EC2106 PUBLIC ECONOMICS
LECTURE 3

David Seim

Fall 2022

Externalities

- Outline:
- What if market does not work?
- Role of externalities.
- Go to (Menti).

Repetition

- **Market failure:** A problem that violates one of the assumptions of the 1st Welfare theorem. ⇒ Market outcome does not maximize efficiency.
- **Externality:** Externalities arise when the actions of one agent **directly** affects another agent outside of the market mechanism.
- Externality-Example: A steel plant that pollutes a river, which is used for recreation.
- Non-Externality-Example: A steel plant uses more electricity and bids up the price of electricity for other customers.

Externalities are important cases of market failures.

Repetition

- **Market failure:** A problem that violates one of the assumptions of the 1st Welfare theorem. ⇒ Market outcome does not maximize efficiency.
- **Externality:** Externalities arise when the actions of one agent **directly** affects another agent outside of the market mechanism.
- Externality-Example: A steel plant that pollutes a river, which is used for recreation.
- Non-Externality-Example: A steel plant uses more electricity and bids up the price of electricity for other customers.

Externalities are important cases of market failures.

Externality Theory

1. Negative **production** externality.

   A firm's production reduces the well-being of others (not compensated by the firm).

- Concepts:

(i) **Private marginal cost (PMC):** The direct cost of producing one additional good.

(ii) **Marginal Damage (MD):** Additional cost of producing one additional good imposed on others and not paid by the firm.

- **Social Marginal Cost (SMC = PMC + MD):** The private marginal cost to producers plus the marginal damage.

Example: Steel plant pollutes a river but does not face regulation.

Externality Theory

1. Negative **production** externality.

   A firm's production reduces the well-being of others (not compensated by the firm).

- Concepts:

(i) **Private marginal cost (PMC):** The direct cost of producing one additional good.

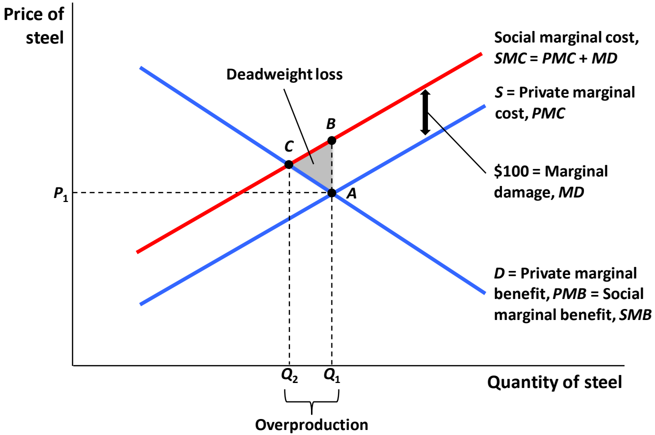
(ii) **Marginal Damage (MD):** Additional cost of producing one additional good imposed on others and not paid by the firm.

- **Social Marginal Cost (SMC = PMC + MD):** The private marginal cost to producers plus the marginal damage.

  Example: Steel plant pollutes a river but does not face regulation.

5.1

Economics of Negative Production Externalities: Steel Production



Externality Theory

2. Negative **consumption** externality.

   An individual's consumption reduces the well-being of others (not compensated by the individual).

- Concepts:
- **Private Marginal Benefit (PMB):** The direct benefit of consuming one additional good.
- **Social Marginal Benefit (SMB):** The private marginal benefit to consumers net of costs imposed on others.
- Example: using a car and emitting carbon.

Externality Theory

2. Negative **consumption** externality.

   An individual's consumption reduces the well-being of others (not compensated by the individual).

- Concepts:
- **Private Marginal Benefit (PMB):** The direct benefit of consuming one additional good.
- **Social Marginal Benefit (SMB):** The private marginal benefit to consumers net of costs imposed on others.
- Example: using a car and emitting carbon.

Example of negative consumption externalities

- Increased consumption of large cars, such as SUVs.

