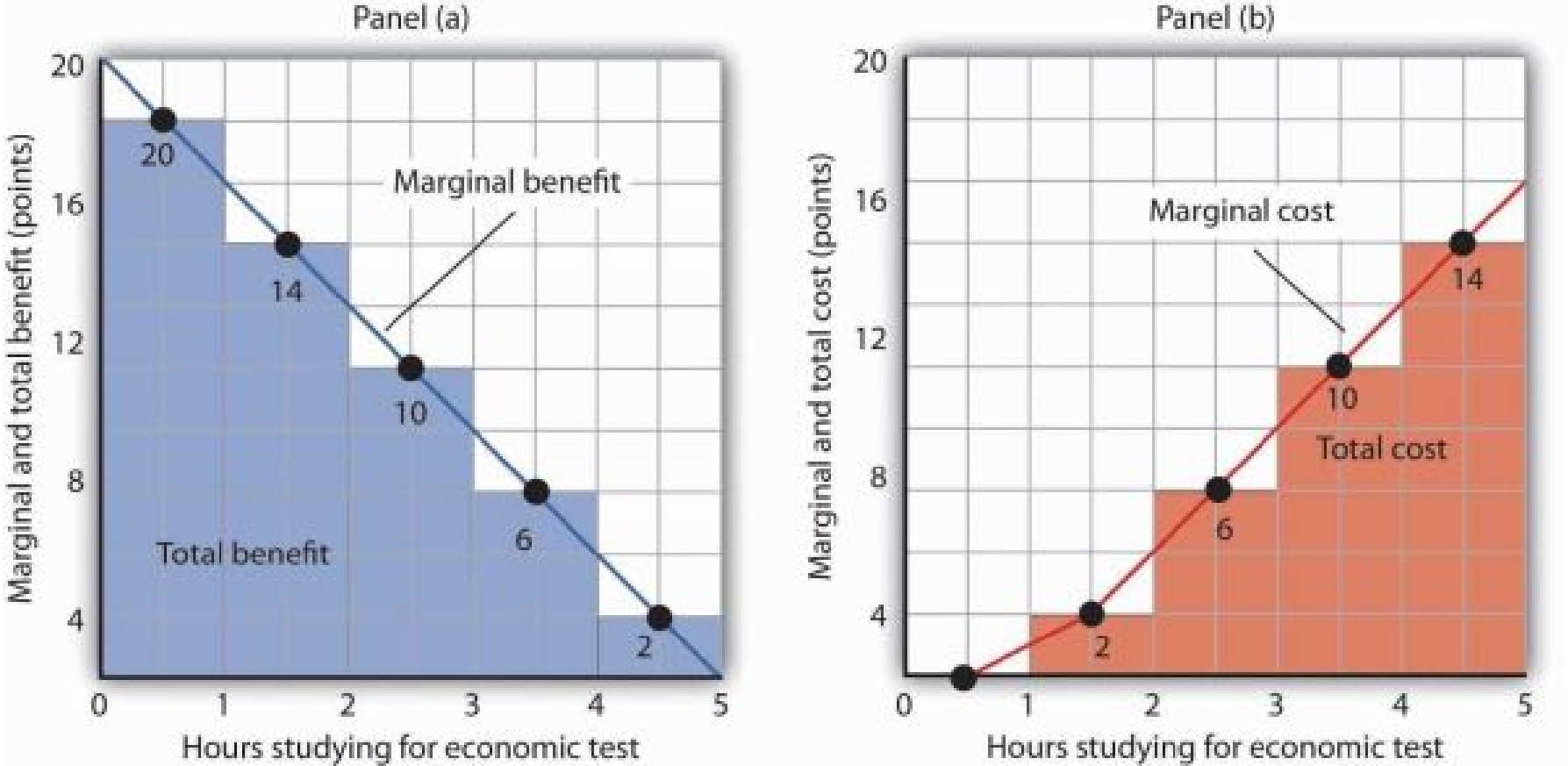
# Social Cost of Carbon

## Module 11

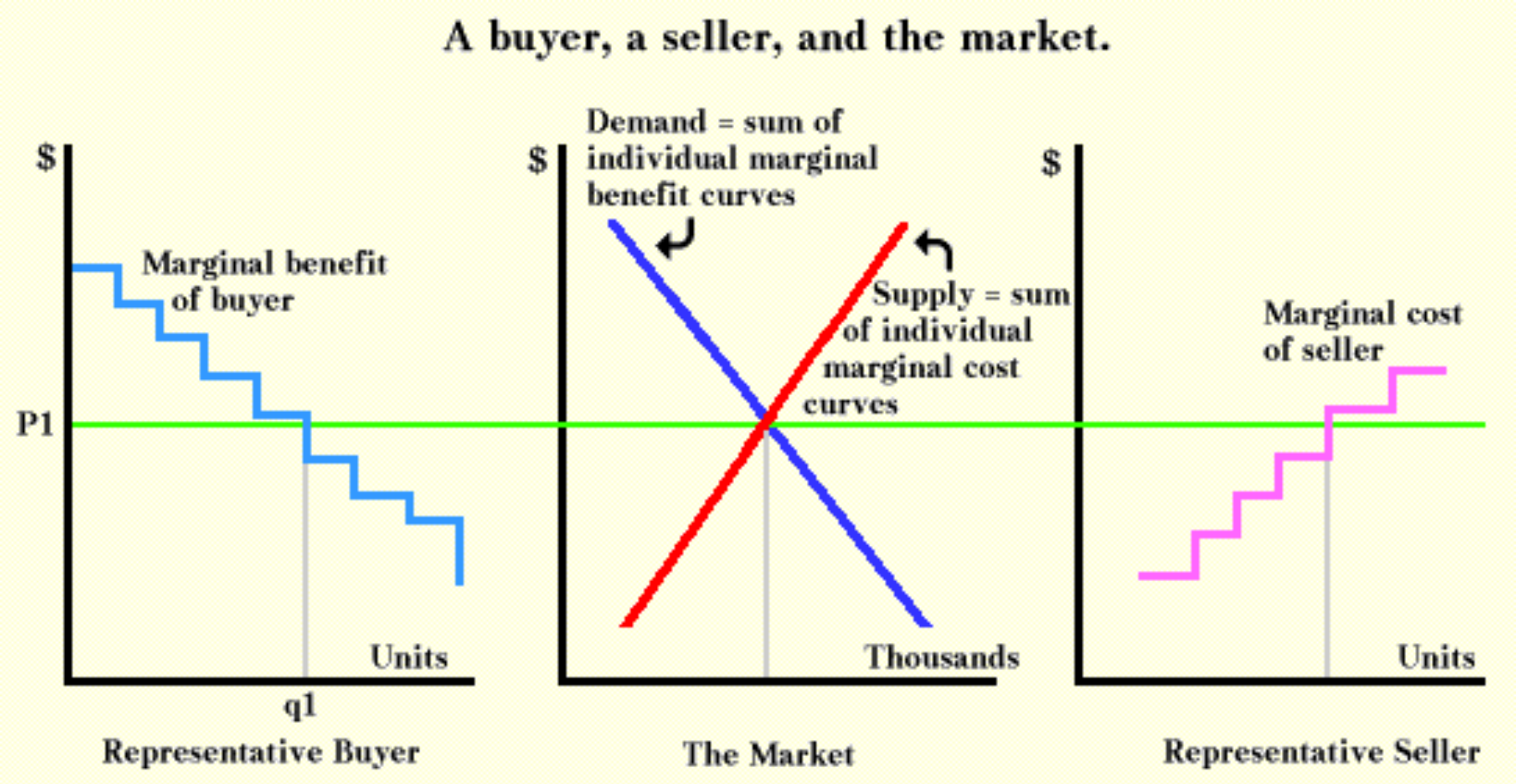
# Efficient Markets

# Economics at the Margin

- *Marginal changes* are small, incremental adjustments.
- People make decisions by comparing costs and benefits at the margin.



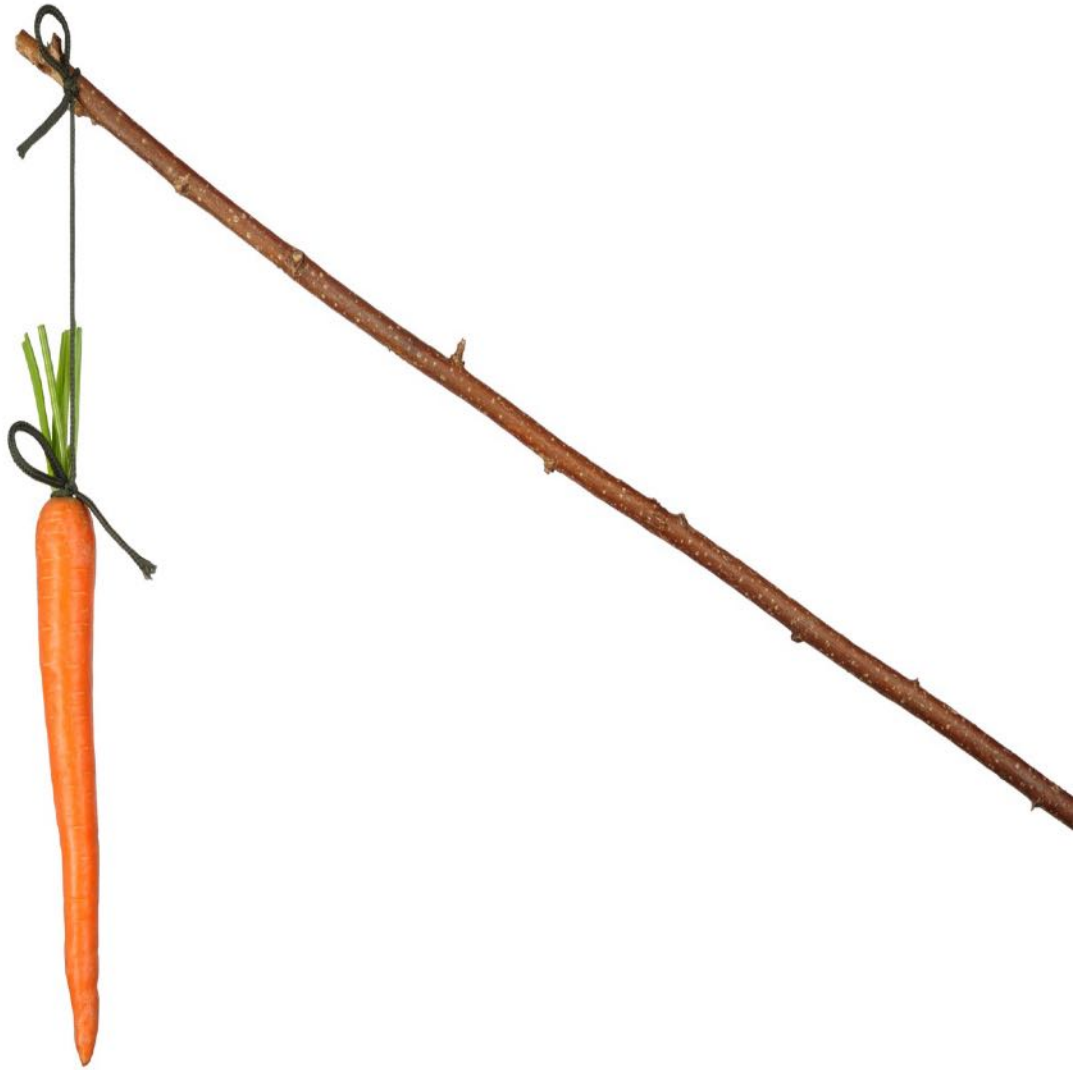
# Balancing Supply & Demand



# Incentives

- Marginal changes in costs or benefits, like taxes, motivate people to respond.

- As a policy prescription, the best way to achieve an efficient outcome is to set the incentives (prices/taxes) such that people choose the efficient outcome or their own.



