Undergraduate Public Finance: Externalities

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Externalities

Market failure: A problem that violates one of the assumptions of the 1st welfare theorem and causes the market economy to deliver an outcome that does not maximize efficiency

Externality: Externalities arise whenever the actions of one economic agent **directly** affect another economic agent outside the market mechanism

Externality example: a steel plant that pollutes a river used for recreation

Not an externality example: a steel plant uses more electricity and bids up the price of electricity for other electricity customers

$\Rightarrow$ Externalities are one important case of market failure

Negative Production Externalities

Negative production externality: When a firm's production reduces the well-being of others not compensated by the firm.

Private marginal cost (PMC): The direct cost to producers of producing an additional unit of a good (look at the supply curve)

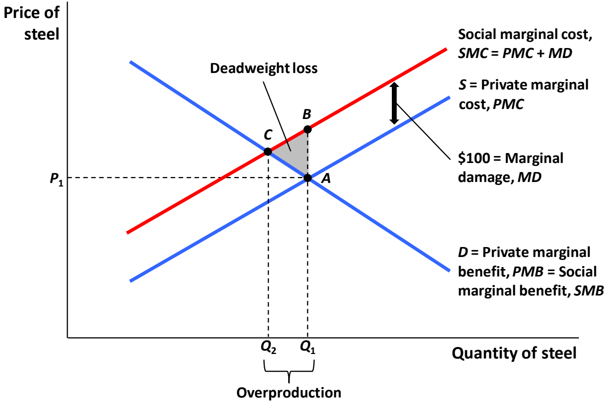
Marginal damage (MD): Additional costs associated with the production of the good that are imposed on others but that producers do not pay

Social marginal cost (SMC = PMC + MD): The private marginal cost to producers plus marginal damage

e.g., steel plant pollutes a river but does not face any pollution regulation (and hence ignores pollution when deciding how much to produce)

5.1

Economics of Negative Production Externalities: Steel Production



Why is ABC the deadweight loss?

Negative Consumption Externalities

Negative consumption externality: When an individual's consumption reduces the well-being of others who are not compensated by the individual.

Private marginal benefit (PMB): The direct benefit to consumers of consuming an additional unit of a good by the consumer (look at the demand curve)

Social marginal benefit (SMB): The private marginal benefit to consumers minus any costs associated with the consumption of the good that are imposed on others

e.g., using a car and emitting carbon contributes to global warming

5.1

APPLICATION: The Externality of SUVs

The consumption of large cars such as SUVs produces three types of negative externalities:

1. Environmental externalities: Compact cars get 25 miles/gallon, but SUVs get only 20.
2. Wear and tear on roads: Larger cars wear down the roads more.
3. Safety externalities: The odds of having a fatal accident quadruple if the accident is with a typical SUV and not with a car of the same size.

How would you draw the graph for a negative consumption externality?

Positive Externalities

Positive production externality: When a firm's production increases the well-being of others, but those others do not compensate the firm.

e.g., beehives of honey producers have a positive impact on pollination and agricultural output

Positive consumption externality: When an individual's consumption increases the well-being of others, but those others do not compensate the individual.

e.g., beautiful private garden that passers-by enjoy seeing

How would you draw the graph for a positive production externality?

How would you draw the graph for a positive consumption externality?

Inefficient Market Outcome

With a free market equilibrium, quantity and price are such that $PMB = PMC$.

The social optimum would choose quantity and price such that $SMB = SMC$.

Private market leads to an inefficient outcome

$\Rightarrow$ **The first welfare theorem breaks down!**

Negative production externalities lead to ... overproduction

Positive production externalities lead to ... underproduction

Negative consumption externalities lead to ... overconsumption

Positive consumption externalities lead to ... underconsumption

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Positive production externalities lead to ... underproduction

Negative consumption externalities lead to ... overconsumption

Positive consumption externalities lead to ... underconsumption

Private-Sector Solutions

Ronald Coase (Nobel Prize winner and Chicago libertarian economist) is famous for considering private-sector solutions to externalities.

He basically asks:

Are externalities really outside the market mechanism?