  1. **Environmental externalities:** SUV's more thirsty $\equiv$ emit more CO2.
  2. SUVs wear down roads more.
  3. **Safety externalities:** The likelihood of fatal accident in collision with SUV is many times larger.

Externality Theory

3. Positive **production** externality.

    A firm's production increases the well-being of others (but is not compensated by the individual).

    Example 1: Beehives of honey producers affect pollination and agriculture positively.

    Example 2: R&D investments affects innovations in the economy positively.

4. Positive **consumption** externality.

    An individual's consumption increases the well-being of others (but is not compensated by others).

    Example: Beautiful private garden that passers-by enjoy.

Externality Theory: **Market Outcome is Inefficient**

- On the free market, quantities and prices are set as:

$$PMB = PMC. \tag{1}$$

- But, social optimum is achieved when

$$SMB = SMC. \tag{2}$$

⇒ Private market leads to an inefficient outcome (1st welfare theorem).

- Cases:
  1. **Negative** production externality ⇒ over-production.
  2. **Positive** production externality ⇒ under-production.
  3. **Negative** consumption externality ⇒ over-consumption.
  4. **Positive** consumption externality ⇒ under-consumption.

Solutions

- "In microeconomics, the market is innocent until proven guilty."
  Jon Gruber, Ch 5.
- Ronald Coase, Nobel Prize winner, libertarian:
  - Are externalities really outside the market mechanism?
- **Internalizing the externality:**
  - When private negotiations or government action leads the market price to **include** the external costs or benefits.

Solutions

- **Coase Theorem (part I):** When property rights are well-defined, negotiations b/w the party creating the externality and the party affected by the externality can achieve the socially optimal market quantity.

- **Coase Theorem (part II):** The socially optimal quantity does not depende on which party is assigned property rights. Key is that someone is assigned them.

Solutions

- **Coase Theorem (part I):** When property rights are well-defined, negotiations b/w the party creating the externality and the party affected by the externality can achieve the socially optimal market quantity.

- **Coase Theorem (part II):** The socially optimal quantity does not depende on which party is assigned property rights. Key is that someone is assigned them.

Coase Theorem Example

- Setup: Firms pollute a river enjoyed by swimmers.

1. **Swimmers own river.**
   - Swimmers charge firm for pollution.

     In equilibrium, they charge firms the marginal damage (MD) per pollution unit.

     Why is the price at MD? If $p > MD$, swimmers would want to sell one unit of pollution more and gain $p - MD$, so price must fall.

2. **Firms own river.**
   - Firm charges swimmers for polluting less.

     In equilibrium, they charge swimmers the marginal damage (MD) per pollution unit.

     Equilibrium pollution is the same in 1. and 2.

Coase Theorem Example

- Setup: Firms pollute a river enjoyed by swimmers.

1. **Swimmers own river.**
   - Swimmers charge firm for pollution.

     In equilibrium, they charge firms the marginal damage (MD) per pollution unit.

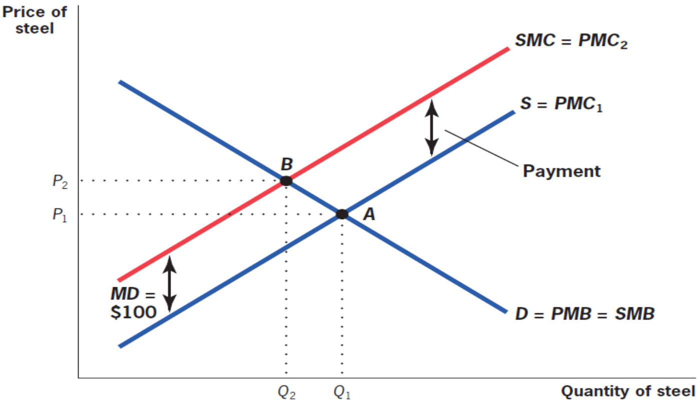
     Why is the price at MD? If $p > MD$, swimmers would want to sell one unit of pollution more and gain $p - MD$, so price must fall.
2. **Firms own river.**
   - Firm charges swimmers for polluting less.

