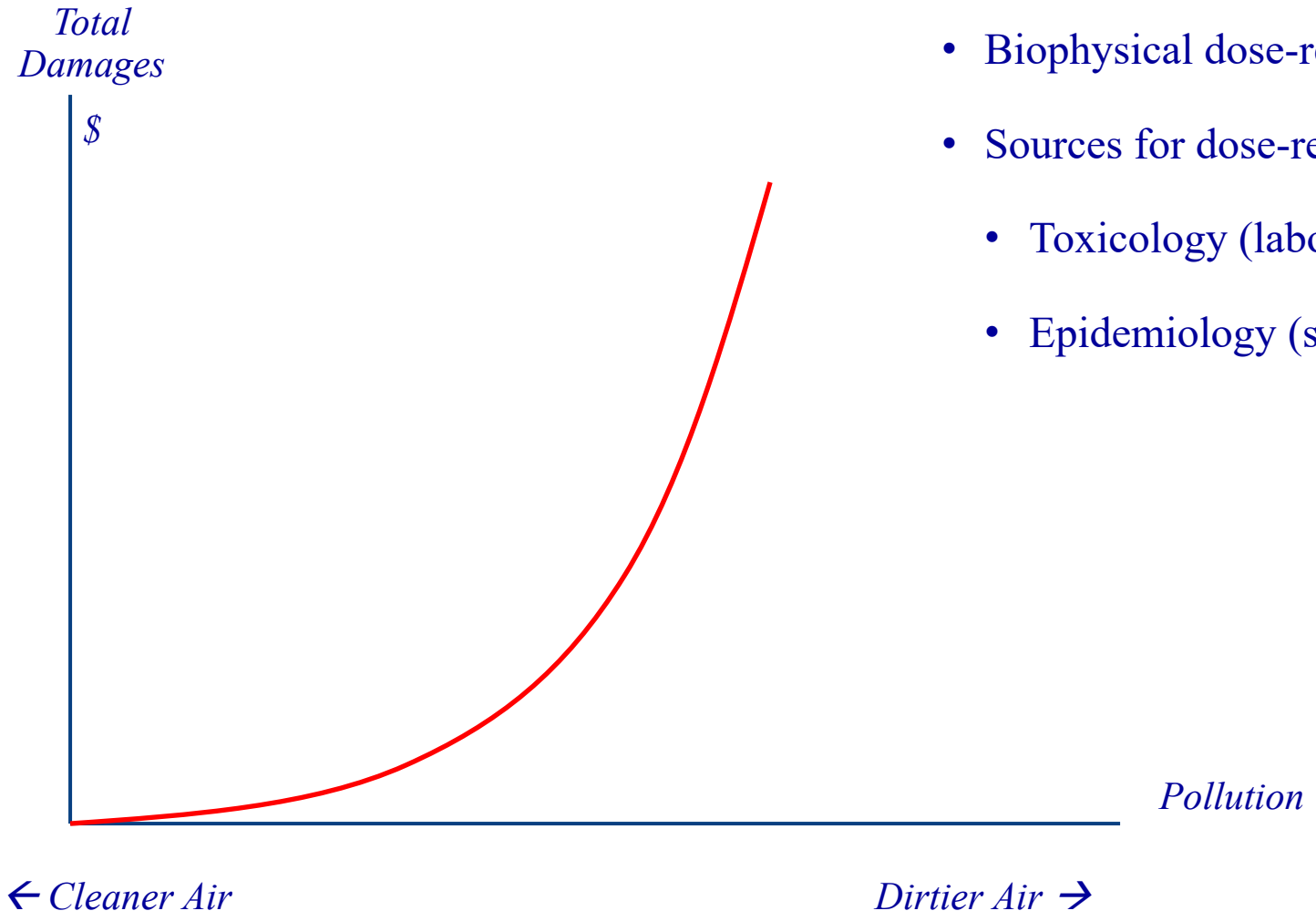
- How much does it cost to reduce GHGs?
- From many studies, total costs increase at *increasing rate*
- In other words, incremental or *marginal costs increase*.