Coase Theorem

Coase Theorem (Part I): When there are well-defined property rights and costless bargaining, then negotiations between the party creating the externality and the party affected by the externality can bring about the socially optimal market quantity.

Coase Theorem (Part II): The efficient quantity for a good producing an externality does not depend on which party is assigned the property rights, as long as someone is assigned those rights.

A Concrete Example

Firms pollute a river enjoyed by swimmers. If firms ignore swimmers, there is too much pollution.

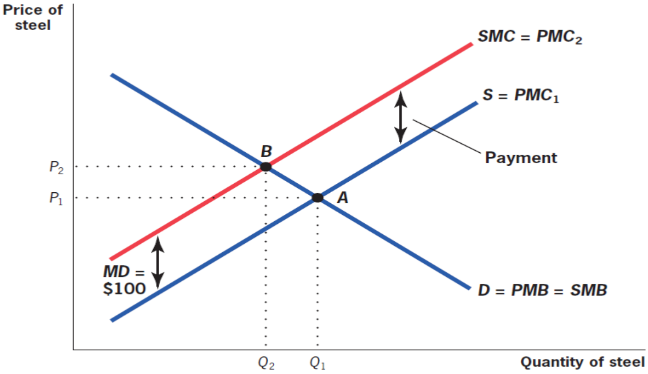
1) Swimmers own river: If river is owned by swimmers then swimmers can charge firms for polluting the river. They will charge firms the marginal damage (MD) per unit of pollution.

2) Firms own river: If river is owned by firms then firms can charge swimmers in exchange of polluting less. They will also charge swimmers the MD per unit of pollution reduction.

$\Rightarrow$ **The final level of pollution will be the same in 1) and 2)!**

5.2

The Solution: Coasian Payments



Problems with the Coasian Solution

In practice, the Coase theorem is unlikely to solve many of the types of externalities that cause market failures.

1) The assignment problem: In cases where externalities affect many agents, then assigning property rights is difficult (e.g., global warming)

⇒ Coasian solutions are likely to be more effective for small, localized externalities than for larger, more global externalities involving many people and firms

2) Transaction Costs and Negotiating Problems: The Coasian approach ignores the fundamental problem that negotiation is costly, and increasingly so with the number of parties involved

⇒ This problem is amplified for an externality such as global warming, where the potentially divergent interests of billions of parties on one side must be somehow aggregated for a negotiation.

Problems with the Coasian Solution (ctd)

Ronald Coase's insight that externalities can sometimes be internalized via private negotiations was useful.

It provides the competitive market model with a defense against the onslaught of market failures.

The market may be able to internalize some small-scale, localized externalities (e.g. beehives for pollination in agriculture has become a business rather than a side-effect of honey production)

But the Coasian solution is unlikely with large-scale, global externalities, where only a "government" can successfully aggregate the interests of all individuals suffering from externality

Public Sector Solutions

Public policy makers employ two types of remedies to resolve the problems associated with negative externalities:

1) Quantity regulation: government limits use of externality producing chemicals.

e.g., CFCs [chlorofluorocarbons] that deplete ozone layer banned in 1990s

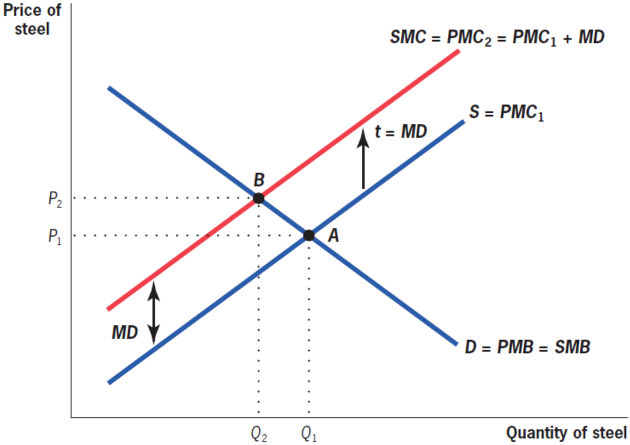
2) Corrective taxation: corrective tax or subsidy equal to marginal damage per unit (known as a "Pigouvian" tax)

e.g., carbon tax to fight global warming due to CO2 emissions

1) and 2) can be combined with **tradable emissions permits** to firms that can then be traded (cap-and-trade for carbon emissions)