     In equilibrium, they charge swimmers the marginal damage (MD) per pollution unit.

     Equilibrium pollution is the same in 1. and 2.

5.2

The Solution: Coasian Payments



Coase Theorem in Practice

- In reality, the Coase theorem is not solving many externality-problems.

1. **The assignment problem:**
   - If externalities affect many agents – e.g. global warming – it is impossible to assign property rights.
   - How can we assign value to the damage?

2. **The holdout problem:** Shared ownership of property rights ⇒ Power of all the others, because **everyone** must agree to Coasian solution.

3. **Transaction costs and negotiations:** Coasian solution ignores that it is hard to negotiate when there are many agents involved.

- Bottom line:

1. Coasian solution more effective for small, local externalities. Example: water wells in California, Ostrom 1990.
2. Coasian solution does not solve large-scale, global externalities, such as global warming (which must include the government).

Coase Theorem in Practice

- In reality, the Coase theorem is not solving many externality-problems.

1. **The assignment problem:**
   - If externalities affect many agents – e.g. global warming – it is impossible to assign property rights.
   - How can we assign value to the damage?

2. **The holdout problem:** Shared ownership of property rights $\Rightarrow$ Power of all the others, because **everyone** must agree to Coasian solution.

3. **Transaction costs and negotiations:** Coasian solution ignores that it is hard to negotiate when there are many agents involved.

- Bottom line:

1. Coasian solution more effective for small, local externalities. Example: water wells in California, Ostrom 1990.
2. Coasian solution does not solve large-scale, global externalities, such as global warming (which must include the government).

Government solutions

- Three typical types of remedies:

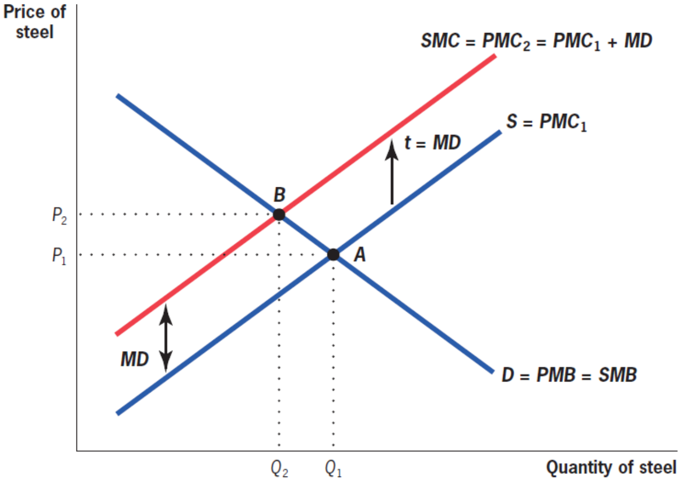
1. **Corrective / Pigouvian taxation:** Corrective tax / subsidy that equals the marginal damage (MD).
   - Example: Carbon tax to fight CO2-emissions.
   - Example: R&D subsidies to spur innovation.

2. **Quantity regulation:** Government limits the use of production.
   - Example: CFCs (Chlorofluorocarbons), present in cooling systems, deplete ozone layer.

3. **Cap-and-trade:** Give / sell emissions rights.

5.3

Corrective Taxation



Empirical Example: Acid Rain and Health

- How large are environmental externalities in the real world?
  - Estimate a component of the **MD**.

- Key Question: How does acid rain (or SO_2) affect health outcomes? (Chay and Greenstone, 2003.)

(i) Naive approach: Correlation between health outcomes (e.g. mortality) and level of particulates in the air.
  - Problem: Areas with more particulates different in many ways, not just in the amount of particulates in the air.

(ii) Chay and Greenstone (2003) use **1970 Clean Air Act:** First major federal legislation in the US to regulate air pollution.
  - Mainly regulating emissions of sulfur dioxide (SO_2; *svaveldioxid* in Swedish) and nitrogen oxide (NO_x; *kväveoxid* in Swedish).