Extreme Case:

Annual Cost of Carbon Reductions in the Pacific Northwest (already very clean)



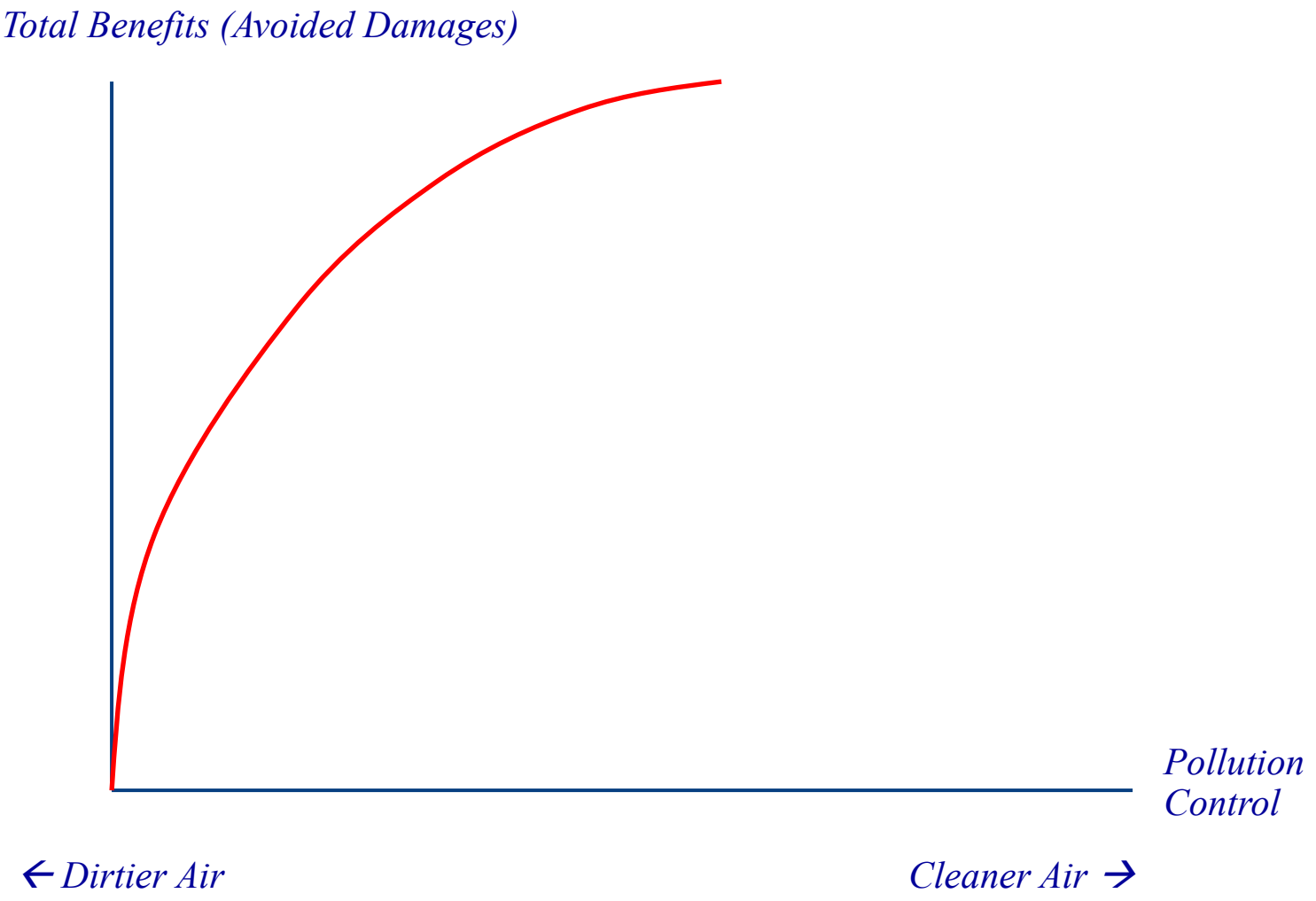
The Damages of Pollution



Economic damage function based on:

- Biophysical dose-response function
- Sources for dose-response function:
  - Toxicology (laboratory animals)
  - Epidemiology (statistical analysis)

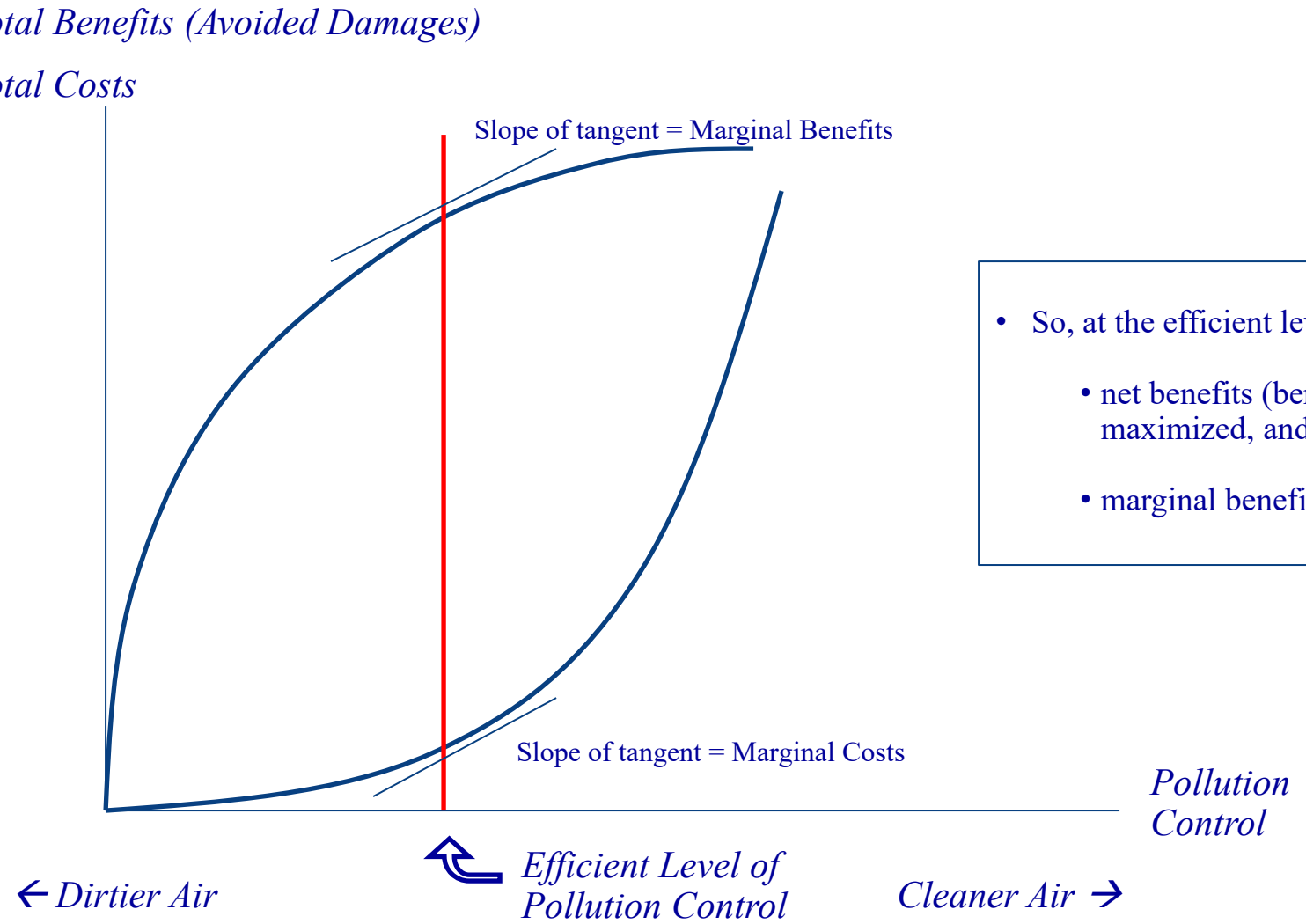
The Benefits of Pollution Control



Think About Your Own Pollution-Control Policies

- We all exercise pollution control policies, where we get the benefits and we pay the costs
  - Keeping the *kitchen floor* clean
  - Do you keep it *perfectly* clean?
  - *Why not?*
- And how clean do you keep your *garage* floor? Why?
- What about the cleanliness you expect in a *surgical theatre*? Why?
- *Why* do we individually and collectively choose different levels (standards) of acceptable cleanliness in these different cases?
  - It seems that *benefits and costs* matter.
  - In fact, we behave *as if* we're doing a very specific kind of analysis!