5.3

Corrective Taxation



Corrective Taxes vs. Tradable Permits

Two differences between corrective taxes and tradable permits (carbon tax vs. cap-and-trade in the case of CO2 emissions)

1) Initial allocation of permits: If the government sells them to firms, this is equivalent to the tax

If the government gives them to current firms for free, this is like the tax + large transfer to initial polluting firms.

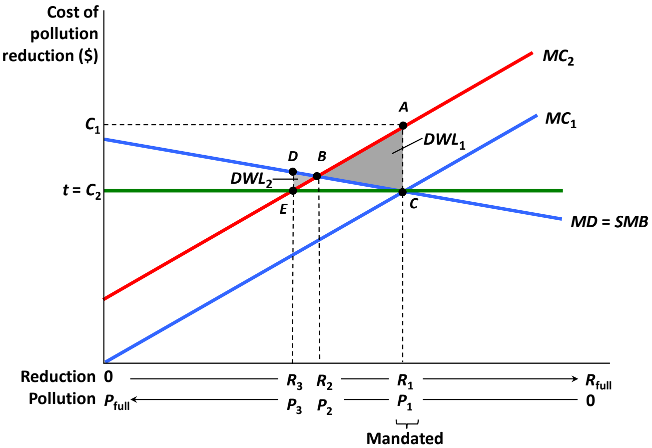
2) Uncertainty in marginal costs: With uncertainty in costs of reducing pollution, a tax cannot target a specific quantity while tradable permits can

$\Rightarrow$ The two policies are no longer equivalent.

In theory, taxes are preferable when the MD curve is flat, and tradable permits are preferable when the MD curve is steep (see graphs).

5.4

Uncertainty About Costs of Reduction: Case 1: Flat *MD* Curve (Global Warming)



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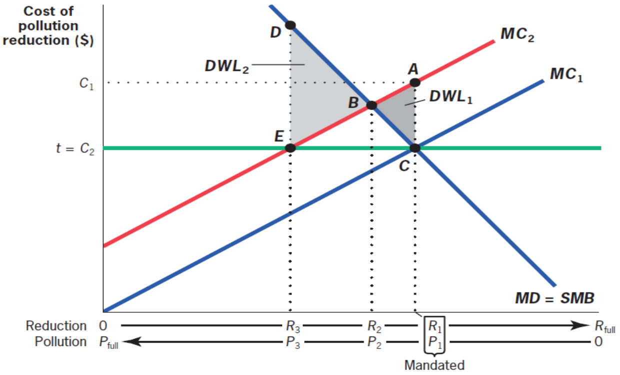
Uncertainty About Costs of Reduction:

Case 2: Steep *MD* Curve (Nuclear leakage)



Case Study: Acid Rain and Health

Acid rain due to contamination by emissions of sulfur dioxide (SO_2) and nitrogen oxide (NO_x).

1970 Clean Air Act: Landmark federal legislation that first regulated acid rain-causing emissions by setting maximum standards for atmospheric concentrations of various substances, including SO_2.

The 1990 Amendments and Emissions Trading:

SO_2 allowance system: The feature of the 1990 amendments to the Clean Air Act that granted plants permits to emit SO_2 in limited quantities and allowed them to trade those permits.

Case Study: Effects of Clean Air Act of 1970

How does acid rain (or SO_2) affect health?

Observational approach: relate mortality in a geographical area to the level of particulates (such as SO_2) in the air

Problem: Areas with more particulates may differ from areas with fewer particulates in many other ways...

