Non-Market Valuation and Regulation

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Outline for Today: Non-Market Valuation as the Fundamental Problem of Environmental Economics

What are the benefits of improving environmental quality?

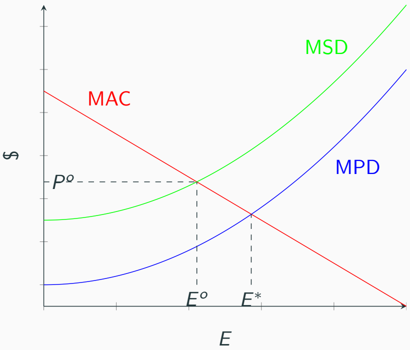
- Ask people (stated preferences)
- Watch people (revealed preferences)
    - Hedonics and Recreation Demand
- Bottom up accounting
    - Add up observable physical impacts and apply a dollar value (crop yields, mortality)

How should we aggregate benefits across different (groups of) people?

- Distributional considerations and environmental justice

The Fundamental Problem of Environmental Economics

Last time - Efficient Pigovian taxes require knowledge of the magnitude of external costs (e.g. Social Cost of Carbon)



How do we know the slope of the damage function? Unlike private goods, no prices we can use.

Cost-Benefit Analysis

This is all basically a way of saying we are doing cost-benefit analysis

Many regulations can be modelled as some sort of tax

- We want to make sure the marginal benefits (reduced social damages) outweigh the marginal costs (abatement)

But a key question in environmental economics is how to value non-monetary benefits

- Better health from cleaner air or water
- Recreation opportunities
- Existence values

Story Time: The Tellico Dam and the Snail Darter

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Stated Preferences

Stated Preferences

Simple idea: How much would you be willing to pay to save the snail darter?

- Economists tend to be skeptical of hypothetical questions.
- Under fairly weak assumptions looking at how people make choices in the world reveals their true preferences.

Carson and Groves (2007): under the right circumstances, responses to stated preference surveys can be treated as revealed preferences:

- Need to believe that answers will be used to inform real policy.
- Need to believe there is some mechanism (taxes) that they will actually enforce payment.
- In other words, it needs to seem as if the stakes are real.

Exxon Valdez Oil Spill 1989

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When the Exxon Valdez ran aground on Bligh Reef on March 24, 1989, it was transporting 53 million gallons of Alaskan North Slope crude oil bound for California. The spill dumped 10.8 million gallons of the tanker's cargo into Prince William Sound, eventually damaging 1,300 miles of shoreline. Staff/TNS/Newscom

Passive Use vs Direct Use Values

- Hausman, Leonard, McFadden (1995) found $4 million lost recreation value
- Exxon settled with fishermen for $67 million

Passive Use vs Direct Use Values

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- Exxon settled with fishermen for $67 million
- Carson et al (1992) found passive use values of $3 *billion*

Contingent Valuation Survey

Here's how the program would work.

Two large Coast Guard ships specially designed for Alaskan waters will escort each tanker from Valdez all the way through Prince William Sound until they get to the open sea. These escort ships will do two things.

First, they will help prevent an accident in the Sound by making it very unlikely that a tanker will stray into dangerous waters. **(PAUSE)**

Second, if an accident does occur, the escort ships will carry the trained crew and special equipment necessary to keep even a very large spill from spreading beyond the tanker. **(PAUSE)**

This drawing shows how this would be done. **(PAUSE)**

SHOW CARD 6

Escort ship crew would immediately place a boom that stands four feet above the water and five feet below the water, called a Norwegian sea fence, around the entire area of the spill. **(POINT IF NECESSARY)** Because oil floats on the water, in the first days of a spill, the sea fence will keep it from floating away. The oil trapped by the sea fence would be scooped up by skimmers, and pumped into storage tanks on the escort ships. Within hours, an emergency rescue tanker would come to the scene to aid in the oil recovery and transport the oil back to Valdez.

This system has been used successfully in the North Sea by the Norwegians.

Contingent Valuation Survey

Because two tankers usually sail from Valdez each day, the Coast Guard would have to maintain a fleet of escort ships, skimmers, and an emergency tanker, along with several hundred Coast Guard crew to run them.

Although the cost would be high, the <u>escort ship</u> program makes it virtually certain there would be <u>no damage</u> to Prince William Sound's environment from another large oil spill during the ten years it will take all the old tankers to be replaced by double-hulled tankers.

It is important to note that this program would <u>not</u> prevent damage from a spill anywhere else in the United States because the escort ships could only be used in Prince William Sound.

If the program was approved, here is how it would be paid for.

All the oil companies that take oil out of Alaska would pay a special <u>one</u> time tax which will reduce their profits. Households like yours would also pay a special <u>one</u> time charge that would be added to their federal taxes in the first year and <u>only</u> the first year of the program.

This money will go into a Prince William Sound Protection Fund. The <u>one time</u> tax will provide the Fund with enough money to pay for the equipment and ships and all the yearly costs of running the program for the next ten years until the double hulled tanker plan takes full effect. By law, no <u>additional</u> tax payment could be required.

Contingent Valuation Survey

Because everyone would bear part of the cost, we are using this survey to ask people how they would vote if they had the chance to vote on the program.

We have found some people would vote for the program and others would vote against it. Both have good reasons for why they would vote that way.

Those who vote for say it is worth money to them to prevent the damage from another large spill in Prince William Sound.

Those who vote against mention concerns like the following.

Some mention that it won't protect any other part of the country except the area around Prince William Sound.

Some say that if they pay for this program they would have less money to use for other things that are more important to them.