# Markets are used to organize economic activity

- A *market economy* is an economy that allocates resources through the decentralized decisions of many firms and households as they interact in markets for goods and services
- Theoretically, efficient markets allocate resources to produce the “best” outcome

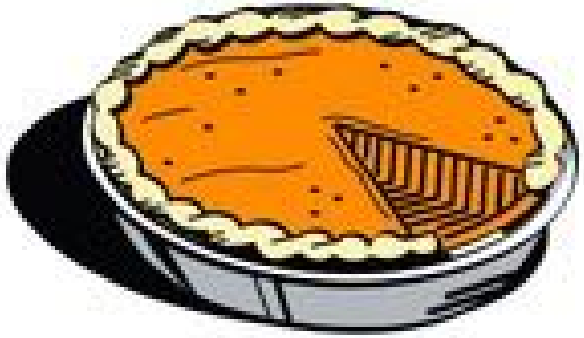
# What Economists Mean by "Best"

- **Efficient** markets seek to maximize the **aggregate** size of the pie producing

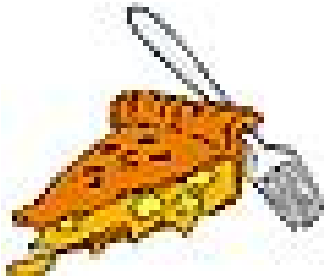
*"The greatest good for the greatest number"*

# Best for Whom?

My slice:



Your slice:



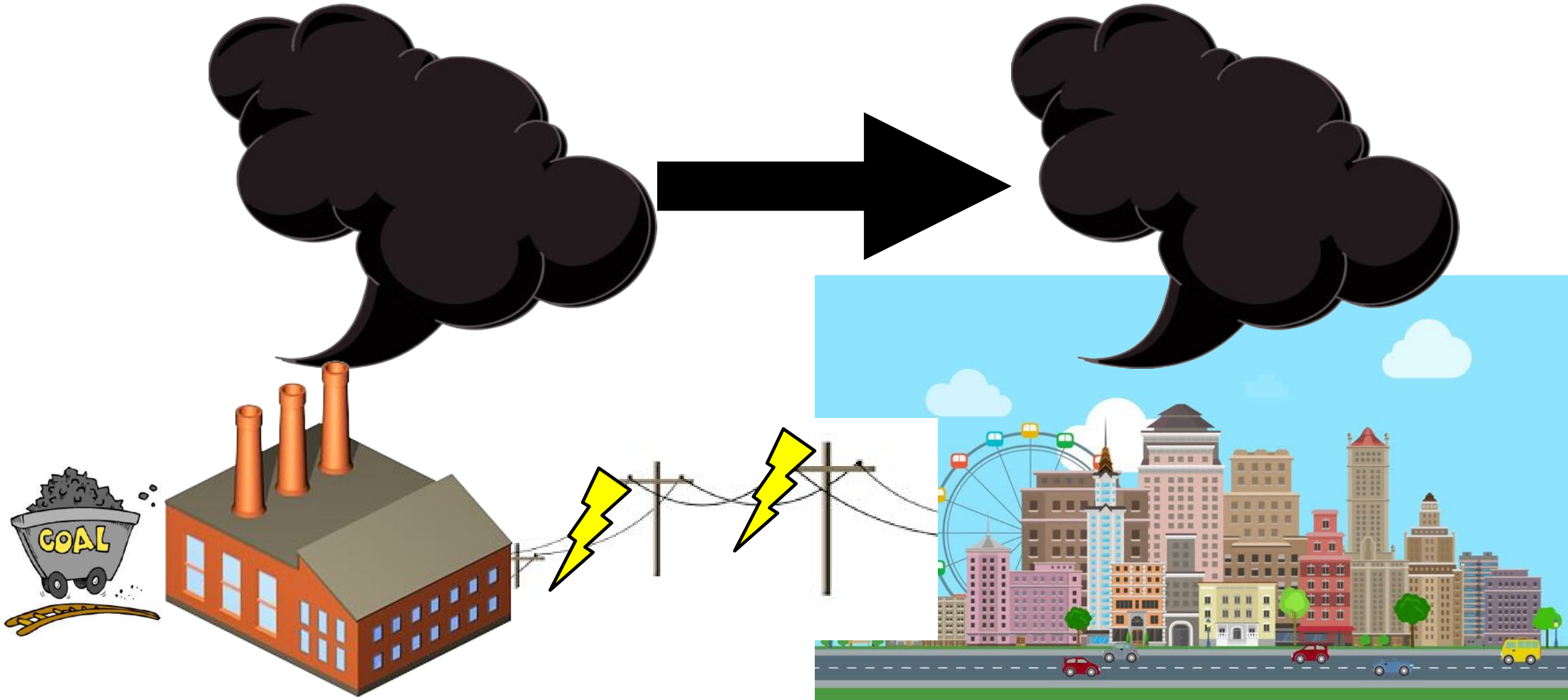
**Distribution!**

# Market Externalities

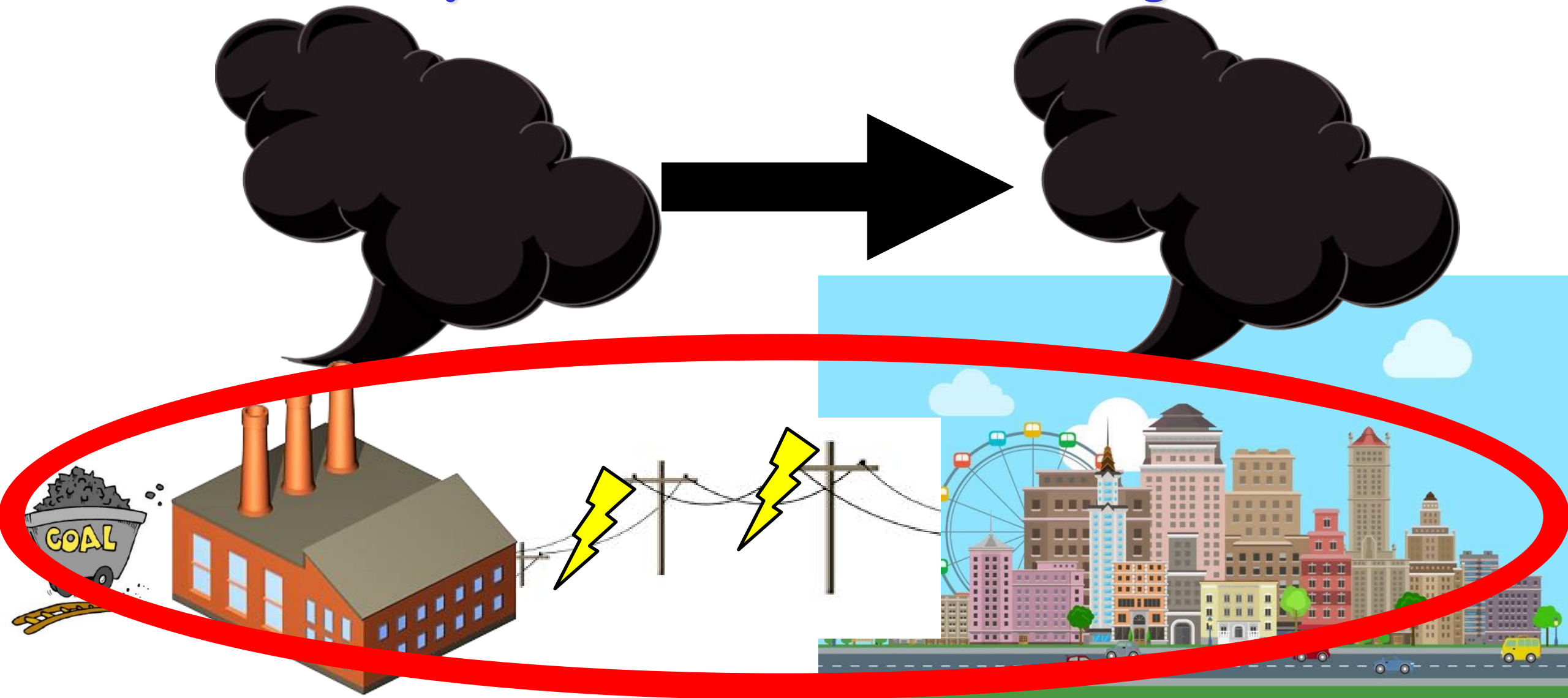
# The harm from emissions is an externality

- A (negative) externality arises whenever harm from an activity falls outside the actor producing it
  - Pollution is a leading example
- Externalities typically lead to social problems become markets do not "see" them
- As a result, the outcome of a market system is not in the best interests of society when externalities are present (market failure)
- This could be a small deal or a big deal depending on the importance of the accompanying harm

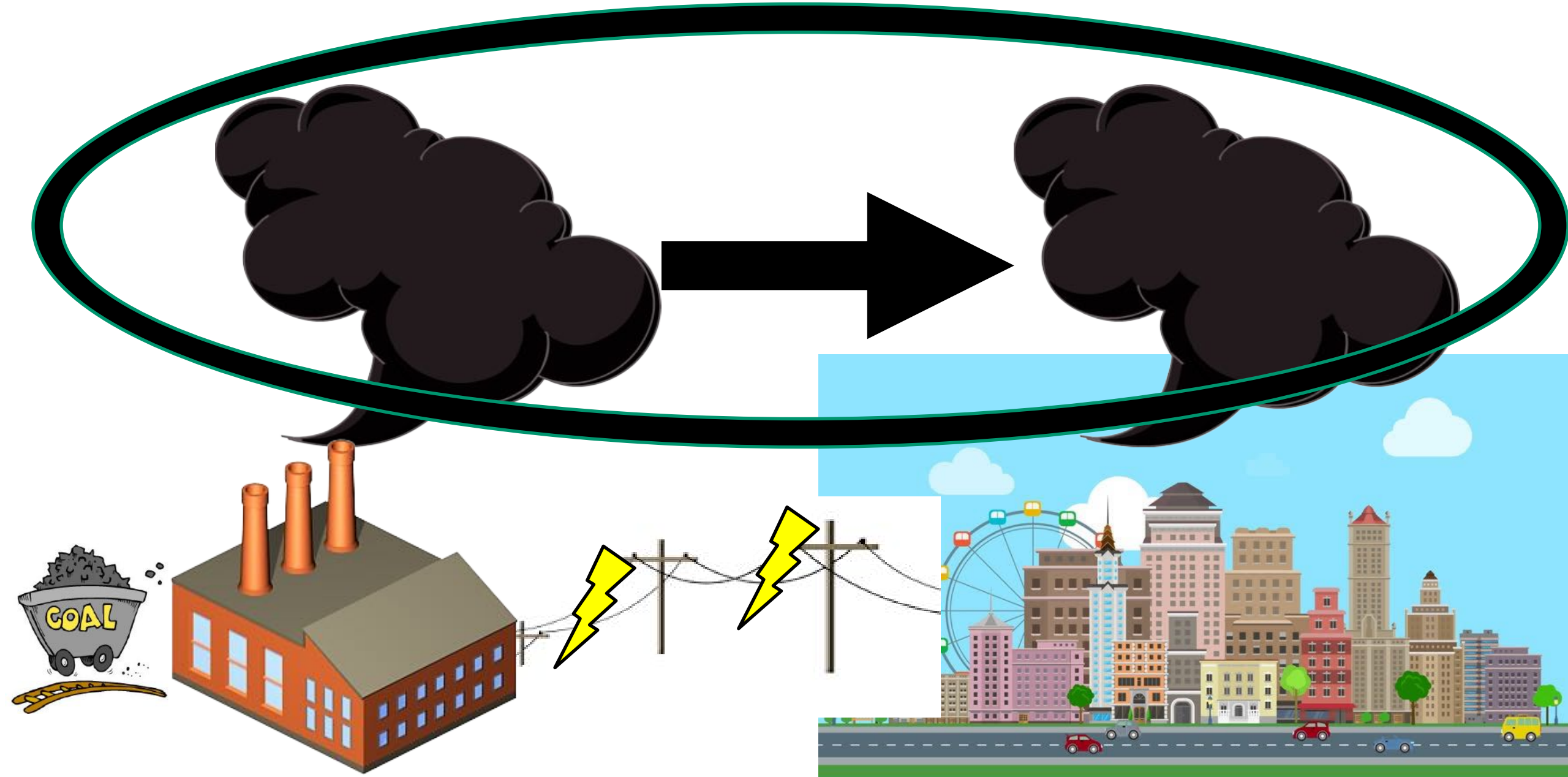
# Example: a coal-fired power plant upwind of a town.