- Reform assigned US counties into:
  1. Non-attainment status (**TREATMENT**) – Total Suspended Particulates (TSPs) $>$ threshold.
  2. Attainment status (**CONTROL**) – TSPs $\leq$ threshold.

  - **DD-approach**

Empirical Example: Acid Rain and Health

- How large are environmental externalities in the real world?
  - Estimate a component of the **MD**.

- Key Question: How does acid rain (or SO_2) affect health outcomes? (Chay and Greenstone, 2003.)

(i) Naive approach: Correlation between health outcomes (e.g. mortality) and level of particulates in the air.
  - Problem: Areas with more particulates different in many ways, not just in the amount of particulates in the air.

(ii) Chay and Greenstone (2003) use **1970 Clean Air Act:** First major federal legislation in the US to regulate air pollution.
  - Mainly regulating emissions of sulfur dioxide (SO_2; *svaveldioxid* in Swedish) and nitrogen oxide (NO_x; *kväveoxid* in Swedish).

- Reform assigned US counties into:
  1. Non-attainment status (**TREATMENT**) – Total Suspended Particulates (TSPs) > threshold.
  2. Attainment status (**CONTROL**) – TSPs ≤ threshold.
  - **DD-approach**

Empirical Example: Acid Rain and Health

- How large are environmental externalities in the real world?
  - Estimate a component of the **MD**.

- Key Question: How does acid rain (or SO_2) affect health outcomes? (Chay and Greenstone, 2003.)

(i) Naive approach: Correlation between health outcomes (e.g. mortality) and level of particulates in the air.
  - Problem: Areas with more particulates different in many ways, not just in the amount of particulates in the air.

(ii) Chay and Greenstone (2003) use **1970 Clean Air Act:** First major federal legislation in the US to regulate air pollution.
  - Mainly regulating emissions of sulfur dioxide (SO_2; *svaveldioxid* in Swedish) and nitrogen oxide (NO_x; *kväveoxid* in Swedish).

- Reform assigned US counties into:
  1. Non-attainment status (**TREATMENT**) – Total Suspended Particulates (TSPs) > threshold.
  2. Attainment status (**CONTROL**) – TSPs $\leq$ threshold.

  - **DD-approach**

Empirical Example: Acid Rain and Health

- How large are environmental externalities in the real world?
  - Estimate a component of the **MD**.

- Key Question: How does acid rain (or SO_2) affect health outcomes? (Chay and Greenstone, 2003.)

(i) Naive approach: Correlation between health outcomes (e.g. mortality) and level of particulates in the air.
  - Problem: Areas with more particulates different in many ways, not just in the amount of particulates in the air.

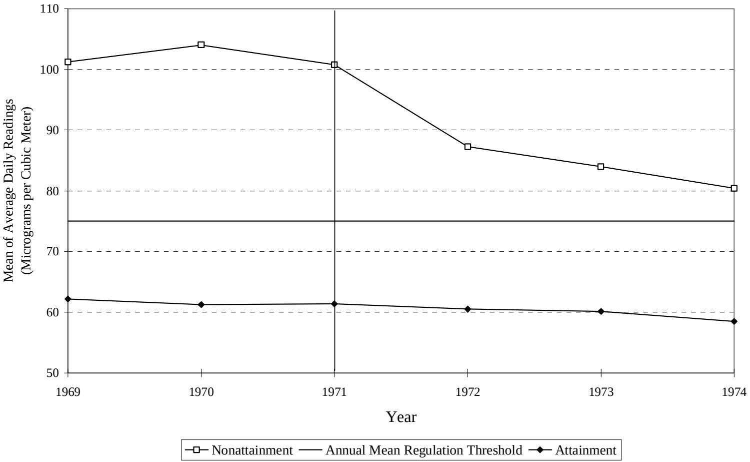
(ii) Chay and Greenstone (2003) use **1970 Clean Air Act:** First major federal legislation in the US to regulate air pollution.
  - Mainly regulating emissions of sulfur dioxide (SO_2; *svaveldioxid* in Swedish) and nitrogen oxide (NO_x; *kväveoxid* in Swedish).