And some say the money they would have to pay for the program is more than they can afford.

(PAUSE)

Contingent Valuation Survey

Of course whether people would vote for or against the escort ship program depends on how much it will cost their household.

At present, government officials estimate the program will cost your household a total of $*60*. You would pay this in a special one time charge in addition to your regular federal taxes. This money would only be used for the program to prevent damage from another large oil spill in Prince William Sound. **(PAUSE)**

If the program cost your household a total of $*60* would you vote for the program or against it?

Other Examples

Endangered Species: Loomis and White (1996)

Table 1
Summary of economic values of rare and T/E species ($1993)

	Low value	High value	Average of all studies
Studies reporting annual WTP			
Northern spotted owl	$44	$95	$70
Pacific salmon/Steelhead	$31	$88	$63
Grizzly bears			$46
Whooping cranes			$35
Red-cockaded woodpecker	$10	$15	$13
Sea otter			$29
Gray whales	$17	$33	$26
Bald eagles	$15	$33	$24
Bighorn sheep	$12	$30	$21
Sea turtle			$13
Atlantic salmon	$7	$8	$8
Squawfish			$8
Striped shiner			$6
Studies reporting lump sum WTP			
Bald eagles	$178	$254	$216
Humpback whale			$173
Monk seal			$120
Gray wolf	$16	$118	$67
Arctic grayling/Cutthroat trout	$13	$17	$15

Other Examples

WTP for 2 degrees climate change: Kotchen and Ashenfarb (2023)

Table 1: Summary of responses to the WTP question for each specified dollar amount

Specified amount	Total obs.	Yes	No	Protest responses	Refused responses
$6	101	56	12	26	7
$16	102	39	20	39	4
$26	202	95	47	56	4
$45	203	88	62	47	6
$85	204	75	70	49	10
$124	103	30	32	38	3
$165	100	22	45	30	3
Total	1015	405	288	285	37

Criticisms and Caveats

- Hypothetical biases
  - Might not know, might want to please the researcher, might be cheap talk

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- Scope Insensitivity (Desvousges et al 1992)

Table 5-1. Univariate Results for Three Migratory-Waterfowl Questionnaires: Censored Data Sets

	2,000 Birds (WTP $)	20,000 Birds (WTP $)	200,000 Birds (WTP $)
Mean	80	78	88
Standard Deviation	187	132	166
Median	25	25	25
Mode	0	100	100
Range	0–1,550	0–1,000	0–1,000
Shapiro-Wilk statistic[a]	0.43	0.60	0.54
N	288	286	281

[a] This test statistic indicates that these distributions are not normal.

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- Framing effects
  - 1/3 will live vs 2/3 will die (Kahneman and Tversky 1981).
- Scope Insensitivity (Desvousges et al 1992)
- Endowment effects
  - Divergence between WTP and WTA

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Takeaways

Even if CV isn't perfect, it is clearly better than the alternative of assigning zero to existence values

- Clearly there are also issues with revealed preference assumptions
- CV compares favorably with similarly worded ballot initiatives

A properly designed survey is of the highest importance

Revealed Preferences

Revealed Preferences and Close Complements

Sometimes we can infer something about the value of a non-market good by studying markets for closely related private goods

- Hard to put a price on whales (no market)

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- Easy to put a price on whale watching tours

Revealed Preferences and Close Complements

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- Hard to put a price on whales (no market)
- Easy to put a price on whale watching tours
- Price of the latter can tell us something about the value of the former
    - Recreation demand or travel cost models estimate the expenditures induced by a marginal change in the environmental good as a lower-bound on the value of the good.

Hedonic Methods: Housing

When people buy a house they are purchasing a bundle of goods:

- Roof and walls

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Real Estate markets have several other useful features:

- Competitive and thick
- Consequential - buyers and sellers likely to be well-informed
- Clearly reflect the value of local public goods

The Hedonic Model

House prices are a function of characteristics: $P(x, E)$:

- x: rooms, bathrooms, school district, distance to boulangerie
- E: local air quality, water quality, park, etc...
- Prices arise in equilibrium of buyer-seller interactions

Consumers choose a house to solve:

$$\max_{x,E,z} u(x, E, z) \tag{1}$$

$$y = z + P(x, E)$$

Assumes consumers can choose E (by sorting across space?)

- z is purchases on all other goods, y is income

The Hedonic Model

$$\max_{x,E,z} U(x,E,z) + \lambda(y - z - P(x,E)) \tag{2}$$

First order conditions give:

$$\frac{dU}{dx} = \lambda \frac{dP}{dx}$$
$$\frac{dU}{dE} = \lambda \frac{dP}{dE}$$
$$\frac{dU}{dz} = \lambda$$

Rearranging the last two gives:

$$\frac{\frac{dU}{dE}}{\frac{dU}{dz}} = \frac{dP}{dE}$$

The Hedonic Model

The left hand side is the MRS between environmental goods and other goods: WTP for E

$$\frac{\frac{dU}{dE}}{\frac{dU}{dz}} = \frac{dP}{dE}$$

The right hand side is how a change in E changes the price of the house. In principle, we can estimate this in a regression:

$$P_i = \beta_1 x_i + \beta_2 E_i + e_i \tag{3}$$

What is $\frac{dP}{dE}$?

The Hedonic Method: Identification

$$\log P_i = \beta_1 x_i + \beta_2 E_i + e_i \tag{4}$$

Why doesn't this work in practice?