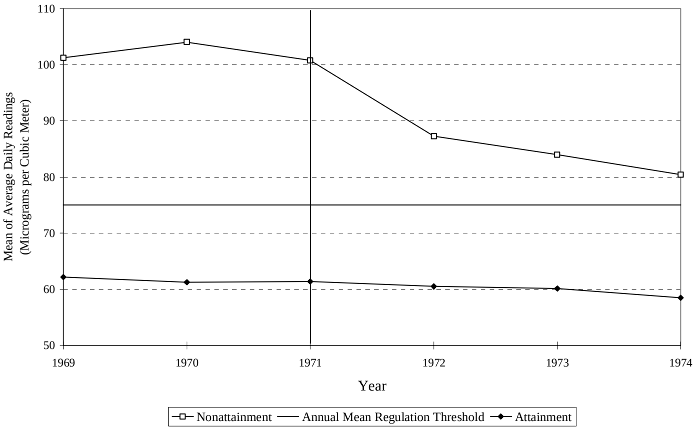
Chay and Greenstone (2003) use the Clean Air Act of 1970 for causal identification.

Areas with more particulates than the threshold are required to clean up air [treatment group], while areas with less particulates than the threshold are not [control group].

Compares infant mortality across 2 types of places before and after (i.e., difference in differences approach)

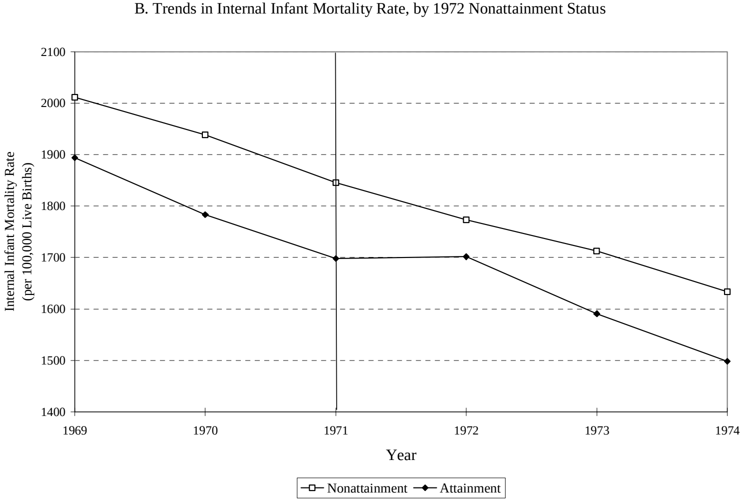
Figure 2: Trends in TSPs Pollution and Infant Mortality, by 1972 Nonattainment Status

A. Trends in Mean TSPs Concentrations, by 1972 Nonattainment Status



Source: Authors' tabulations from EPA's "Quick Look Reports" data file.

Source: Chay and Greenstone (2003)



Source: Chay and Greenstone (2003)

Climate Change and CO2 Emissions

Industrialization has dramatically increased CO2 emissions and atmospheric CO2 generates global warming

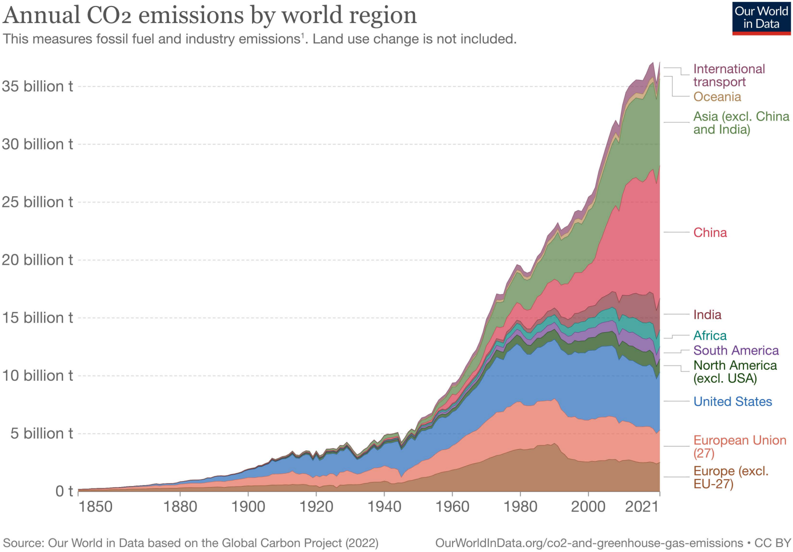
Four factors make this externality challenging (Wagner-Weitzman 2015):

1) Global: Emissions in one country affect the full world

2) Irreversible: Atmospheric CO2 has long life (centuries) [absent carbon capture tech breakthrough]

3) Long-term: Costs of global warming are decades/centuries away [how should this be discounted?]