- Reform assigned US counties into:
  1. Non-attainment status (**TREATMENT**) – Total Suspended Particulates (TSPs) > threshold.
  2. Attainment status (**CONTROL**) – TSPs $\leq$ threshold.

  - **DD-approach**

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

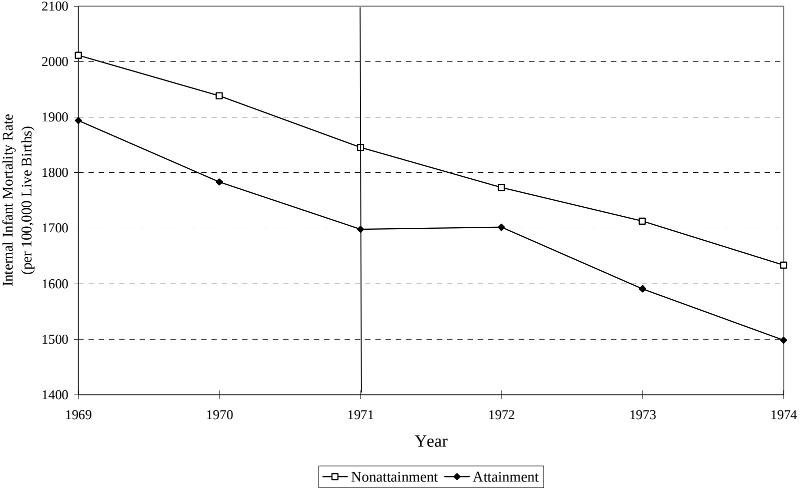
A. Trends in Mean TSPs Concentrations, by 1972 Nonattainment Status



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

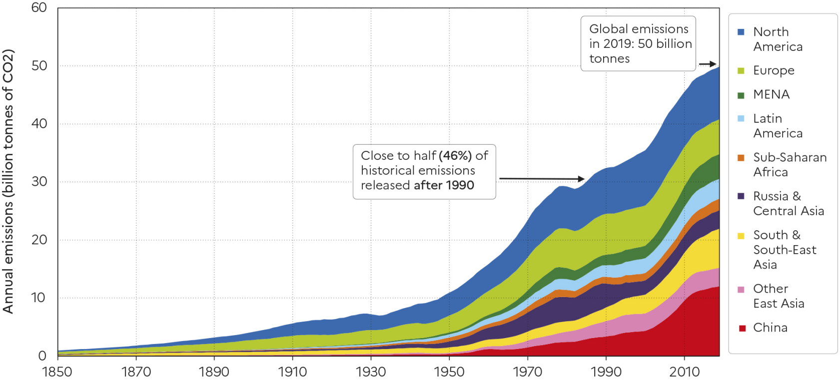
Source: Chay and Greenstone (2003)

B. Trends in Internal Infant Mortality Rate, by 1972 Nonattainment Status



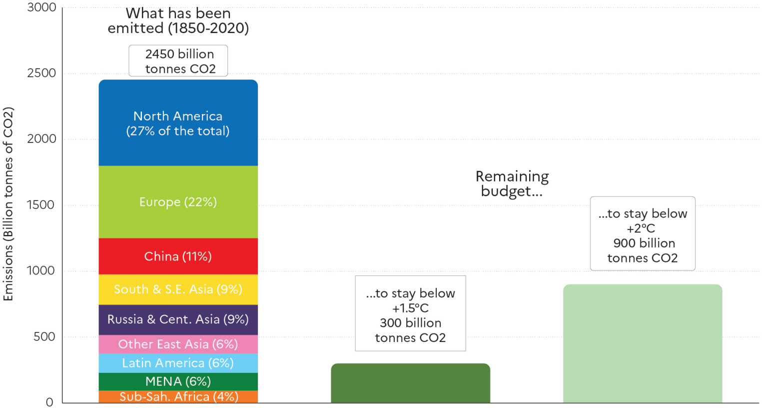
Source: Chay and Greenstone (2003)