- e_i could be correlated with E and P_i
- x_is are endogenous, could have been chosen as a result of E.
- We need exogenous variation in E

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Chay and Greenstone (JPE) 2003: Look at changes in home prices resulting from 'exogenous' changes in air pollution

- In 1975, the Clean Air Act designated certain counties as non-attainment if they were above a pollution threshold
- In principle counties just below and just above that threshold should be very similar, except that areas just above the threshold experienced bigger improvements in air quality

The Hedonic Method: Results

People are willing to pay for better AQ (about 2% per 1μg).

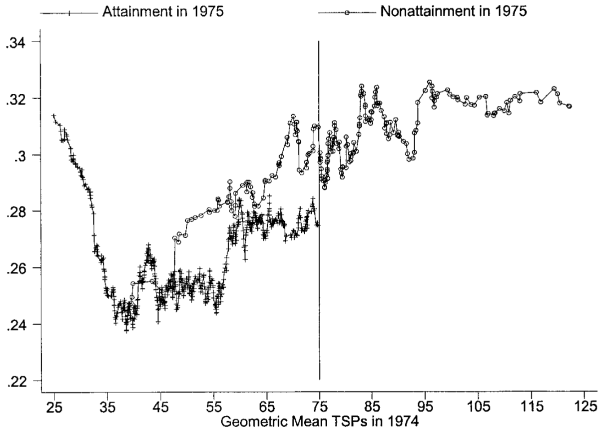


FIG. 5.—1970–80 change in log housing values by 1975 nonattainment status and the geometric mean of TSPs in 1974.

Takeaways

Hedonics are often the first tool in the kit for environmental economists

- Muehlenbachs, Spiller and Timmins (2015) - Fracking
- Schlenker et al (2005) - Agriculture and Global Warming
- Kaiser and Shapiro (2018) - Clean Water Act - municipal wastewater treatment

Several important considerations:

- Only captures use values related to the property
- Mobility between houses
  - See Christensen and Timmins (2022). Sorting or Steering: The Effects of Housing Discrimination on Neighborhood Choice
- Perfect information
- Well functioning capital markets

Non-Market Valuation

Design a stated-preference and a revealed preference approach to study the value of:

- The Mona Lisa
- Scientific research on a vaccine for cancer
- Honeybees
- Better weather forecasts
- Bringing high speed internet to a rural village

What are some limitations of your studies?

Bottom up

Estimating Pollution Damages: Bottom Up

Given the assumptions involved in both revealed and stated preference approaches, empirical researchers often attempt to measure the effect of pollution on more clearly defined physical variables:

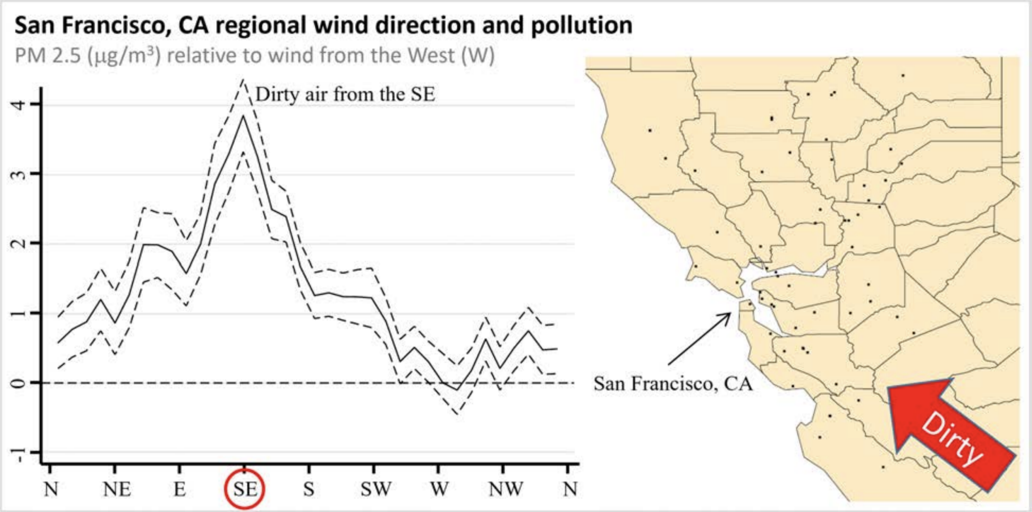
- Crop Yields
- Morbidity and Mortality
- Property damages of natural disasters

Improvement in understanding of causal inference contributing to more credible identification. What is the problem with:

$$Y_i = \beta PM2.5_i + e_i \tag{5}$$


The Mortality and Medical Costs of Air Pollution: Evidence from Changes in Wind Direction
Tatyana Deryugina
Garth Heutel
Nolan H. Miller
David Molitor
Julian Reif
AMERICAN ECONOMIC REVIEW
VOL. 109, NO. 12, DECEMBER 2019
(pp. 4178-4219)

Wind Direction as an IV



Regression Specification:

$$Y_{cdmy} = \beta PM2.5_{cdmy} + X_{cdmy}\gamma + \alpha_c + \alpha_s m + \alpha_{my} + e_{cdmy} \tag{6}$$

- Y_{cdmy} is outcome in county c on day d in month m and year y: three-day total death rate (d, d+1, d+2) per million, hospital admissions
- daily PM2.5 levels + 2 leads + 2 lags
- High dimensional controls: daily max temp into 17 bins, same for min temp, indicators for deciles of daily precipitation and wind speed, indicators for all possible interactions of these temp, precipitation, and wind speed variables (28,899)
- County c, state-by-month, and month-by-year FE
- Cluster se at the county level and weight