Benefits and Costs of Pollution Control



- So, at the efficient level of pollution control,
  - net benefits (benefits minus costs) are maximized, and
  - marginal benefits equal marginal costs

The Benefits of Climate Change Policy: The "Social Cost of Carbon"

- An *efficient* policy sets the price faced by CO_2 emission sources at value of marginal *damages* (through carbon tax, cap-and-trade, or other – later)
  - This *maximizes net benefits* (by equating marginal benefits and marginal costs)
- **Social Cost of Carbon**: *present discounted value* of future stream of monetized *damages* of incremental increase in CO_2 *emissions in a given year*
- U.S. Interagency Working Group on the Social Cost of Carbon (Obama)
  - Used in some 100 regulations, with gross benefits over $1 trillion: RIAs for fuel economy (CAFE) standards, appliance standards, EPA greenhouse gas standards

Evolving History of Social Cost of Carbon (SCC) Estimates

- In 2009, Obama administration issued temporary SCC, formed the Interagency Working Group (IWG) to develop SCC
- Obama estimate updated by Trump, using only domestic damages & higher interest rate
- In 2017, National Academies stated that SCC no longer reflected best research, and issued recommendations
- Research groups (Climate Impact Lab, Resources for the Future, etc.) undertook research to update SCC to reflect latest science, economics
- Updated by Biden administration in December, 2023

Source	Discount Rate	Central Estimate ($2020)
Obama (IWG) 2009, 2013, 2015	3%	$20/tCO$_2$, $43/tCO$_2$, 51/tCO$_2$
Trump (Domestic Only)	3-7%	$1-7/tCO$_2$
Biden (Interim)	3%	$51/tCO$_2$
Carleton & Greenstone (CIL)	2%	$125/tCO$_2$
Resources for the Future (RFF)	2%	$185/tCO$_2$
Biden Update (December 2023)	1.5%-2%	$190/tCO$_2$

Method of Empirically Estimating SCC

- **Approach:** Use Integrated Assessment Models (ISMs) to combine climate processes, economic growth, and climate-economy feedbacks into single modeling framework [basic climate science plus CGE model]