Figure 6.1 ***Global annual CO2 emissions by world region, 1850-2019***



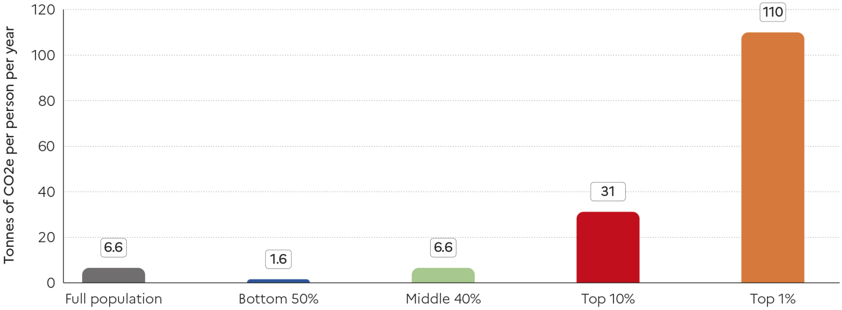
Interpretation: *The graph shows annual global emissions by world regions. After 1990, emissions include carbon and other greenhouse gases embedded in imports/exports of goods and services from/to other regions.* ***Sources and series:*** *wir2022.wid.world/methodology and Chancel (2021). Historical data from the PRIMAP-hist dataset. Post-1990 data from Global Carbon Budget.*

Figure 6.2 ***Historical emissions vs. remaining carbon budget***



Interpretation: *The graph shows historical emissions by region (left bar) and the remaining global carbon budget (center and right bars) to have 83% chances to stay under 1.5°C and 2°C, according to IPCC AR6 (2021). Regional emissions are net of carbon embedded in imports of goods and services from other regions.* ***Sources and series:*** *wir2022.wid.world/methodology and Chancel (2021). Historical data from the PRIMAP-hist dataset.*

Figure 6.5a ***Global carbon inequality, 2019: emissions by group***



Interpretation: *Personal carbon footprints include emissions from domestic consumption, public and private investments as well as imports and exports of carbon embedded in goods and services traded with the rest of the world. Modeled estimates based on the systematic combination of tax data, household surveys and input-output tables. Emissions split equally within households.* ***Sources and series:*** *wir2022.wid.world/methodology and Chancel (2021).*

Climate change and CO2 Emissions

- Industrialization has increased CO2-emissions dramatically. This generates global warming.

- How can we address it?

- Four challenging factors (Wagner-Weitzman, 2015):
  1. **Global:** Emissions in one country affect the world.
  2. **Irreversible:** Atmospheric CO2 has long life (centuries).
     - Absent carbon capture techn.
  3. **Long-term:** Costs of global warming last decades / centuries. How should we discount future costs?
  4. **Uncertain:** Great uncertainty in costs of global warming.

- How fast should we cut emissions? Stern-Weitzman argue for fast path, Nordhaus wants slower reduction.

Climate change and CO_2 Emissions

- Industrialization has increased CO_2-emissions dramatically. This generates global warming.

- How can we address it?

- Four challenging factors (Wagner-Weitzman, 2015):
  1. **Global:** Emissions in one country affect the world.
  2. **Irreversible:** Atmospheric CO_2 has long life (centuries).
     - Absent carbon capture techn.
  3. **Long-term:** Costs of global warming last decades / centuries.
     How should we discount future costs?
  4. **Uncertain:** Great uncertainty in costs of global warming.

- How fast should we cut emissions? Stern-Weitzman argue for fast path, Nordhaus wants slower reduction.

Point 3: How to discount future costs?

- Suppose the interest rate is 5%. I will give you 9000 SEK today or 14000 in 10 years. What do you prefer?

- In general, getting X SEK today is worth $Y = (1 + r)^T$ SEK in T years.

- Therefore, getting Y SEK in T years is worth, $X = \frac{1}{(1+r)^T} Y$ today.

  If $r \uparrow$, $\frac{1}{(1+r)^T} \downarrow$ so $X \downarrow$.