First stage:

$$PM2.5_{cdmy} = \sum_{g} \sum_{b=0}^{2} WindDir_{cdmy}^{90b} + X_{cdmy}\sigma + \alpha_c + \alpha_s m + \alpha_{my} + e_{cdmy} \quad (7)$$

- $WindDir_{cdmy}^{90b} = 1$ if daily average wind direction in county c falls in [90b, 90B + 90] and 0 otherwise
- 100 spatial group g for pollution monitors

Wind Direction as an IV: Results

Table 2: OLS and IV estimates of effect of PM 2.5 on elderly mortality, by age group

	(1) 65+	(2) 65–69	(3) 70–74	(4) 75–79	(5) 80–84	(6) 85+
Panel A: OLS estimates						
PM 2.5 ($\mu g/m^3$)	0.095***	0.041***	0.029	0.022	0.142***	0.425***
	(0.021)	(0.014)	(0.018)	(0.022)	(0.036)	(0.072)
Dep. var. mean	385	131	197	312	508	1,127
Effect relative to mean, percent	0.025	0.032	0.015	0.007	0.028	0.038
Observations	1,980,549	1,980,549	1,980,549	1,980,549	1,980,549	1,980,549
Adjusted R-squared	0.254	0.080	0.085	0.082	0.077	0.110
Panel B: IV estimates						
PM 2.5 ($\mu g/m^3$)	0.685***	0.267***	0.329***	0.348***	0.877***	2.419***
	(0.061)	(0.066)	(0.068)	(0.098)	(0.159)	(0.246)
F-statistic	298	285	292	303	309	315
Dep. var. mean	385	131	197	312	508	1,127
Effect relative to mean, percent	0.178	0.204	0.167	0.111	0.173	0.215
Observations	1,980,549	1,980,549	1,980,549	1,980,549	1,980,549	1,980,549

Notes: Table reports OLS and IV estimates of equation (1) from the main text. Dependent variable is the three-day mortality rate per million beneficiaries in the relevant age group. All regressions include county, month-by-year, and state-by-month fixed effects; flexible controls for temperatures, precipitation, and wind speed; and two leads of these weather controls. OLS (IV) estimates also include two lags and two leads of PM 2.5 (instruments). Estimates are weighted by the number of beneficiaries in the relevant age group. Standard errors, clustered by county, are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

How big are these effects?

How can we compare these effects to the costs of reducing air pollution? We need a common denominator

- Value of Statistical Life (VSL) approach:
    - Several ways of estimating WTP for reducing the probability of death: wage-premia on risky jobs (hedonic wage regressions), WTP for safety features on e.g. cars, medicines that extend lifespan, contingent valuation surveys...
    - Back to relying on revealed preference or CV!
    - Equity issues can get very difficult
- Cost-effectiveness approach: Cost per life saved
    - Is this the most cost-effective way to save lives?

But there is another problem as well...

- Estimates are static, historical, don't account for adaptation

Effects of Temperature Shocks on Mortality

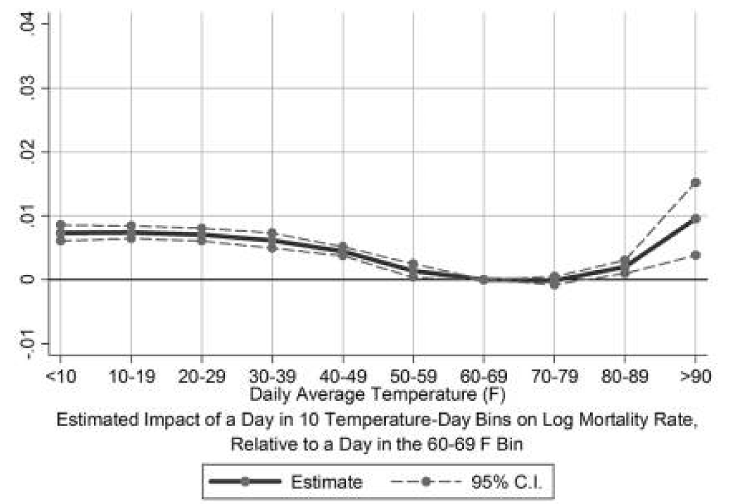
Barreca et al (2016):

$$\log(Y_{sym}) = \sum_j \theta_j T_{symj} + X_{sym}\beta + \alpha_{sm} + \rho_{ym} + e_{ysm} \tag{8}$$

- Semi-parametric approach to temperature - number of days in a month in a certain degree range
- Time varying controls for precipitation and population age structure
- State seasonal fixed effects and national month fixed effects