4) Uncertain: Great uncertainty in costs of global warming [mitigation vs. amplifying feedback loops]



1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO_2) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO_2 includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

Main Costs of Global Warming

Enormous variation across geographical areas and economic development. The pace of change makes adaptation daunting.

1) Sea rise will flood low-lying coasts and many major population centers.

2) Impact on biodiversity (e.g., mass extinctions).

3) Agricultural production could be disrupted by climate change creating food security risks.

4) Droughts and heat waves will make many places less livable.

In fine, some societies may collapse and generate mass migration movements.

Adjusting to Global Warming

Estimating the costs of global warming is difficult because society will adapt and reduce costs (relative to a scenario with no adaptation).

e.g., heat waves and mortality analysis of Barreca et al. (2016)

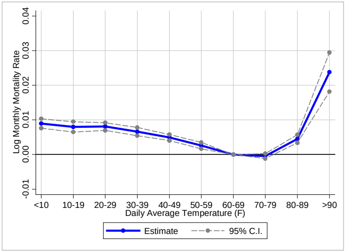
1) The mortality effect of an extremely hot day (80^oF+) declined by about 75% between 1900-1959 and 1960-2004.

2) Adoption of residential air conditioning (AC) explains the entire decline

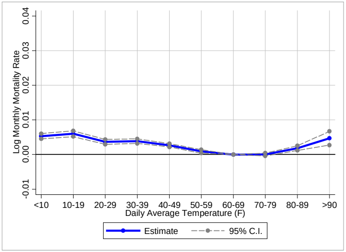
3) Worldwide adoption of AC will speed up the rate of climate change (if fossil fuel-powered)

Figure 2: Estimated Temperature-Mortality Relationship (Continued)

(c) 1929-1959



(d) 1960-2004



Notes: Figure 2 plots the response function between log monthly mortality rate and average daily temperatures, obtained by fitting Equation (1). The response function is normalized with the 60°F – 69°F category set equal to zero so each estimate corresponds to the estimated impact of an additional day in bin j on the log monthly

Source:Barreca, Alan, et al (2013)

Global Warming: An Economic View

Economists view global warming as a classical externality

CO2 emissions impose a global warming externality ⇒ Solution is to impose a carbon tax equal to the marginal damage of CO2 emissions and let market forces work their magic

But what is the marginal damage of CO2? Costs hard to evaluate and depend greatly on how you discount the future

Economists use interest rate r to discount future: \$1 today is worth $\$(1+r)^T$ in T years (long-distance future heavily discounted: e.g., $r = 4\%$ and $T = 1000 \Rightarrow (1+r)^T = 10^{17}$)

If interest rate is high (=individual humans are impatient), it is desirable to let global warming happen and societies collapse...

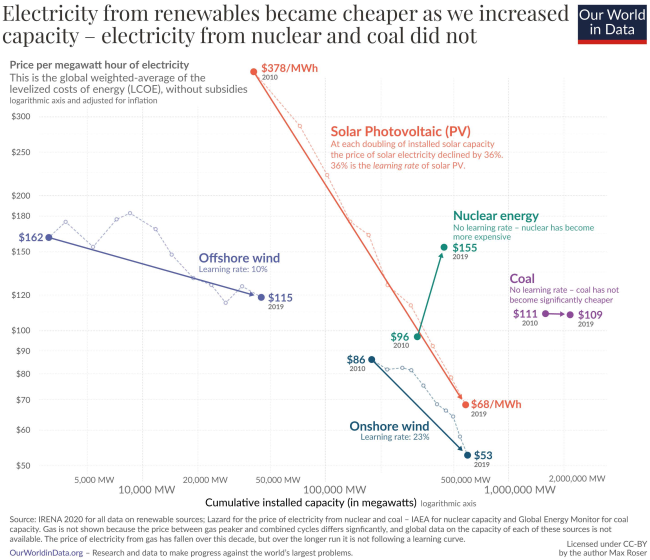
Global Warming: A Broader View

Massive CO_2 emissions pose existential civilizational risk (like CFC destroying vital ozone layer)