- **Social cost of carbon (SCC):**

  The expected present discounted value of future damage caused by releasing one more ton of CO2 today.

  If I dont care that much about the future – if I discount the future more – SCC $\downarrow$.

  If interest rate is high – human individuals are impatient – it is better to let global warming happen and societies collapse!

Point 3: How to discount future costs?

- Suppose the interest rate is 5%. I will give you 9000 SEK today or 14000 in 10 years. What do you prefer?
- In general, getting X SEK today is worth $Y = (1+r)^T$ SEK in T years.
- Therefore, getting Y SEK in T years is worth, $X = \frac{1}{(1+r)^T} Y$ today.

  If $r \uparrow$, $\frac{1}{(1+r)^T} \downarrow$ so $X \downarrow$.

- **Social cost of carbon (SCC):**

  The expected present discounted value of future damage caused by releasing one more ton of $CO2$ today.

  If I dont care that much about the future – if I discount the future more – SCC $\downarrow$.

  If interest rate is high – human individuals are impatient – it is better to let global warming happen and societies collapse!

Point 3: How to discount future costs?

- Suppose the interest rate is 5%. I will give you 9000 SEK today or 14000 in 10 years. What do you prefer?
- In general, getting X SEK today is worth $Y = (1+r)^T$ SEK in T years.
- Therefore, getting Y SEK in T years is worth, $X = \frac{1}{(1+r)^T} Y$ today.

  If $r \uparrow$, $\frac{1}{(1+r)^T} \downarrow$ so $X \downarrow$.

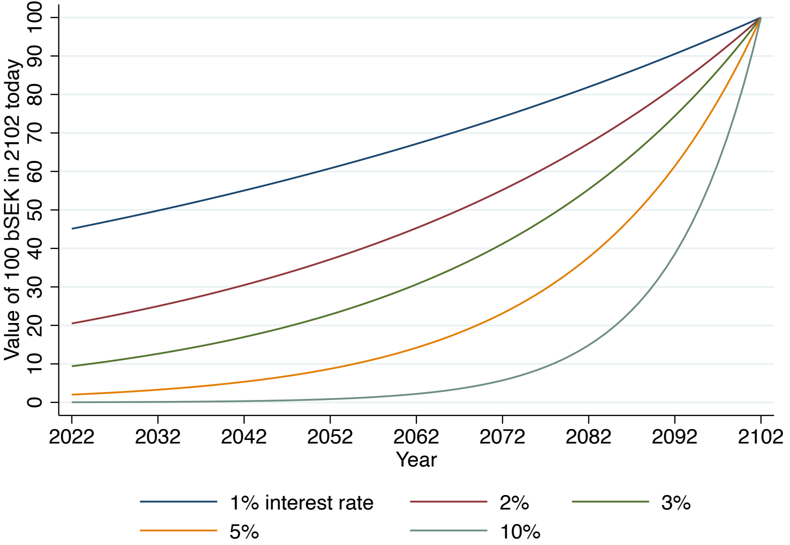
- **Social cost of carbon (SCC):**

  The expected present discounted value of future damage caused by releasing one more ton of CO2 today.

  If I dont care that much about the future – if I discount the future more – SCC $\downarrow$.

  If interest rate is high – human individuals are impatient – it is better to let global warming happen and societies collapse!

Examples with different discount rates



Main Costs of Global Warming

- **Enormous variation** – large heterogeneity (as economists say) – across geographical areas and economic development.

1. Sea rise $\Rightarrow$ floods low-lying coasts and population centers.

2. Biodiversity $\Downarrow$ (mass extinctions).

3. Agriculture production $\Downarrow$.

   Demand for food inelastic $\Rightarrow$ Large variation in prices.

4. Draughts and heat waves $\Uparrow$ $\Rightarrow$ Many places become impossible to live in.

   $\Rightarrow$ Mass migration movements.

Empirical Example: Cost of Global Warming

- Estimating the costs of global warming is difficult b/c society adapts and reduces costs.

- Point 4. from *the challenging factors*.

- Example: Heat waves and mortality (Barreca et al., 2016).