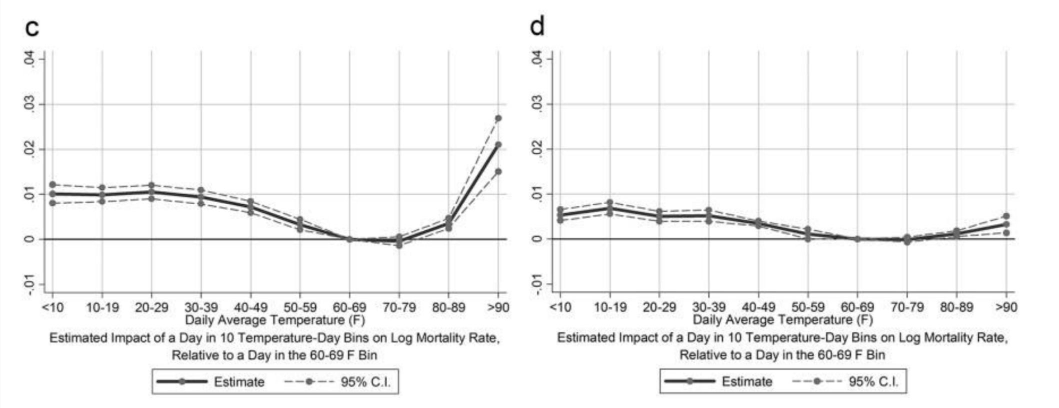
Barecca et al Results

High and Low Temps Increase Mortality



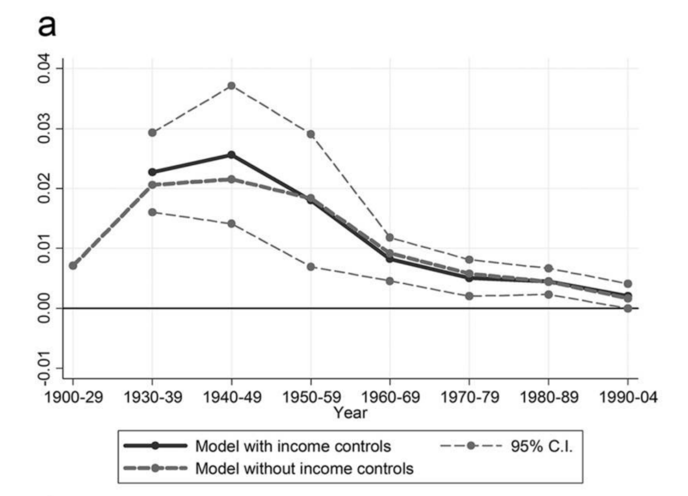
Barecca et al Results

On the left - effects before 1960, on the right - after 1960



Barecca et al Results

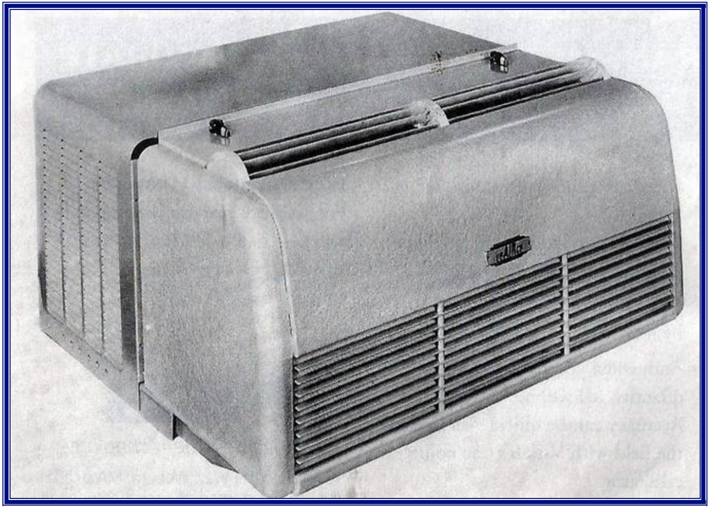
The effect of a hot day on mortality over time



Adaptation and Innovation

De La Vergne room air conditioning unit, mid-1930s

Adaptation and Innovation



Window air conditioning unit by US Air Conditioning Corporation, c.1950

AC saves lives

TABLE 8
ROBUSTNESS ANALYSIS OF THE EFFECT OF RESIDENTIAL AIR CONDITIONING ON THE TEMPERATURE-MORTALITY RELATIONSHIP, 1960–2004

	(1)	(2)	(3)	(4)	(5)
Number of days above 90°F × share with residential AC	−.0212***	−.0212***	−.0343*	−.0376***	−.0264**
	(.0054)	(.0055)	(.0139)	(.0065)	(.0088)
Number of days between 80°F and 89°F × share with residential AC	−.0048***	−.0048***	−.0060**	−.0041**	−.0013
	(.0010)	(.0010)	(.0020)	(.0013)	(.0011)
Number of days below 40°F × share with residential AC	−.0004	−.0003	.0038	.0016	−.0010
	(.0009)	(.0009)	(.0024)	(.0014)	(.0012)
Baseline controls	Yes	Yes	Yes	Yes	Yes
State-month cubic time trends	No	Yes	No	No	No
2-year window around census years	No	No	Yes	No	No
Temperature × year trends	No	No	No	Yes	No
Exposure window = 4 months	No	No	No	No	Yes
Observations	26,411	26,411	4,655	26,411	26,313

Takeaways

- Bottom up approaches have increased in popularity due to advances in measurement and causal inference
- Still need to rely on assumptions to get something useful for policy
- Lucas Critique: Can be tricky to project econometric results into the future

Valuing Climate: The Social Cost of Carbon

History of the Social Cost of Carbon

The Social Cost of Carbon: The present discounted value of the future damages associated with the emissions of 1 ton of C02:

- 1992: Nordhaus DICE model shows optimal carbon tax of $5
- 2009-2013: Obama Interagency Working Group ($45 in 2020)
- 2020: Trump Administration lowers to $1
  - Exclude damages outside the US
  - 7% discount rate
- 2022: Biden Administration Preliminary Estimate ($190 in 2020)

OMB Circular A-4 aka how to count costs and benefits

Key Updates to BCA

- Discounting
- Risk Aversion
- Distributional Analysis
- Benefits outside US
- Non-market valuation