# Everything in this circle is paid for with money.



# The pollution is a Negative Externality!

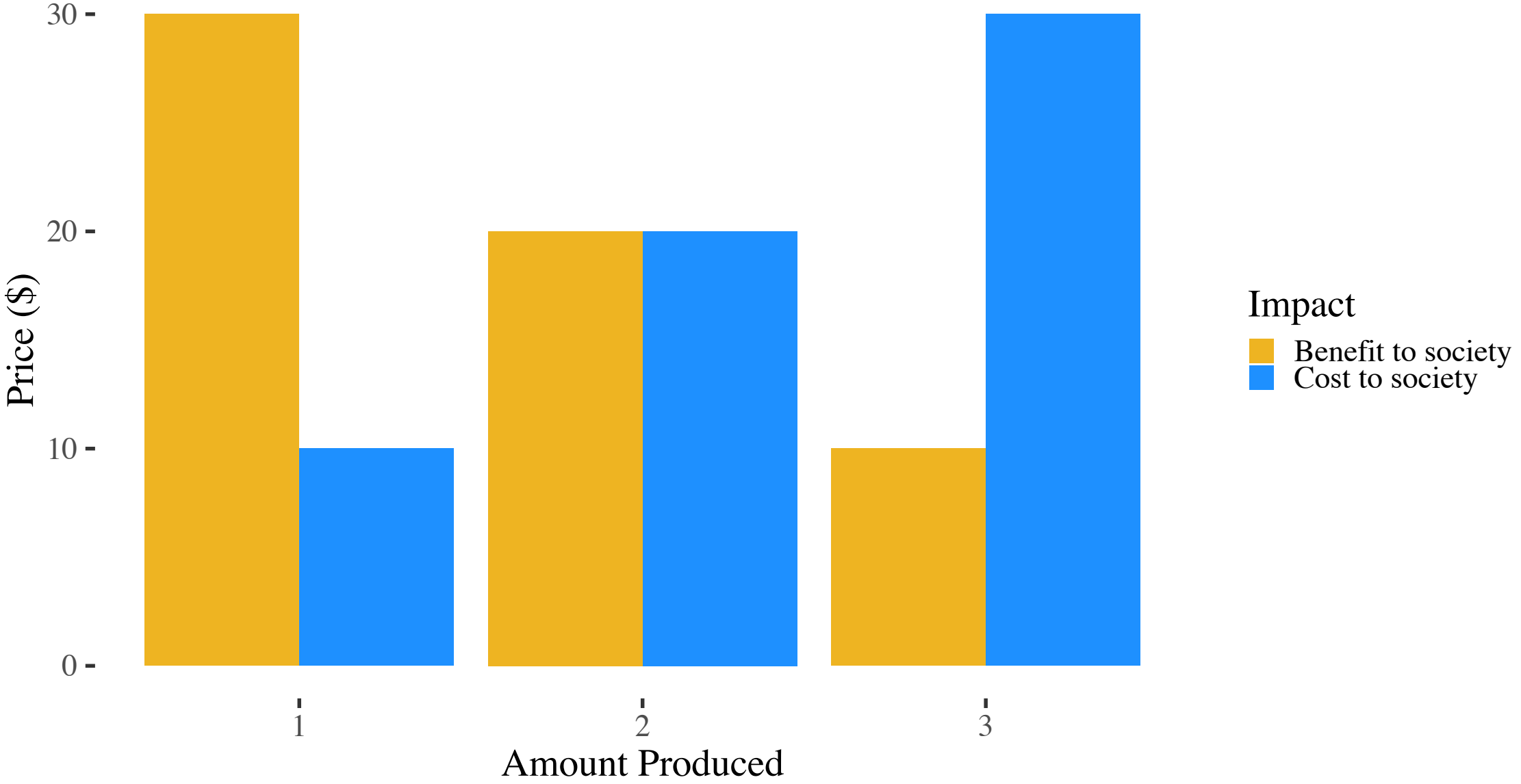


# External costs

- Firms maximize profit
- This means that they will try to minimize private costs—the costs that affect the balance in their bank account at the end of the month
- External costs are true costs to society that don't affect a firm's bank account
  - Environmental costs are a leading example

Social cost = private costs + external costs

# ‘Economic Efficiency’ is defined as the point at which the costs and benefits of activity to society balance.



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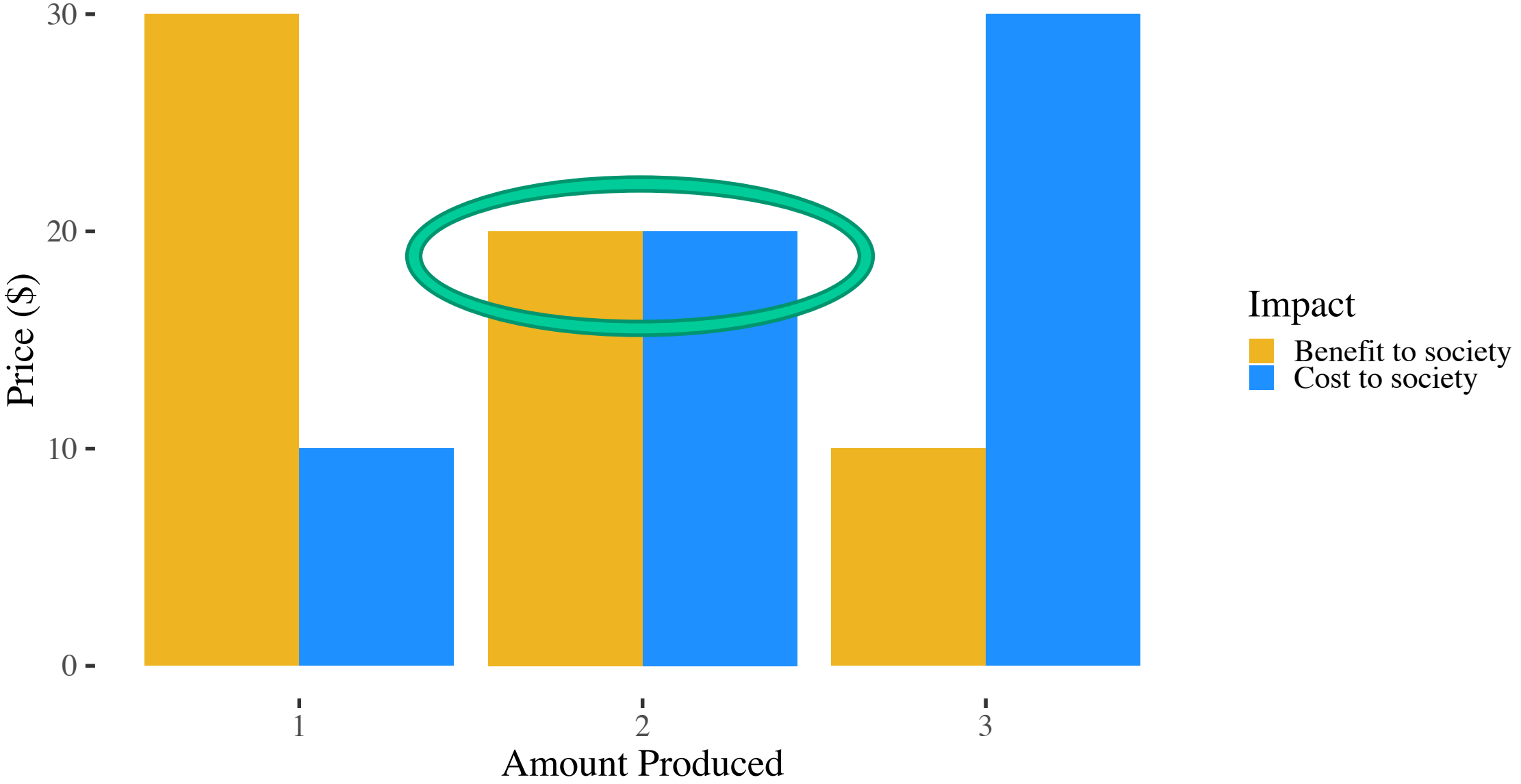
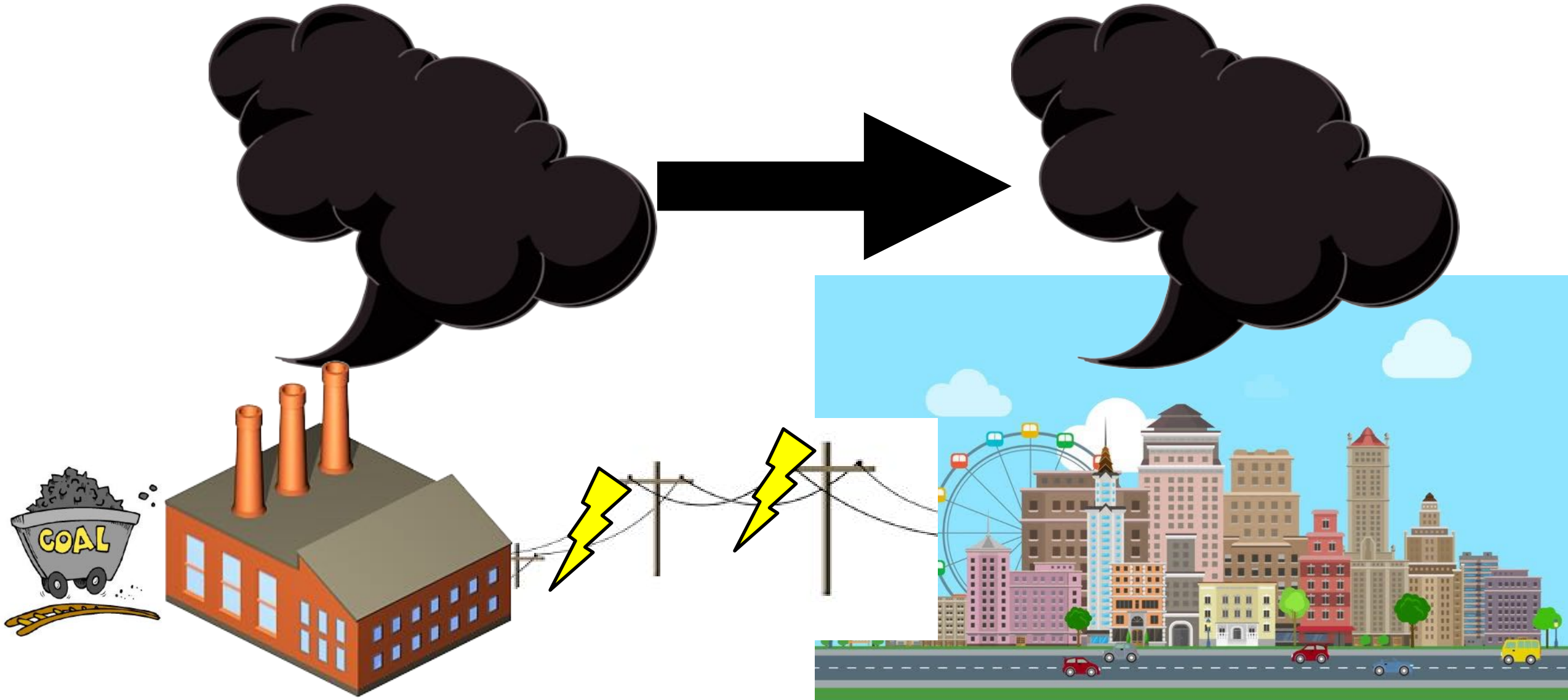
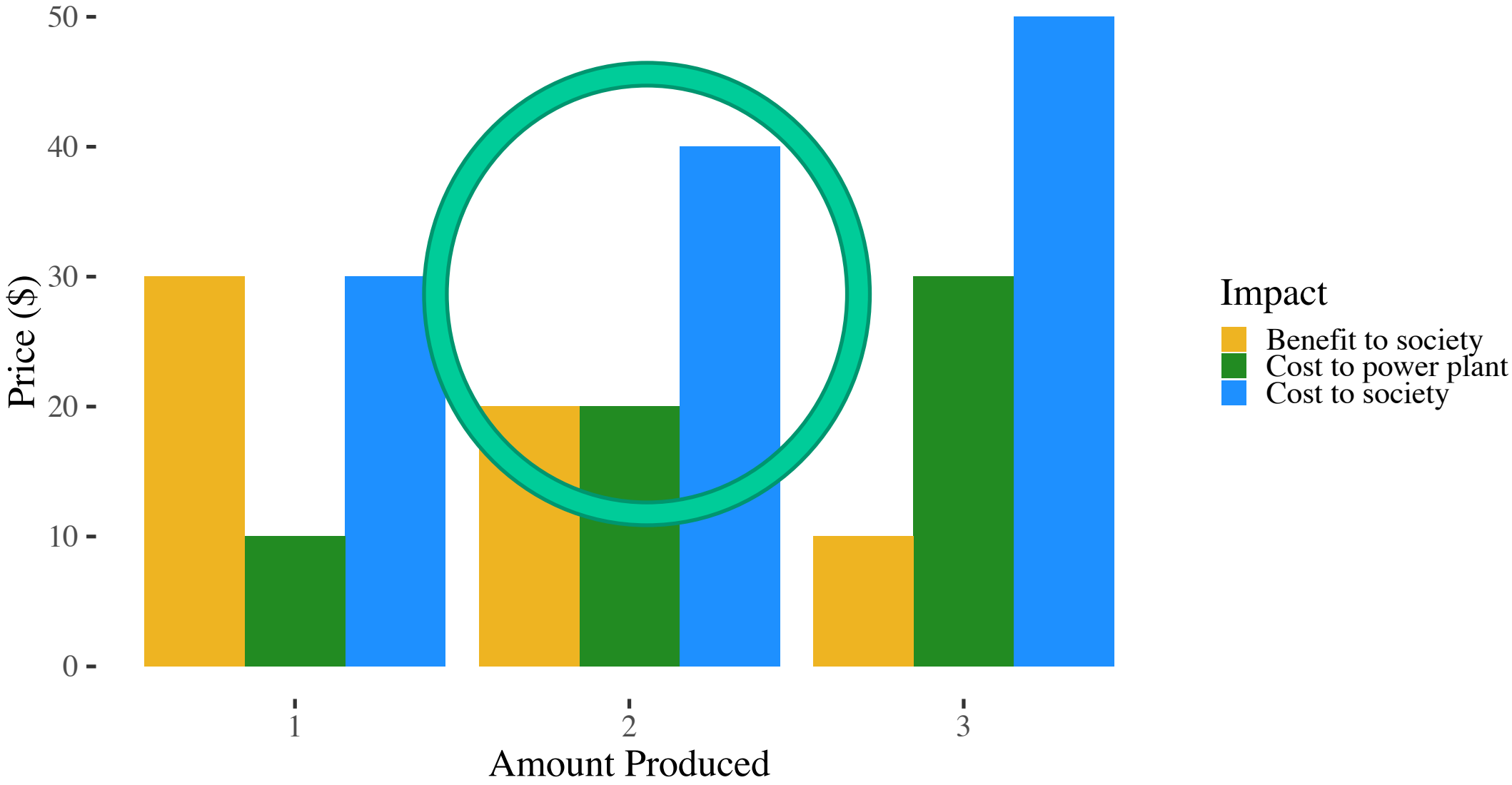