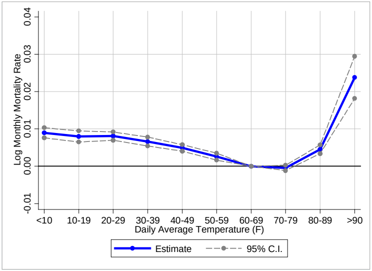
1. The effect of an extremely hot day (80+ degrees Fahrenheit / 27+ degrees Celsius) on mortality declined by **75%** between 1900 – 1959 to 1960-2004.

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

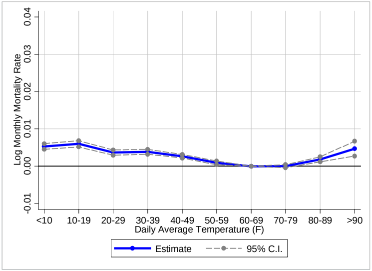
3. Worldwide adoption of AC speeds up climate change.

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 (2012)

Remedies: How to Decarbonize?

- Carbon tax set equal to marginal damage.
- Encourage research on renewable technologies (both public and private).
- **Industrial Policy:** Plan phase-out of carbon in various sectors. Weaken fossil fuel industry power, Sachs (2020).
  - Cost of decarbonization: 1-2 % of GDP per year until 2050.
  - Cost of WWII: up to 43 % of GDP per year.
  - Cost of the pandemic: around 4% of GDP per year.
  - Start with easy-to-adjust sectors, such as electricity and cars. Wait with aviation, steelmaking.
- Compensate low-income losers (avoid yellow-vests)
- Impose tariffs on carbon-content of imported goods.

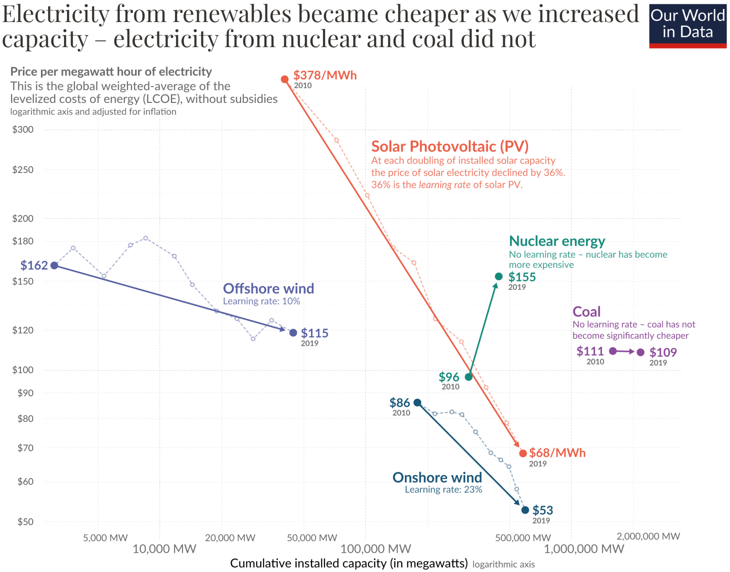
National Policy Framework (Sachs, 2020)

1. End energy-based emissions of CO_2 by 2050.

2. A low-cost pathway for this transmission.

3. Compensate vulnerable groups and regions.

Learning Curves in Different Energy Domains



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.

REFERENCES

- 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. (link).
- Chay, K. and M. Greenstone “Air Quality, Infant Mortality, and the Clean Air Act of 1970,” NBER Working Paper No. 10053, 2003. (link).
- Jonathan Gruber, Public Finance and Public Policy, Sixth Edition, 2019 Worth Publishers, Chapter 5. ”Externalities: Problems and solutions”
- Sachs, Jeffrey. 2019. “Getting to a Carbon-Free Economy: The urgent is attainable, and at entirely affordable cost.”, The American Prospect. (link).
- Wagner, Gernot and Martin L. Weitzman. “Climate Shock: The Economic Consequences of a Hotter Planet.” Princeton University Press 2015.