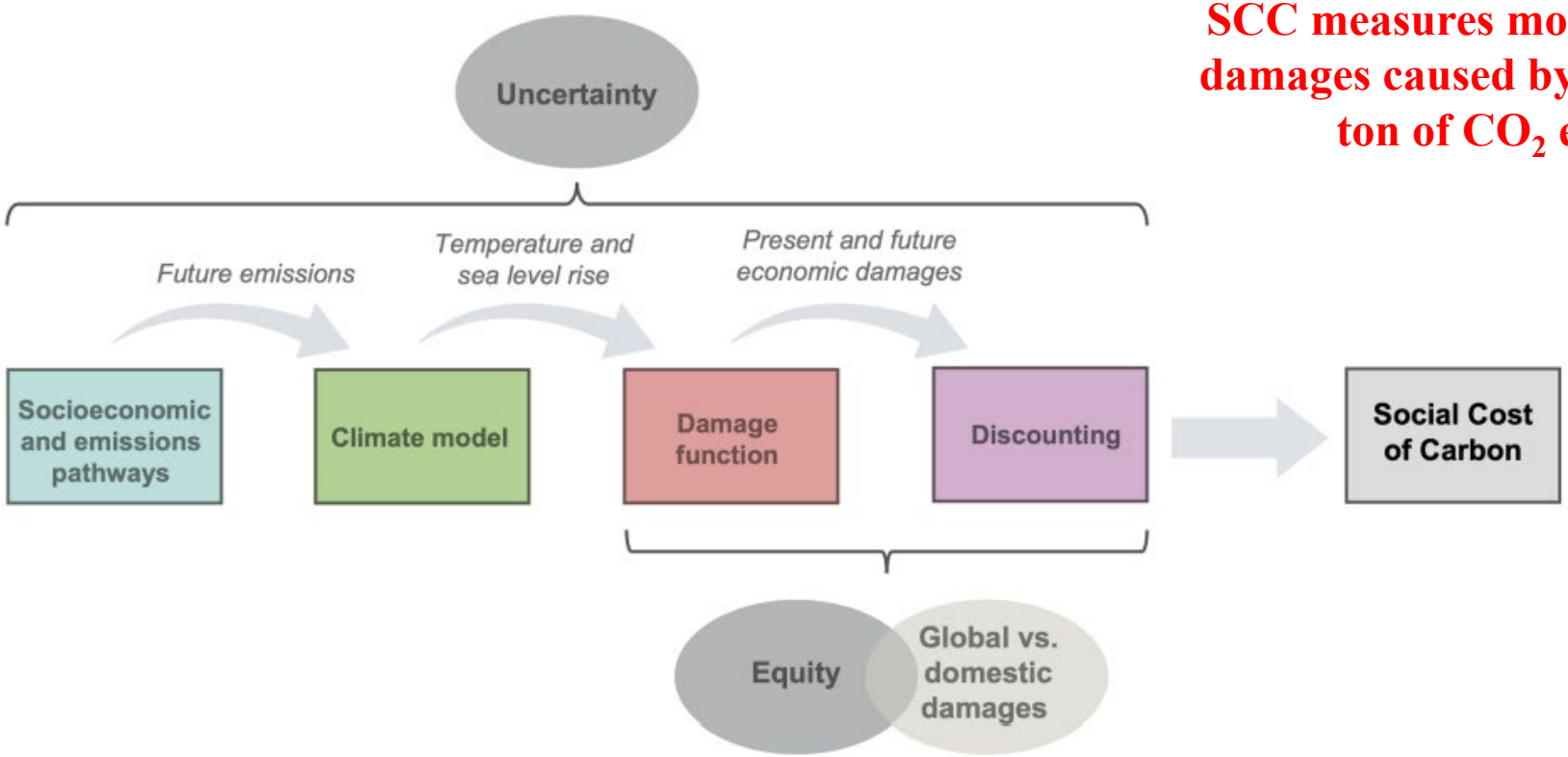
- Three Integrated Assessment Models used by U.S. Government
  - DICE (William Nordhaus, Yale University)
  - PAGE (Christopher Hope, Cambridge University)
  - FUND (Richard Tol, University of Sussex)

- Evaluating climate change impacts requires assessment of:
  - Marginal *damages* and benefits
  - Quantitative *probabilities* of *catastrophic* events
  - Possibilities for and cost of *adaptation*

- Significant *uncertainties* around economic and climate parameters, so *Monte Carlo Analysis* (each model run 10,000 times with range of parameter values)

Key Steps in Estimating SCC

SCC measures monetized value of damages caused by an incremental ton of CO_2 emissions