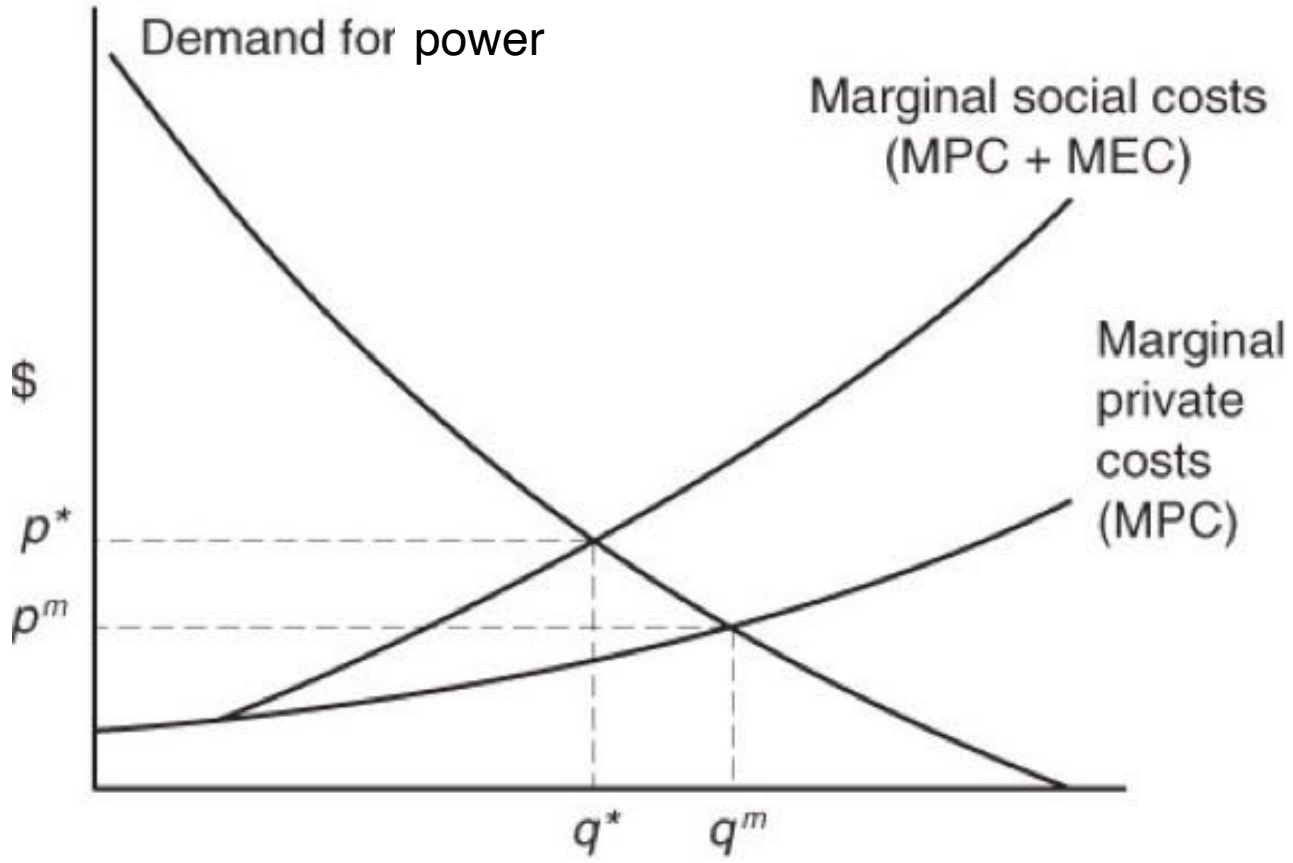
# The power plant in this example is offloading some of its costs on to the city - it isn't paying the full price.



# Because the power plant only makes decisions based on the costs it pays, this means that society suffers.



# Market Failure



# "… the greatest market failure"

- Impacts large (affecting the entire planet!)
- Distance between actor and effect immense
  - Cross country (most damages fall outside own country)
  - Intergenerational (most people affected by current activities not yet born)
- Reflects billions of decisions everyday, so no individual acting alone can slow emissions

# Global institutions to correct global externality do not exist

- Existence of an important market failure requires government intervention to correct
- But for this to work with a global externality, we would need a global authority to impose the solution on everyone
- These institutions don't exist
- Countries acting on their own only have incentive to "internalize" the damages they create that fall on themselves

# Climate Damages

# Traditional Approach

- **Damage $D_t$ is approximated as a quadratic function of temperature**

$$D_t = a_0 + a_1 T_t + a_2 T_t^2 + f_1\big(SLR(t)\big) + f_2(CO_2\ fertilization)$$

- **The basic assumption is that the damages from gradual and small climate changes are modest, but that the damages rise non-linearly with the extent of climate change.**
- **These estimates also assume that the damages are likely to be relatively larger for poor, small and tropical countries than for rich, large and mid-latitude countries (comes from regional aggregation).**

# Key impacts

Managed systems

- **Farming**
- **Health risks**

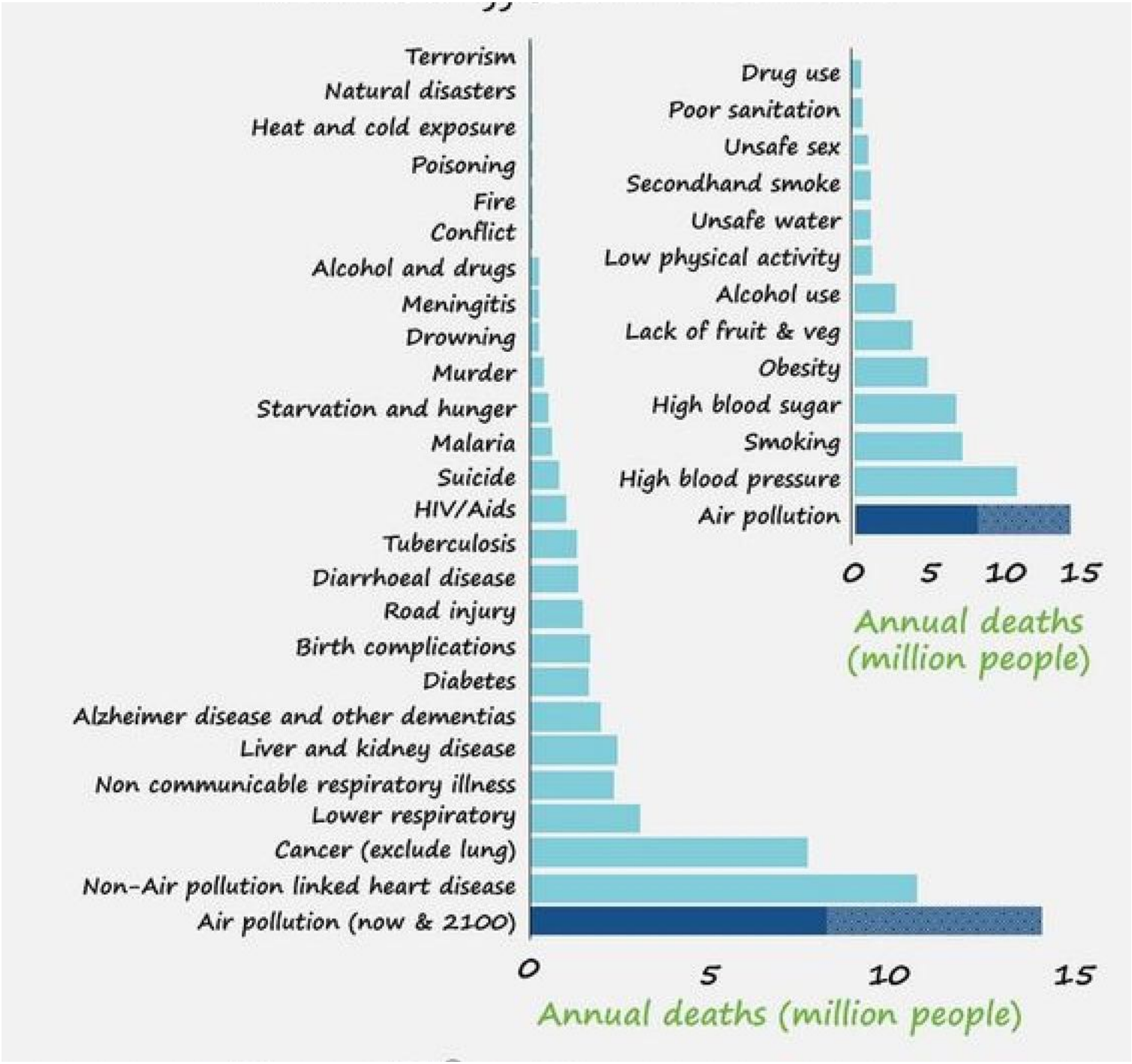
Unmanaged systems

- **Rising sea levels**
- **Ocean acidification**
- **Hurricane intensification**
- **Damage to wildlife and natural ecosystems**

Managed systems benefit more from adaptation and technological change

# Health Costs

Fossil fuel-led air pollution, caused by the particulate matter from combustion, is already a top 3 cause of death across the world. Make no changes to the energy system and it will become the biggest killer in the world.