Only solution is to decarbonize as a social choice and we need to do it fast (within decades not centuries)

Decarbonization is within sight: renewable electricity (solar/wind) + grid + big batteries could power most energy needs and replace most fossil fuels, renewable cost dropping fast

⇒ Could be done without killing economic growth and without huge short-term disruptions


Electricity from renewables became cheaper as we increased capacity – electricity from nuclear and coal did not
Our World in Data
Price per megawatt hour of electricity
This is the global weighted-average of the levelized costs of energy (LCOE), without subsidies
logarithmic axis and adjusted for inflation
$378/MWh
2010
Solar Photovoltaic (PV)
At each doubling of installed solar capacity the price of solar electricity declined by 36%.
36% is the learning rate of solar PV.
Nuclear energy
No learning rate – nuclear has become more expensive
$155
2019
$162
Offshore wind
Learning rate: 10%
$115
2019
Coal
No learning rate – coal has not become significantly cheaper
$111
2010
$109
2019
$96
2010
$86
2010
$68/MWh
2019
Onshore wind
Learning rate: 23%
$53
2019
$300
$250
$200
$180
$150
$120
$100
$90
$80
$70
$60
$50
5,000 MW
10,000 MW
20,000 MW
50,000 MW
100,000 MW
500,000 MW
1,000,000 MW
2,000,000 MW
Cumulative installed capacity (in megawatts) logarithmic axis
Source: IRENA 2020 for all data on renewable sources; Lazard for the price of electricity from nuclear and coal – IAEA for nuclear capacity and Global Energy Monitor for coal capacity. Gas is not shown because the price between gas peaker and combined cycles differs signficantly, and global data on the capacity of each of these sources is not available. The price of electricity from gas has fallen over this decade, but over the longer run it is not following a learning curve.
OurWorldinData.org – Research and data to make progress against the world's largest problems.
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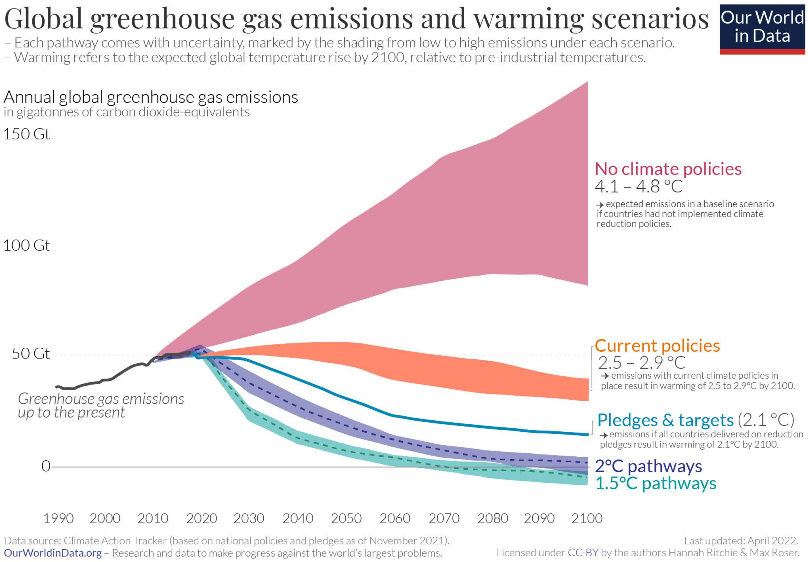
Global greenhouse gas emissions and warming scenarios
– Each pathway comes with uncertainty, marked by the shading from low to high emissions under each scenario.
– Warming refers to the expected global temperature rise by 2100, relative to pre-industrial temperatures.
Our World in Data
Annual global greenhouse gas emissions
in gigatonnes of carbon dioxide-equivalents
150 Gt
100 Gt
50 Gt
0
Greenhouse gas emissions up to the present
No climate policies
4.1 – 4.8 °C
→ expected emissions in a baseline scenario if countries had not implemented climate reduction policies.
Current policies
2.5 – 2.9 °C
→ emissions with current climate policies in place result in warming of 2.5 to 2.9°C by 2100.
Pledges & targets (2.1 °C)
→ emissions if all countries delivered on reduction pledges result in warming of 2.1°C by 2100.
2°C pathways
1.5°C pathways
1990 2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100
Data source: Climate Action Tracker (based on national policies and pledges as of November 2021).
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International Coordination