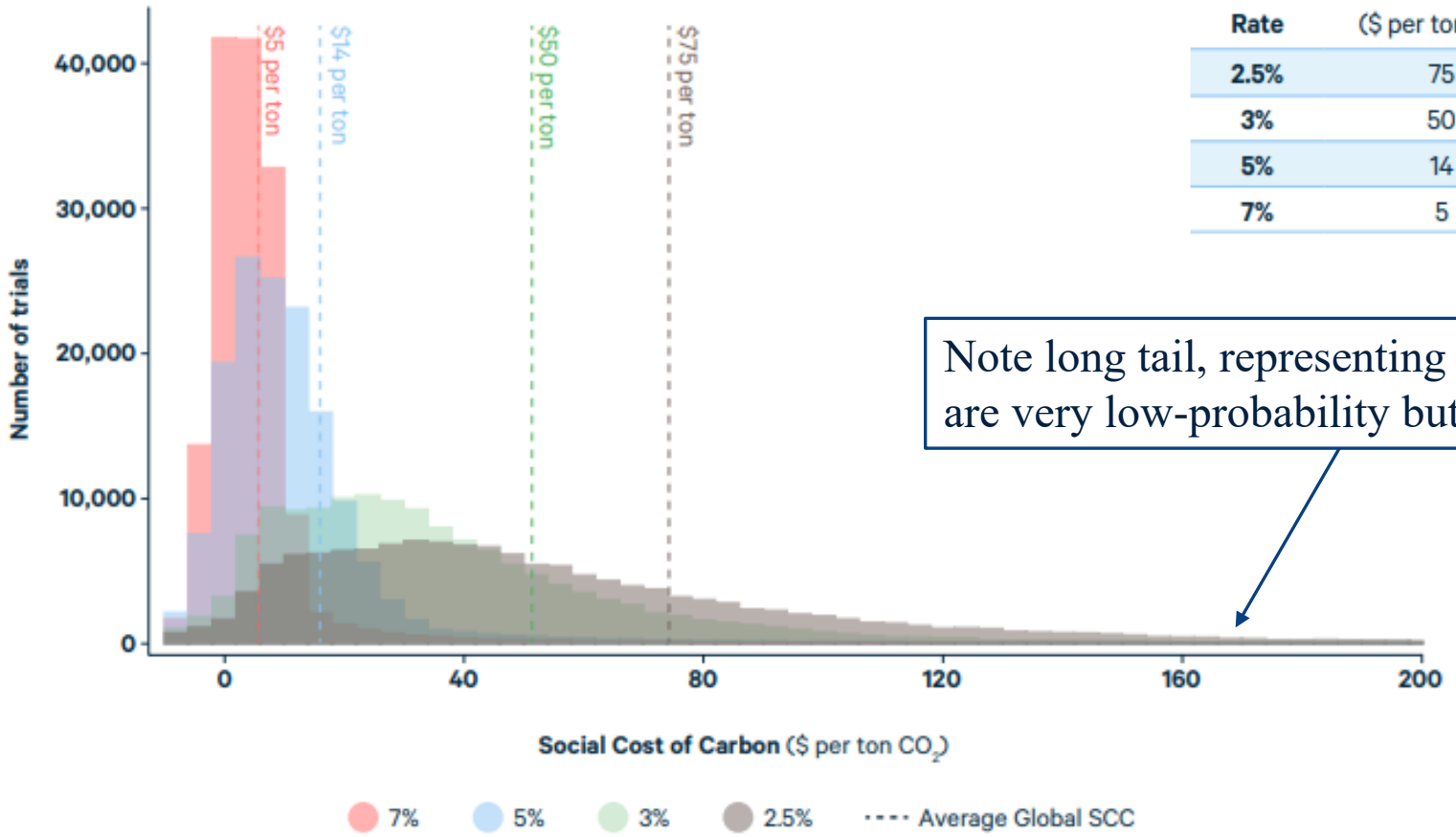
Source: Carleton & Greenstone 2021. Updating the United States Government's Social Cost of Carbon - Climate Impact Lab.

Results: Original SCC Estimates (updated to $2019)

Histograms in four colors show results for four discount rates

The last row in the table shows Trump estimates of global and domestic SCC

Discount Rate	Global SCC ($ per ton CO_2)	Domestic (US) SCC ($ per ton CO_2)
2.5%	75	10
3%	50	7
5%	14	2
7%	5	1