# Deadly Pollution

**Air pollution from burning coal, oil, and gas already kills more than 7 million people every year (worse than COVID)**

**Projected to be the #1 killer (exceeding cancer or heart disease) by 2100**

Hampshire-Waugh 2021
Net-Zero Blog

# Extreme Damages?

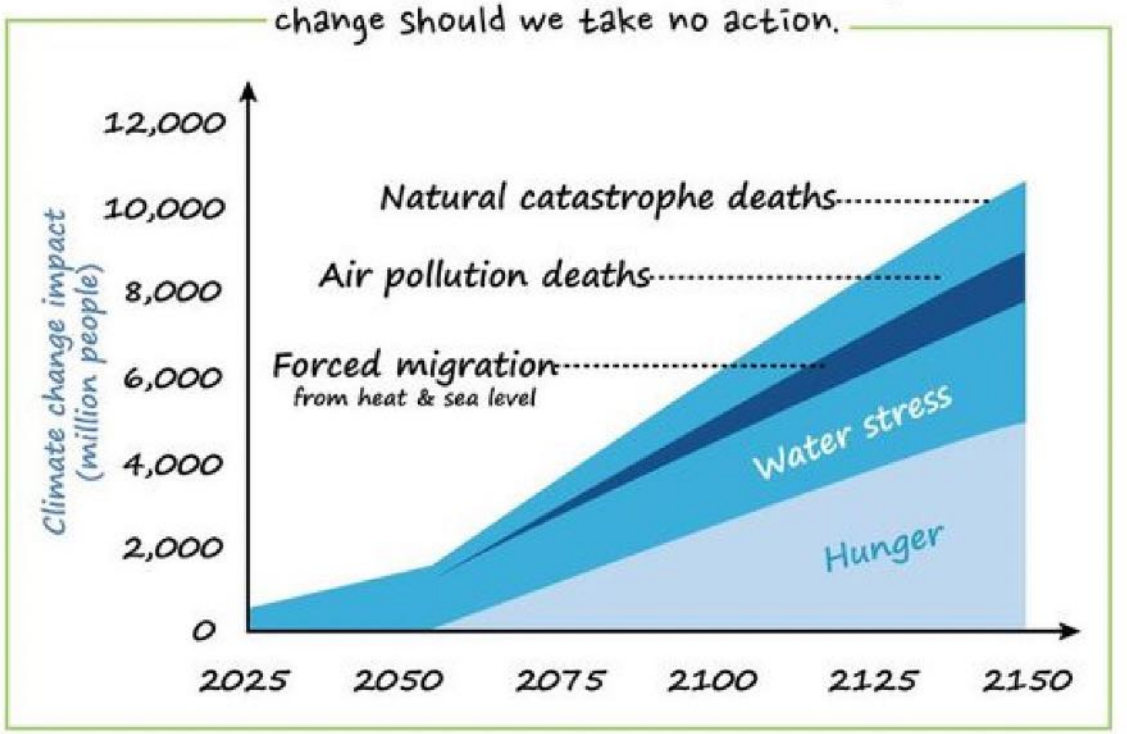
A few economists have considered much more extreme damages from unmitigated climate change

- Catastrophic financial collapse resulting from many trillions of dollars in stranded assets (e.g., fossil fuel reserves, coastal real estate)
- Hundreds of millions of refugees (especially from rising seas)
- Collapse of the global food system
- Social unrest, war, famine
- **Stuff like this violates basic economic assumptions of marginal change!**

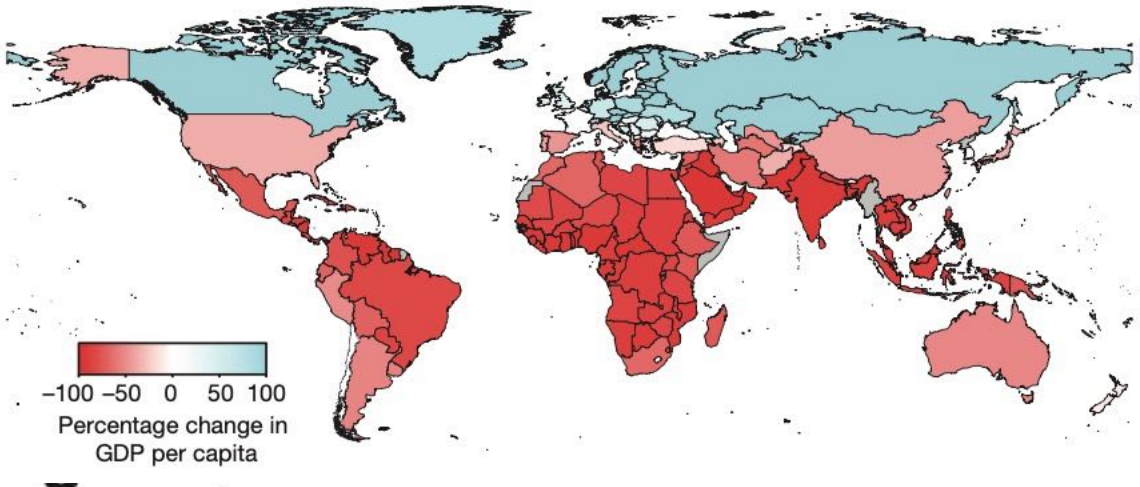
# Affects Everyone

- As damages mount, they build on one another
- Social effects of compounding damage spread across regions
- Eventually, the whole population of the world is impacted

Hampshire-Waugh 2021
Net-Zero Blog

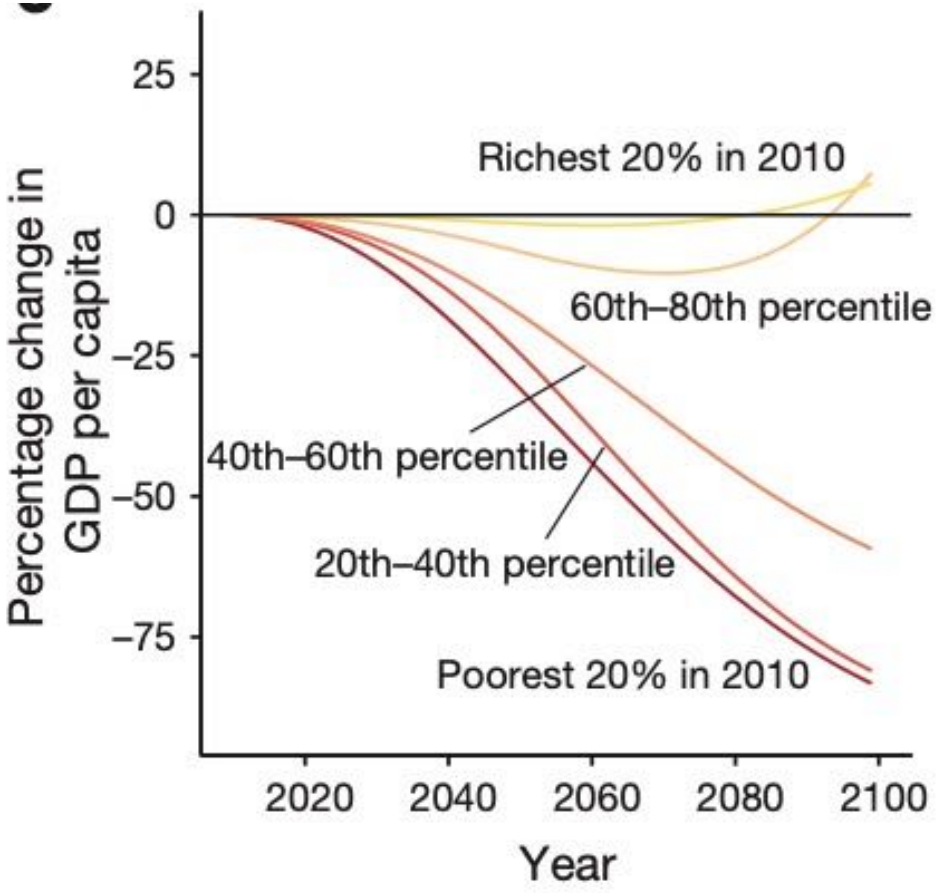


# Uneven Damges



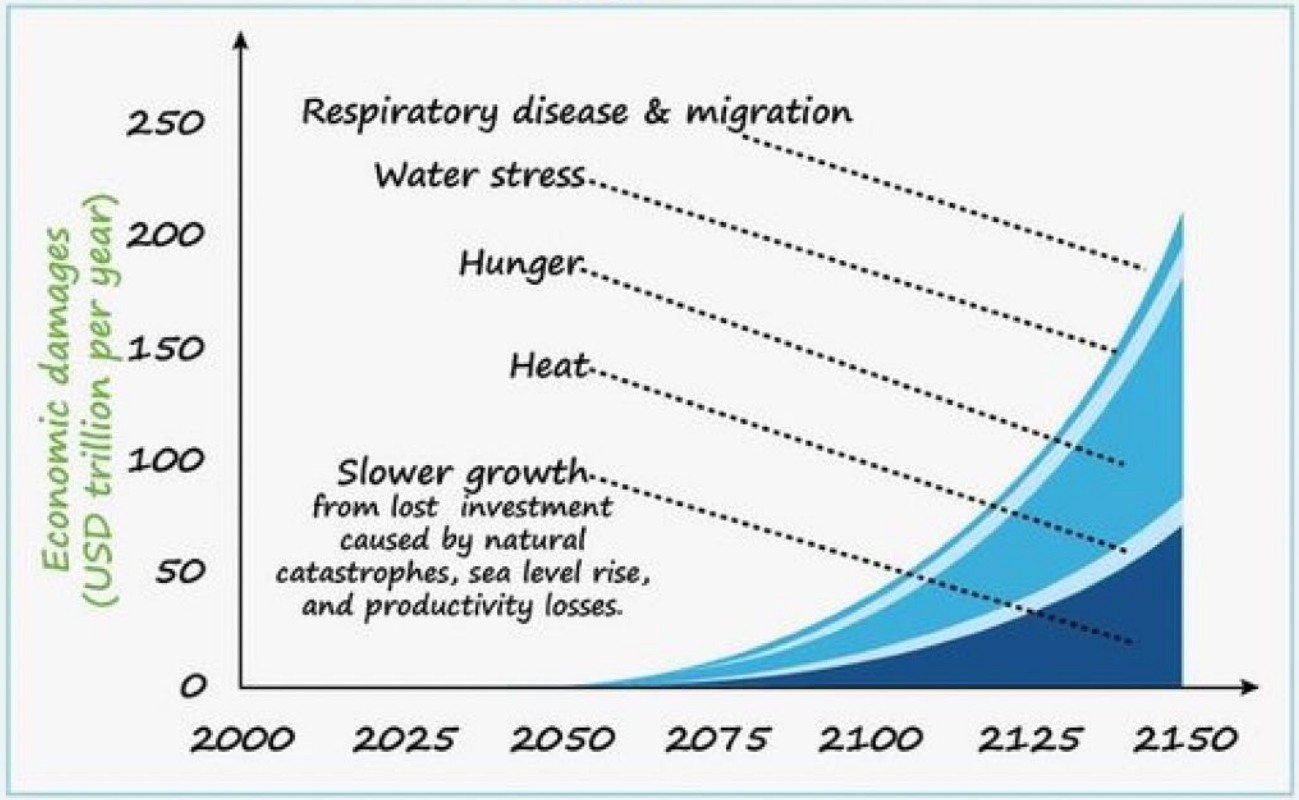

## Global non-linear effect of temperature on economic production

Marshall Burke[1,2]*, Solomon M. Hsiang[3,4]* & Edward Miguel[4,5]




- Burke et al (2015) estimate losses of about 25% of global GDP by 2100
- Dramatically worse in the global south
- Poorest 40% of humanity would lose 75% of per-capita income by 2100 under RCP 8.5

The damage to infrastructure, homes, and industry coupled with job losses, reduced productivity, and poor health will increase faster than incomes.