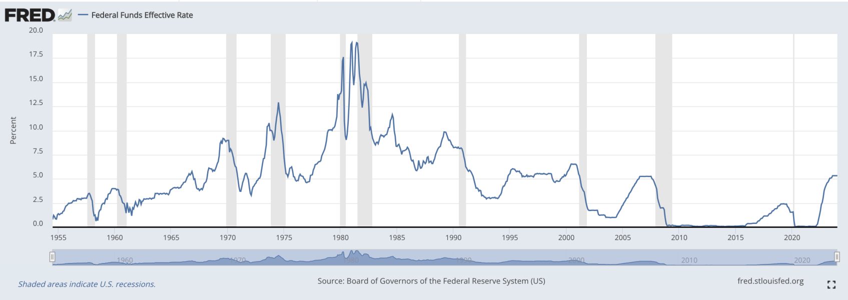
Discounting:

Normative approach:

- We will be richer - declining marginal utility of consumption (2% growth/year)
- Pure rate of time preference - controversial

Descriptive approach: Interest rate on 'risk-free' debt (10 year US Treasuries)

- Changed from 3% to 2% in latest guidelines



The New SCC

Bottom-up empirically-founded damage function:

Table 2.3.1: Current Coverage of Climate Damages in DSCIM

Sector	Damage Categories Represented	Empirical Basis for Damage Function Estimation	Accounting for Adaptation	Documentation
Health	Heat- and cold-related mortality	Subnational annual mortality statistics for 40 countries covering 38% of global population; 1990-2010 or longer for most countries	Accounts for adaptative effects of income growth and estimates the costs of adaptive investments using a revealed preference approach	Carleton et al. (2022)
Energy	Expenditures for electricity and other direct fuel consumption	Annual country-level energy consumption data (residential, commercial, and industrial) by energy source for 146 countries, 1971-2010	Accounts for both climate- and socioeconomics-driven adaptive responses	Rode et al. (2021)
Labor Productivity	Labor disutility costs from labor supply responses to increased temperature	Daily worker-level labor supply data (minutes worked) from 7 countries representing nearly 30% of global population	Accounts for shifts in workforce composition to less weather-exposed industries	Rode et al. (2022)
Agriculture	Production impacts for six crops: maize, rice, wheat, soybeans, sorghum, and cassava	Subnational crop production data for over 12,658 sub-national administrative units from 55 countries	Accounts for CO_2 fertilization effects, varietal switching, changes in production methods (e.g., irrigation, fertilization, planting dates), crop switching, and trade effects	Hultgren et al. (2022)
Coastal regions	Impacts of SLR as realized through inundation, migration, protection, dry and wetland loss, and mortality and physical capital loss from SLR	Numerous empirical findings are used to parameterize the CIAM process model for 9,000 coastal segments. (Low levels of SLR in the historical record prohibit the use of a fully empirical model)	Reflects retreat or protective infrastructure and costs under an optimal adaptation scenario with perfect foresight of SLR	Kopp et al. (2016) and Garner et al. (2021) for SLR; Diaz (2016) and Depsky et al. (2022) for damages

Accounting for Adaptation:

Carleton et al (2022). Valuing the Global Mortality Consequences of Climate Change Accounting for Adaptation Costs and Benefits. Quarterly Journal of Economics.

- Global study with 24,000 regions - 40 countries, 38% of global population
- Going to try to account for not just adaptation effects on mortality but also costs of adaptation – heterogeneity by long-run climate and income
- Result will be a ‘partial’ SCC – accounts for mortality costs

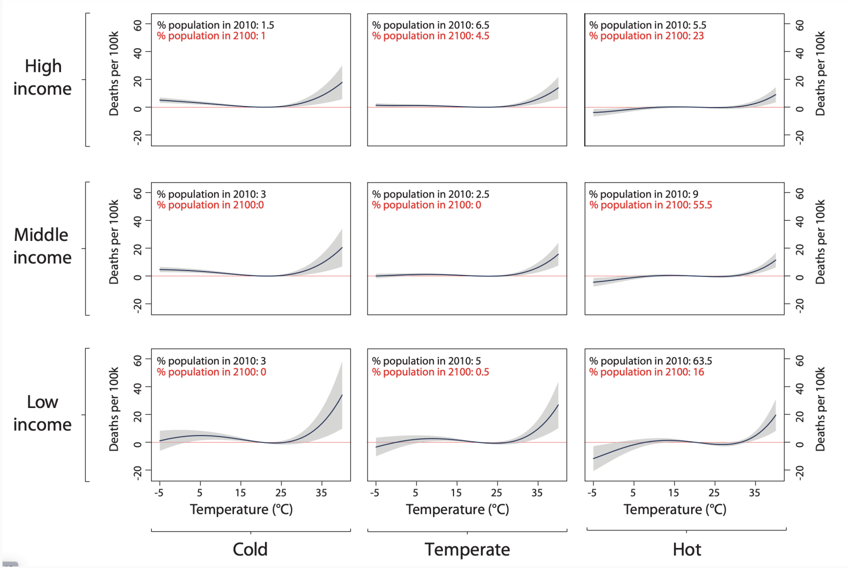
Estimating Equation

$$M_{acit} = g_a(T_{it}, Climate_i, Income_{it}) + q_{ca}(R_{it}) + \alpha_{ai} + \delta_{act} + e_{ait} \tag{9}$$

- Age-country-year and age-region FEs
  - Note that average effect of climate, income is captured by α_{ai}.
- R: second order polynomial of precipitation, interacted with country and age group dummies
- T: fourth order polynomial of daily average temps, interacted with log GDP and mean temps

So what is the identifying variation?