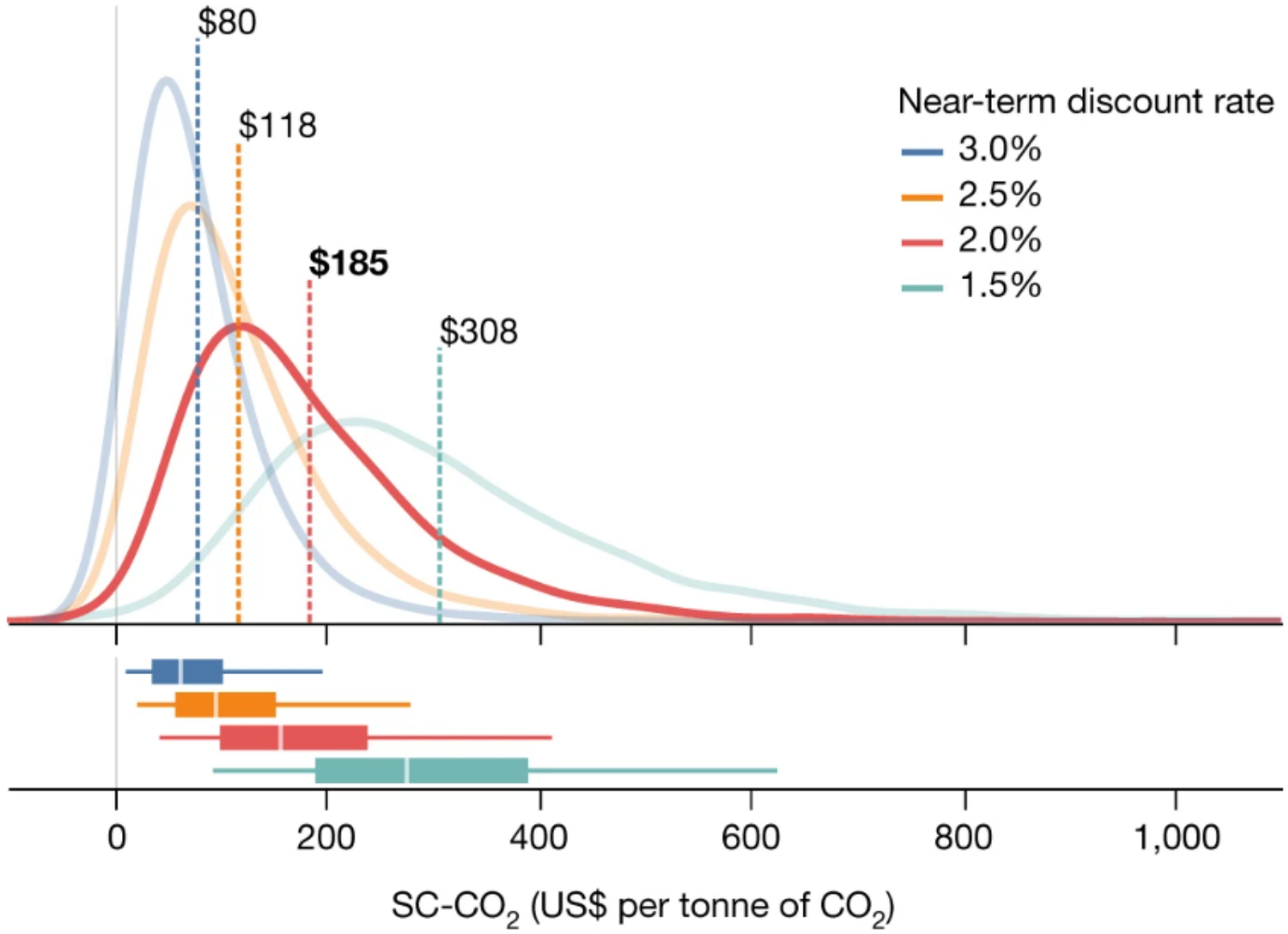


Note long tail, representing outcomes that are very low-probability but "catastrophic"

Results: Range of Recent Estimates (from RFF)

Fig. 2: SC-CO_2 distributions vary with the choice of near-term discount rates.

From: Comprehensive evidence implies a higher social cost of CO_2



Use Global or Domestic Damages in SCC?