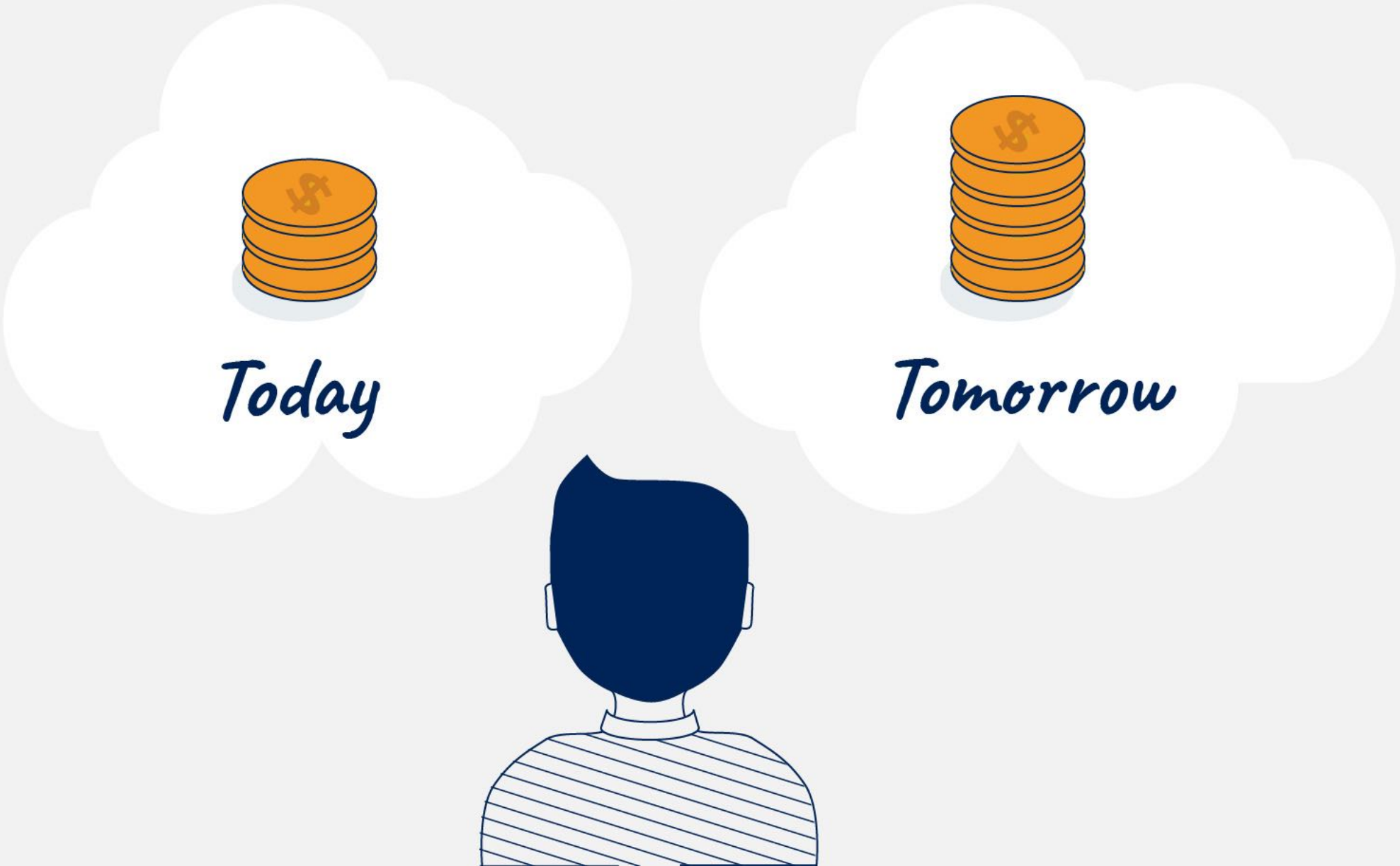



# Reversal of Fortune?

**If damages rise faster than income, climate change could bring about the end of the unprecedented rise in human flourishing that began with the industrial revolution**

Hampshire-Waugh 2021
Net-Zero Blog

# Discounting the Future



# Time in cost benefit analysis

- How should we “add up” costs and benefits that occur at different points in time?
  - For example, how to compare policy costs incurred today with environmental benefits that occur ten years from now?  100 years from now?

# Present Value

- **Compound Interest**
  - Suppose you put $613.90 in the bank today and the interest rate is 5%. How much will be in the account in 10 years? (answer = $1000)

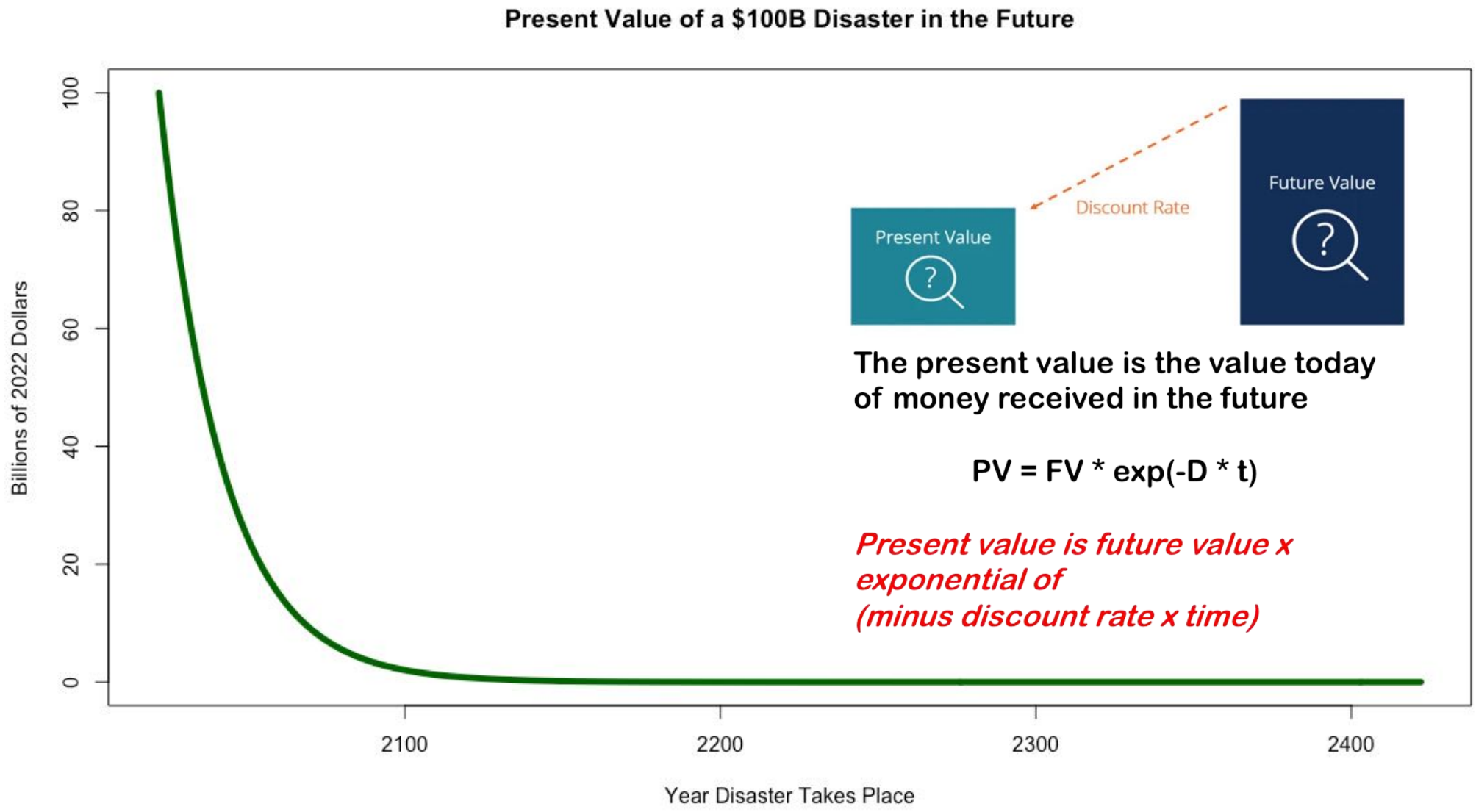

The present value is the value today of money received in the future

- **Discounting**
  - What is the present value of $1000 received in 10 years if the interest rate is 5%? (answer = $613.90)