Results: Adaptation by Income and Climate



Extrapolations: Temporal

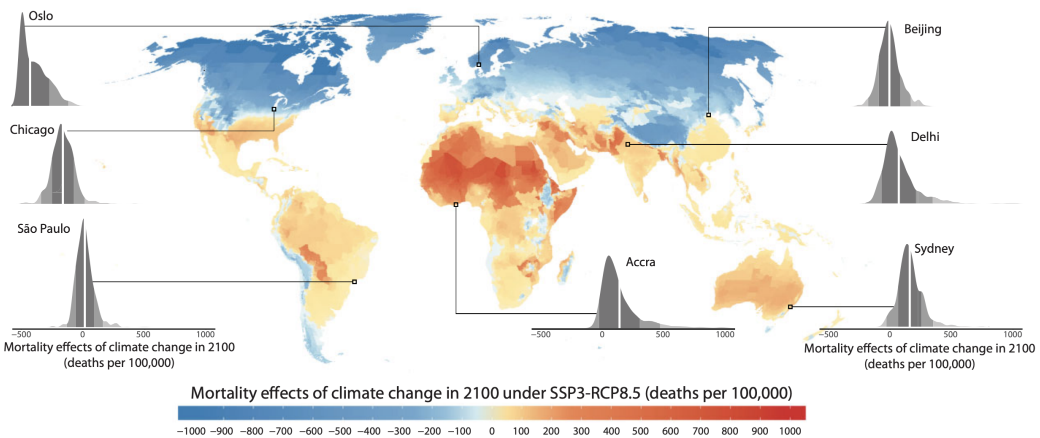


FIGURE IV

The Mortality Effects of Future Climate Change

Importance of Adaptation

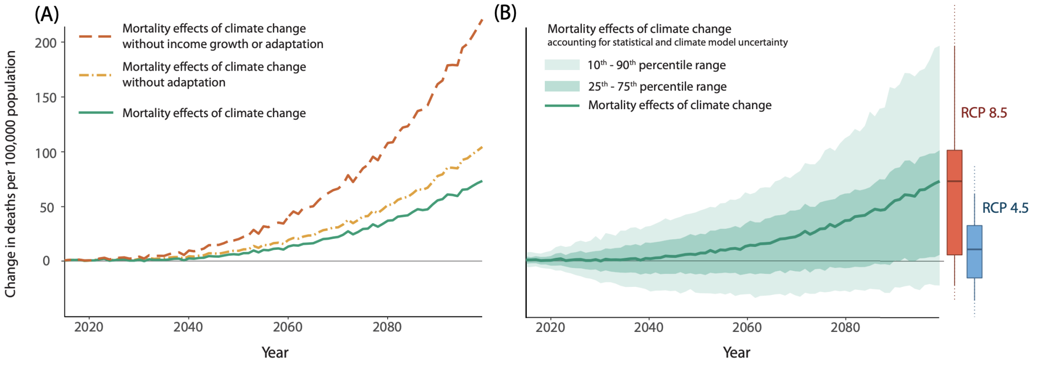


FIGURE V

Time Series of Projected Mortality Effects of Climate Change

The Mortality Costs of Climate Change

Global and Regional Estimates of the Full Mortality Risk of Climate Change in 2100 (High-Emissions Scenario, RCP8.5)

	No income growth or adaptation	Benefits of income growth	Benefits of climate adaptation	Mortality effects of climate change	Costs of climate adaptation	Full mortality risk of climate change	
	Eq. (2a′)	Eq. (2b′)–Eq. (2a′)	Eq. (2′)–Eq. (2b′)	Eq. (2′)	Eq. (7)	Eq. (3′)	
	deaths/100k	deaths/100k	deaths/100k	deaths/100k	deaths/100k	deaths/100k	% of GDP
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Global estimates							
Mean effects	220.6	−116.5	−31.0	73.1	11.7	84.8	3.2
Full uncertainty IQR	[76.4, 258.8]	[−149.4, −39.2]	[−60.1, 3.8]	[5.6, 101.4]	[0.2, 19.4]	[17.4, 116.4]	[−5.4, 9.1]
Panel B: Regional estimates							
China	112.0	−81.8	−28.8	1.4	17.7	19.1	1.9
United States	14.8	−13.2	−1.8	−0.2	10.2	10.1	1.0
India	334.4	−248.2	−25.6	60.6	2.1	62.7	6.0
Pakistan	589.1	−161.7	−105.0	322.4	53.6	376.0	27.5
Bangladesh	382.5	−89.3	−79.3	213.8	34.7	248.5	18.5
Europe	−14.3	−6.2	−74.8	−95.5	90.8	−4.7	0.1
Sub-Saharan Africa	232.5	−77.4	−34.5	121.3	10.5	131.8	8.4

A Partial SCC

Need to estimate costs per unit of emissions, and a discount rate

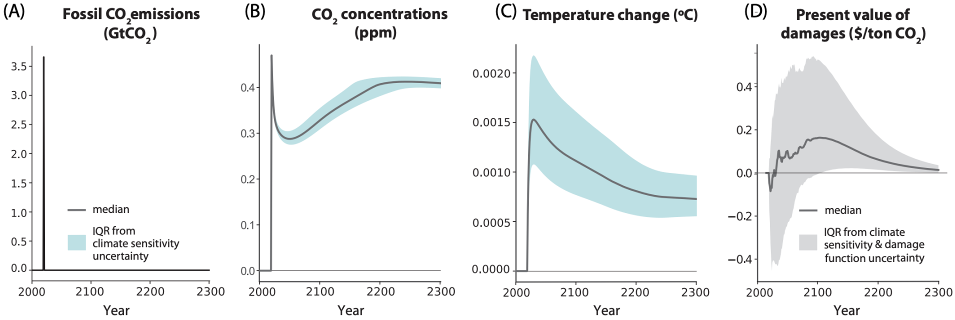


Figure VIII

Change in Emissions, Concentrations, Temperature, and Damages Due to a Marginal Emissions Pulse in 2020