From one country's perspective, decarbonizing is costly and benefit is modest (as global emissions is what matters)

⇒ Countries need to make a coordinated binding agreement to decarbonize together (to avoid free-riding)

Kyoto (1997): 35 industrialized nations (but not US) agreed to reduce their emissions of greenhouse gases to 1990 levels by 2012

Since then, series of international (but non-binding) pledges...

However, big countries want to develop and control future renewable tech (race US vs. China is good in speeding transition)

How to Decarbonize? Richer Countries

Must become a clear policy choice that mobilizes society

Encourage research on renewable technologies both public and private (King, David et al. 2015)

Plan phase-out of carbon in various sectors [industrial policy] and weaken fossil fuel industry political power (Sachs 2019)

Raising the carbon tax could be one tool but we should not bet everything on it as it is regressive and unpopular (e.g., Yellow Vests in France)

Be flexible and redistribute more to the lowest incomes (to avoid political and social unrest)

How to Decarbonize? Developing Countries

Disagreement between rich and developing countries on who should bear the cost of curbing greenhouse gas emissions

Rich countries responsible for most of historical CO2 emissions

Poor countries want to develop using the cheapest available technologies (coal power still cheaper than renewables)

Makes sense for richer countries to encourage/help poorer countries leapfrog carbon in favor of renewable energy

Carrot: R&D on renewables in rich countries can be adopted in poorer countries, direct subsidies can help

Stick: Impose tariffs on carbon content of imported goods

Some References

Jonathan Gruber, Public Finance and Public Policy, 5th Edition, 2019 Worth Publishers, Chapters 5 and 6

Barreca, Alan, et al. “Adapting to Climate Change: The Remarkable Decline in the US Temperature-Mortality Relationship over the 20th Century.” Journal of Political Economy 124(1), 2016, 105-159.(web)

Chancel, Lucas, Thomas Piketty, Emmanuel Saez, and Gabriel Zucman. *The World Inequality Report 2022*, Cambridge: Harvard University Press, 2022. (web)

Chay, K. and M. Greenstone “Air Quality, Infant Mortality, and the Clean Air Act of 1970,”NBER Working Paper No. 10053, 2003.(web)

Ellerman, A. Denny, ed. “Markets for clean air: The US acid rain program.” Cambridge University Press, 2000.(web)

King, David et al. 2015 “A Global Apollo Programme to Combat Climate Change”, LSE Report (web)

Nordhaus, William D., and Joseph Boyer. “Warning the World: Economic Models of Global Warming.” MIT Press (MA), 2000.(web)

Nordhaus, William D. “After Kyoto: Alternative mechanisms to control global warming.” The American Economic Review 96.2 (2006): 31-34.(web)

Nordhaus, William D. *The Climate Casino: Risk, Uncertainty, and Economics for a Warming World*, Yale University Press, 2013.

Our World in Data, 2020. “Why did renewables become so cheap so fast?” by Max Roser (web)

Our World in Data, 2022. “CO2 Emissions?” by Hannah Ritchie and Max Roser (web)

Sachs, Jeffrey. 2019. “Getting to a Carbon-Free Economy: The urgent is attainable, and at entirely affordable cost.”, The American Prospect. (web)

Stern Review, 2007. *The Economics of Climate Change*. Cambridge University Press.

Wagner, Gernot and Martin L. Weitzman. *Climate Shock: The Economic Consequences of a Hotter Planet.* Princeton University Press 2015.