Arguments for Global Damages

- Climate change generates *global externality* and damages
- *Socially optimal solution*: every country uses global damages for SCC
- Global connected economy – *impossible* to separate
- *Altruism* (geographic or generational)
- *Strategic*: Promote *reciprocal* action & international cooperation

Arguments for Domestic Damages

- *Government guidelines* for other regulatory assessments focus on benefits for American public
- In order to set *priorities* among regulatory policies, must be *consistent*
- *Strategic*: Using global damages could prompt other countries to *free ride* on a country that counts global benefits and undertakes greater reductions

Potential Criteria for Policy Assessments

- *Efficient* level of pollution control is the degree of emissions reductions that *maximizes net benefits* (difference between benefits and costs).
  - Markets produce the *efficient* quantity of goods and services for many goods & services, but *not* in the presence of *externalities*.
- So, we have *one* potential economic criterion for assessing policies:
  - an *efficient* policy maximizes net benefits.
- There's also a *less-demanding* economic criterion:
  - a *cost-effective* policy is one that achieves *any target* (whether it's efficient or not) in the *least-cost* way.
  - So, only information about costs is required, no information about benefits (damages) is needed!
  - But beware of designing fast trains to the wrong station!

The Simple Analytics of Cost-Effectiveness

- **Example with Two Sources of Emissions which contribute to a global commons stock of pollution**
  - Source A: Marginal Cost to Reduce Emissions = $10/ton (low-cost controller)
  - Source B: Marginal Cost to Reduce Emissions = $25/ton (high-cost controller)
- **Policy Target = 10 tons of total reductions**
  - If each source reduces by 5 tons …
    - Total Abatement Cost = ($10 x 5) + ($25 x 5) = $50 + $125 = **$175**
  - What if we shift one ton of control from high-cost to low-cost source?
    - Total Abatement Cost = ($10 x 6) + ($25 x 4) = $60 + $100 = **$160**
  - Same total emissions, but lower cost.
- **Remember: Increasing Marginal Cost Curves**
  - So, as A takes on more responsibility, its marginal cost increases
  - And as B takes on less responsibility, its marginal cost decreases

Simple Analytics of Cost-Effectiveness (continued)

- **We can keep shifting control from high-cost to low-cost controller, and total cost will continue to decrease, while …**
  - Marginal control cost of Source A (low-cost controller) increases, and
  - Marginal control cost of Source B (high-cost controller) decreases, until …
  - Marginal control cost of two sources is the same
  - We cannot lower total costs further
  - That's the *cost-effective* allocation of control action between two sources
- **So, *necessary condition* for *cost-effective* allocation is that all sources control at the *same marginal cost***
- **Carbon-pricing instruments (carbon taxes and cap-and-trade) accomplish this: all sources wind up controlling at the same MC**
  - Carbon Tax: Each source reduces emissions until its MC = tax
  - Cap and Trade: Each source reduces emissions until its MC = permit price

Wait! *Who* Gets the Benefits? *Who* Pays the Costs?

- Economics can also examine the *distribution* of benefits and costs
- Are all *efficient* policies *fair*? No.
  - Example: California's investments in electrification & wildfire mitigation increase electricity rates
    - Who gets the benefits?
    - Who pays the costs?
      - Electricity costs are much larger share of income for poorer households
    - So, California electricity policy may be *regressive* (transfer from poor to rich)?
- Does this mean that *all* environmental policies are *regressive*?
  - *No*
  - Example of a *progressive* environmental policy: Superfund, cleaning up abandoned hazardous waste sites (transfer from rich to poor)

Key Take-Aways

1. The *causes* of environmental pollution are economic: pollution is an *externality*
2. The *consequences* of environmental pollution are economic, and the most important pathways are *not* the easiest to analyze
3. *Economic value* of damages are whatever people *truly feel* that they are; reliable methods exist for *quantifying* these values
5. When we get the benefits and pay the costs, we *choose* our own standards of cleanup in different situations based upon perceived *benefits and costs*, and we tend to choose the "*efficient*" level of cleanup
6. While *markets can* provide the *efficient* amount of many goods & services, this breaks down with *externalities* -- a type of *market failure*
    - That's a *legitimate* reason for government intervention
7. A less-demanding economic criterion than efficiency is *cost effectiveness*
8. Economics can also examine the *distribution* of benefits and costs of policies