A Partial SCC

TABLE III

ESTIMATES OF THE MORTALITY PARTIAL SOCIAL COST OF CARBON (SCC)

	Annual discount rate			
	$\delta = 1.5\%$ (1)	$\delta = 2\%$ (2)	$\delta = 3\%$ (3)	$\delta = 5\%$ (4)
Panel A: Mortality partial SCC				
Moderate-emissions scenario (RCP4.5)	28.5	17.1	7.9	2.9
Full uncertainty IQR	[−35.6, 88.5]	[−24.7, 53.6]	[−15.2, 26.3]	[−8.5, 11.5]
High-emissions scenario (RCP8.5)	66.4	36.6	14.2	3.7
Full uncertainty IQR	[−2.8, 126.5]	[−7.8, 73.0]	[−11.4, 32.9]	[−8.9, 13.0]
Panel B: Alternative approaches to calculating the mortality partial SCC				
Excluding adaptation costs (RCP8.5)				
Central estimate	66.9	37.7	15.1	4.1
Full uncertainty IQR	[−3.1, 114.6]	[−6.7, 66.4]	[−9.6, 29.8]	[−8.2, 11.5]
Accounting for risk aversion (RCP8.5)				
Central estimate (risk neutral)	88.4	47.7	17.2	3.7
Certainty equivalent (risk averse)	375.3	192.4	59.2	8.6

- Not significantly different from zero!
- Right skewed
- Relies on extrapolations of income-temperature-climate relationships

Equity

Social Choice and Interpersonal Comparisons

So far we have calculated costs and benefits in dollars. Furthermore, we have implicitly given equal weight to all individuals: a dollar to person A equals a dollar to person B:

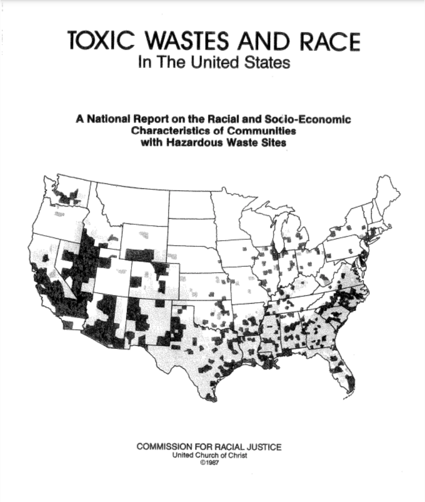
$$W = \sum_i \alpha_i (b_i(E) - c_i(E)) \tag{10}$$

This is consistent with Kaldor Hicks: If we maximize the number of dollars created, we can arrange some side payments such that everyone would be better off

- But these transfers rarely seem to occur in practice
- Discounting and risk aversion both rely on concave utility functions: diminishing marginal returns to a dollar
  - Implies a dollar to a poor person worth more than a dollar to a rich person
- New guidance opens the door to 'equity weighting': $\alpha_i = \frac{1}{U'(x_i)}$
  - Implies individuals have the same utility functions

US Environmental Justice Movement

- 1982 Warren County Hazardous Waste Protests
- 1987 United Church of Christ Report
- Continuing documented disparities in a range of pollutants



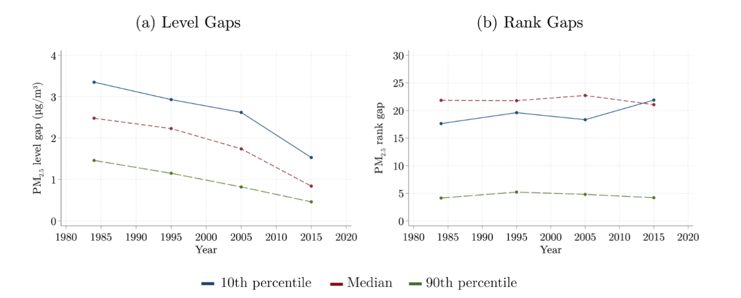
Potential Causes of Disparities

- Firm siting decisions: low land prices, low wages, not necessarily ‘taste-based’ discrimination
- ‘Coming to the Nuisance’: Sorting based explanations - access to jobs or environmental gentrification
  - Might be efficient *given existing distribution of resources*
- Coasian bargaining: If residents have property rights, may be able to hold up permitting processes
  - Low-income/minority communities have lower WTP for clean environment? Lower bargaining power? Again could be efficient *given existing distribution of resources*
  - Less secure property rights? Higher costs of enforcing property rights? (Language barriers, meeting locations, time costs)
- Political Economy: Minority communities may have less influence over institutional processes
  - Regulatory, monitoring/enforcement, remediation

Can Race Blind Policies Close Gaps?

Colmer et al: The Changing Nature of Pollution, Income, and Environmental Inequality in the United States - new data with individual level exposure

- The Clean Air Act in the US has improved air quality for black households more than white households
- Black HHs still face worse AQ than white HHs throughout the distribution



Takeaways

Existence of pollution exposure gaps is widely documented

- Environmental Impacts Frame: US Census data that tracks exposure at the individual and household level

Equity impacts of market-based instruments is an active area of research:

- Hernandez-Cortes and Meng (2023): Do environmental markets cause environmental injustice? Evidence from California's carbon market
- Deschenes and Weber: Equity Impacts of a Market for Clean Air

On the international stage, debates about who will pay for costs of mitigating and damages from climate change are central in current negotiations

- It all goes back to Coase: environmental issues are distributional issues