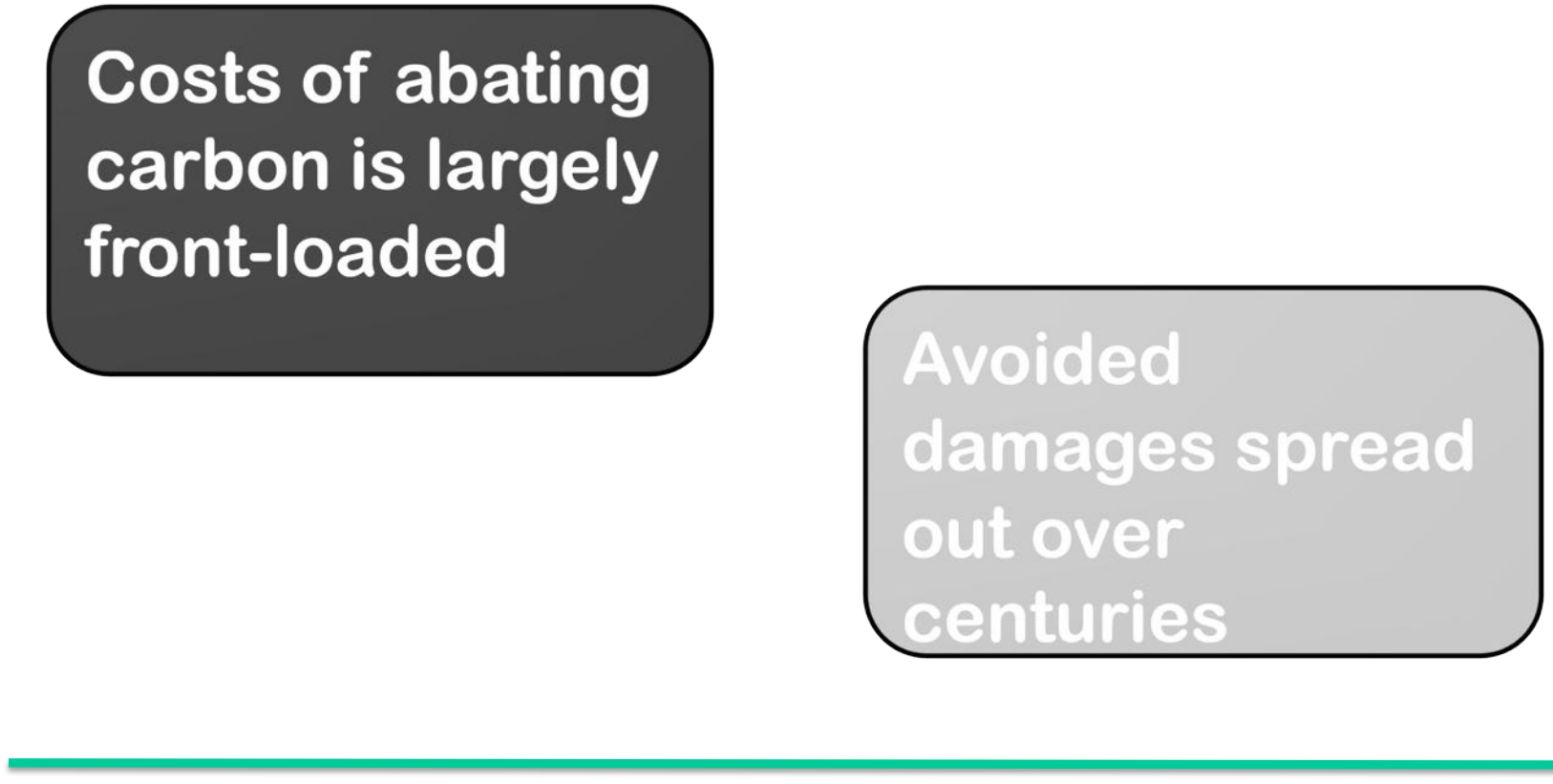
$$PV = FV * \exp(-D * t)$$

***Present value is future value x exponential of (minus discount rate x time)***

# Discounting the Future



# Key Feature of Climate Economics



# Present Value of Damages

Damage = $1 billion

- If discount rate is 5.5%/yr, what is present value of $ 1 billion in 100 years?

$4 million

# Present Value of Damages

Damage = $1 billion

- If discount rate is 5.5%, what is present value of $ 1 billion in 200 years?

$17,000

# Present Value of Damages

Damage = $1 billion

- If discount rate is 5.5%/yr, what is present value of $ 1 billion in 400 years?

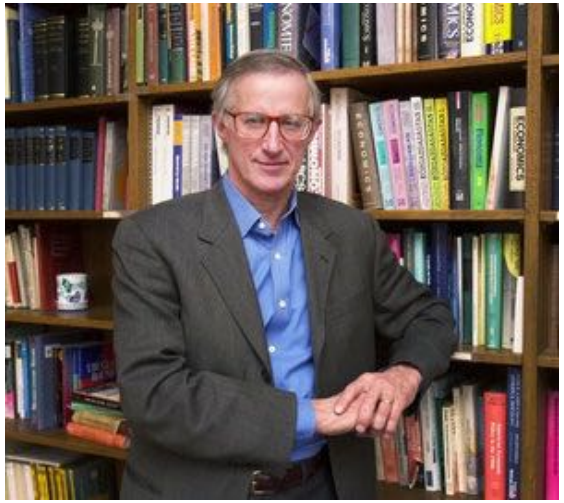
$0.28

# Discount Rates?
# Nordhaus vs Stern

- Climate change can be managed by *gradual emission cuts* with warming ~2x Paris targets

- Climate change threatens to end centuries of economic progress & development, plunging most of humanity into poverty. *Drastic emission cuts ASAP!*

William Nordhaus



- **Main source of the difference:**
  - The discount rate!
  - Nordhaus argued for 5.5% from market data;
  - Stern argued on ethical grounds that the appropriate discount rate is about 1.4%

Nicholas Stern

# Social Cost of Carbon

**estimates the external cost associated with emissions that should be used to set carbon price (tax)**

# Cost benefit analysis for climate change

- Traces links between avoided emissions and corresponding reductions in current and future damages
- To do this, need to aggregate across many categories of damages
- Need to project implications of emissions on time path of future concentrations, temperatures and damages
- Add up damages over long periods of time

Integrated Assessment Models do this

# Integrated Assessment Models

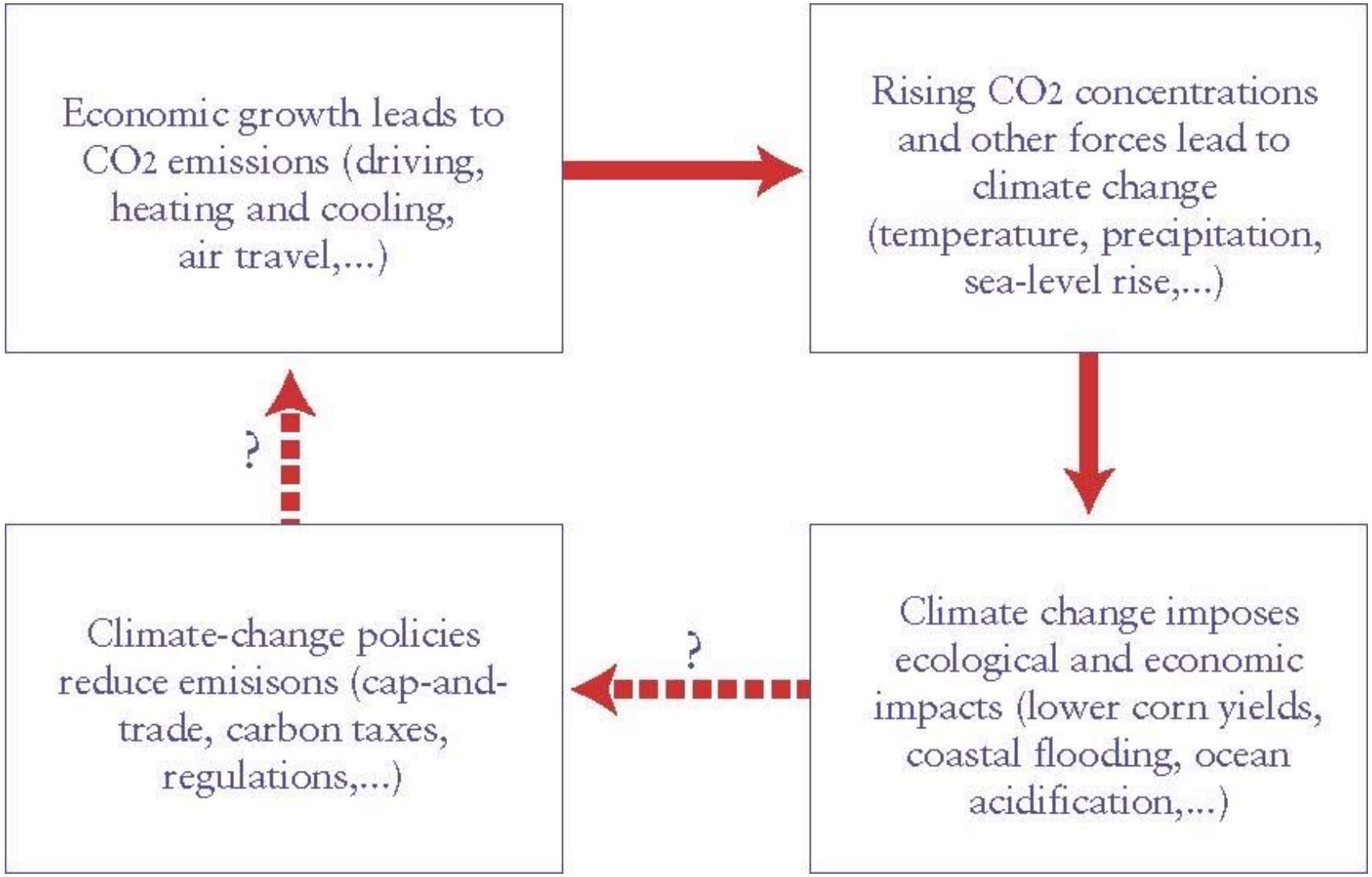



*Figure 1.* The circular flow of global warming science, impacts, and policy.

From "Climate Casino"

# Components of an Integrated CC Assessment

Mitigation Policy

Population, technology, production, consumption

Emissions

Atmospheric concentrations

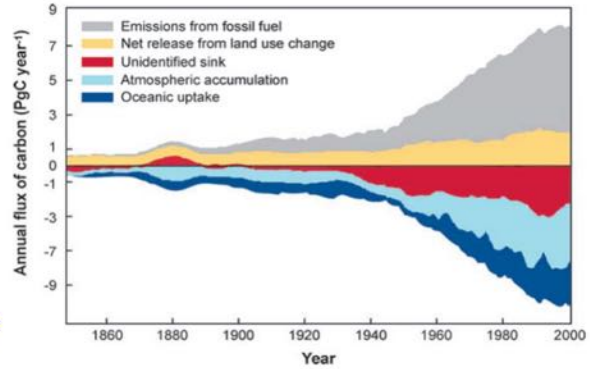
Radiative forcing

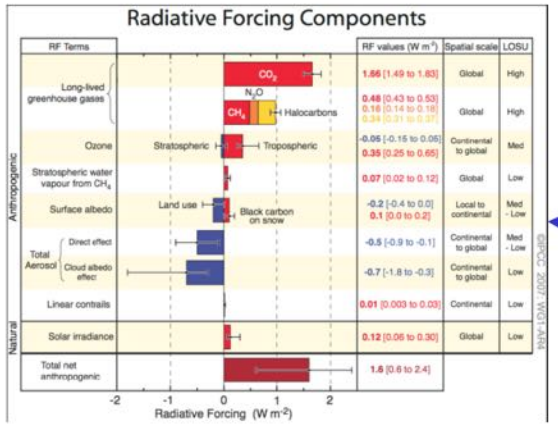
Temperature rise and global climate change

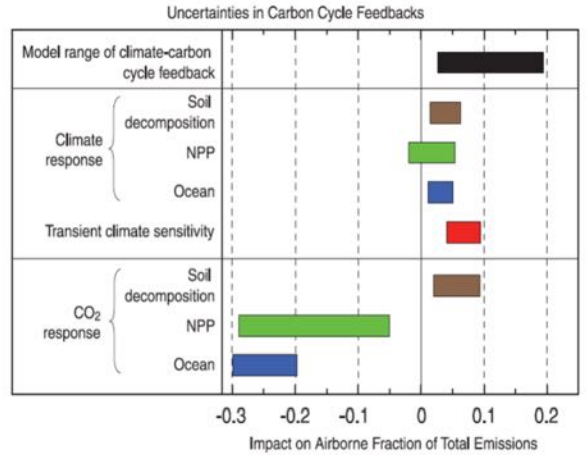
Direct impacts (e.g. crops, forests, ecosystems)

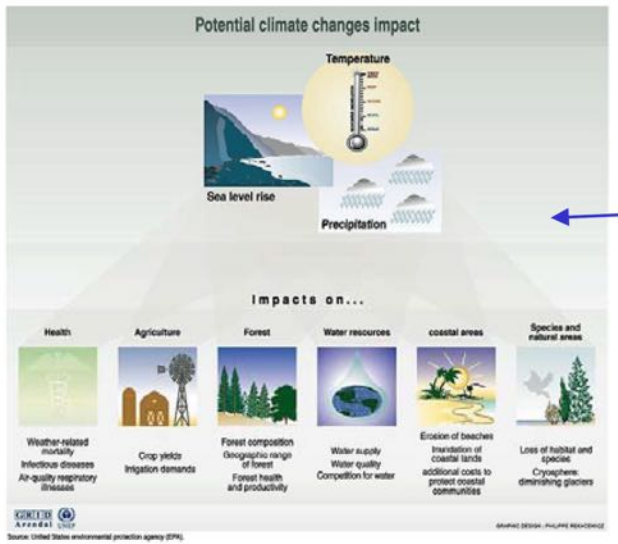
Socio-economic impacts

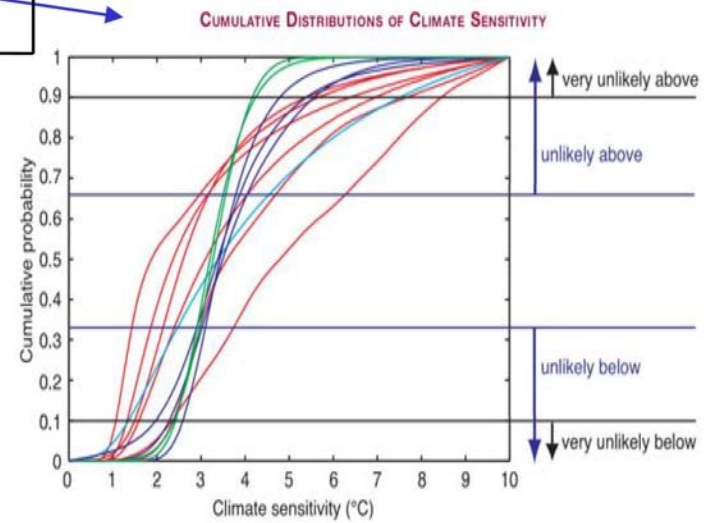
Feedbacks



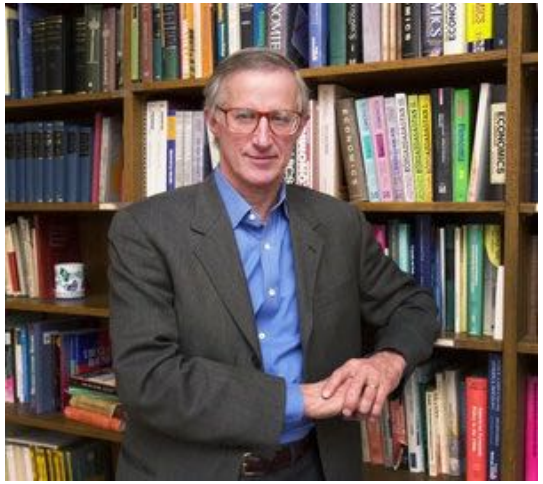



# Dynamic Integrated Model of Climate & the Economy (DICE)



Yale Economist William Nordhaus

- **DICE applies an "optimal" carbon tax to slow $CO_2$ emissions a bit**

- **Resulting warming is a little less than IPCC RCP8.5, but not by much (4 °C and rising fast in 2100)**

**Nordhaus (2017) PNAS**

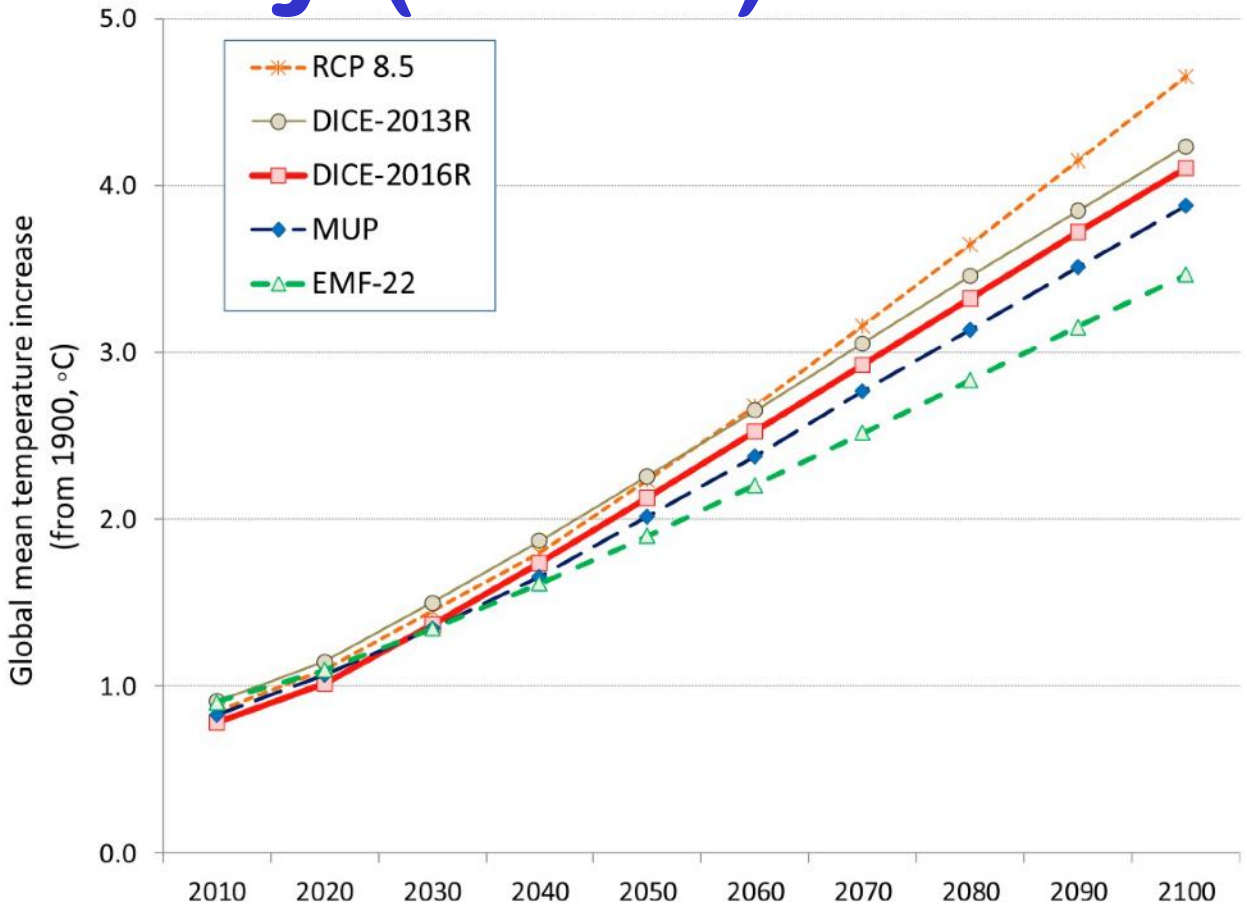



**Fig. 2.** Global mean temperature increase as projected by IPCC scenarios and integrated assessment economic models. The figure compares the projections of the most recent DICE models, the IPCC RCP high scenario (RCP 8.5), and two model comparison exercises.

# Huge Range of Estimates!

**Table 1. Global SCC by different assumptions**

| Scenario | Assumption | 2015 | 2020 | 2025 | 2030 | 2050 |
|---|---|---|---|---|---|---|
| Base parameters | | | | | | |
| | Baseline* | 31.2 | 37.3 | 44.0 | 51.6 | 102.5 |
| | Optimal controls† | 30.7 | 36.7 | 43.5 | 51.2 | 103.6 |
| 2.5 degree maximum | | | | | | |
| | Maximum† | 184.4 | 229.1 | 284.1 | 351.0 | 1,006.2 |
| | Max for 100 y† | 106.7 | 133.1 | 165.1 | 203.7 | 543.3 |
| *The Stern Review* discounting | | | | | | |
| | Uncalibrated† | 197.4 | 266.5 | 324.6 | 376.2 | 629.2 |
| Alternative discount rates* | | | | | | |
| | 2.5% | 128.5 | 140.0 | 152.0 | 164.6 | 235.7 |
| | 3% | 79.1 | 87.3 | 95.9 | 104.9 | 156.6 |
| | 4% | 36.3 | 40.9 | 45.8 | 51.1 | 81.7 |
| | 5% | 19.7 | 22.6 | 25.7 | 29.1 | 49.2 |

The SCC is measured in 2010 international US dollars.

Nordhaus (2017) PNAS

# Social Cost of Carbon

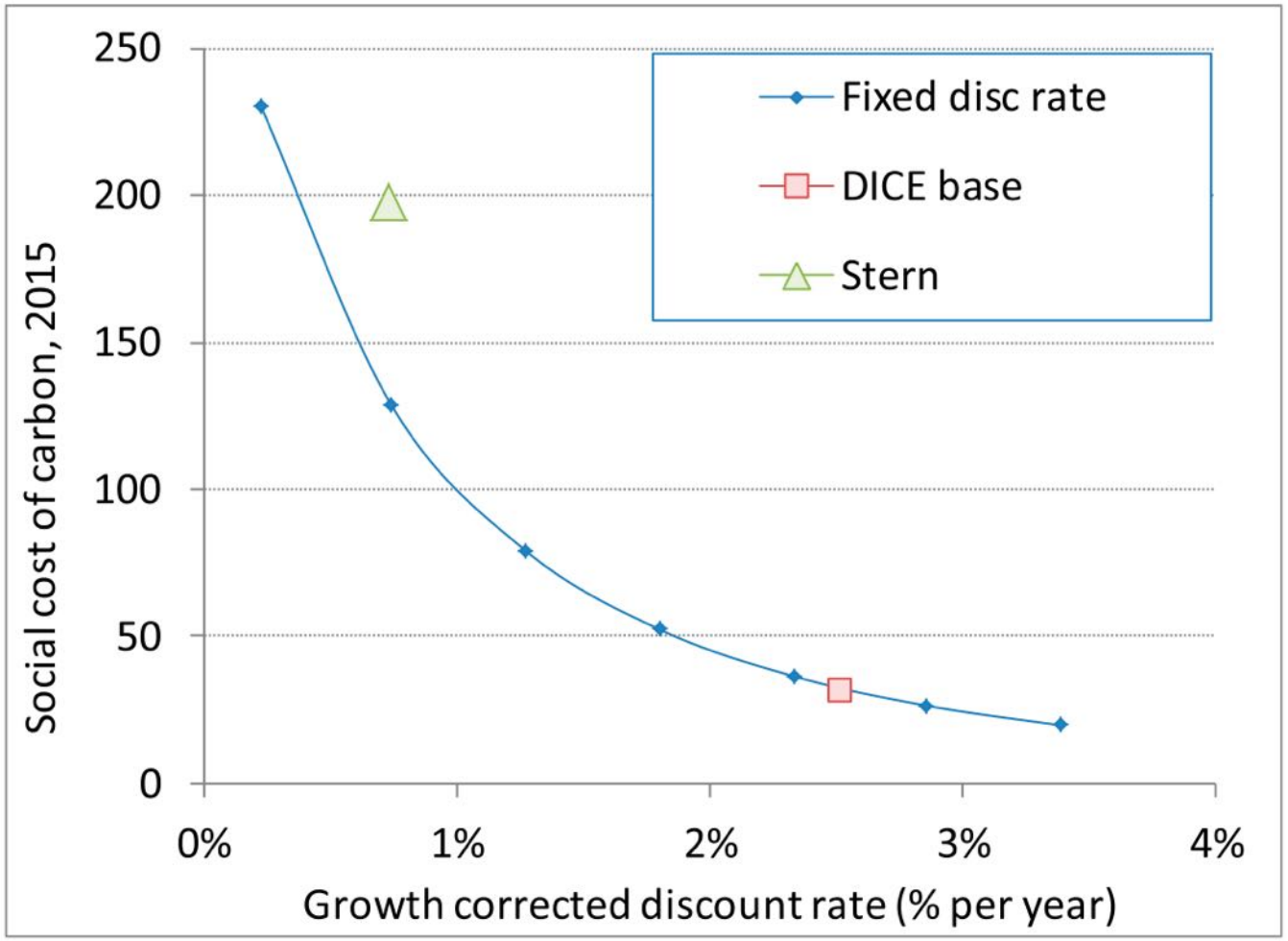



**Fig. 3.** Social cost of carbon and growth-corrected discount rate in DICE model. The growth-corrected discount rate equals the discount rate on goods minus the growth rate of consumption. The solid line shows the central role of the growth-corrected discount rate on goods in determining the SCC in the DICE model. The square is the SCC from the full DICE model, and the triangle uses the assumptions of *The Stern Review* (10). A further discussion and derivation of the growth-corrected discount rate is given in *Supporting Information*.

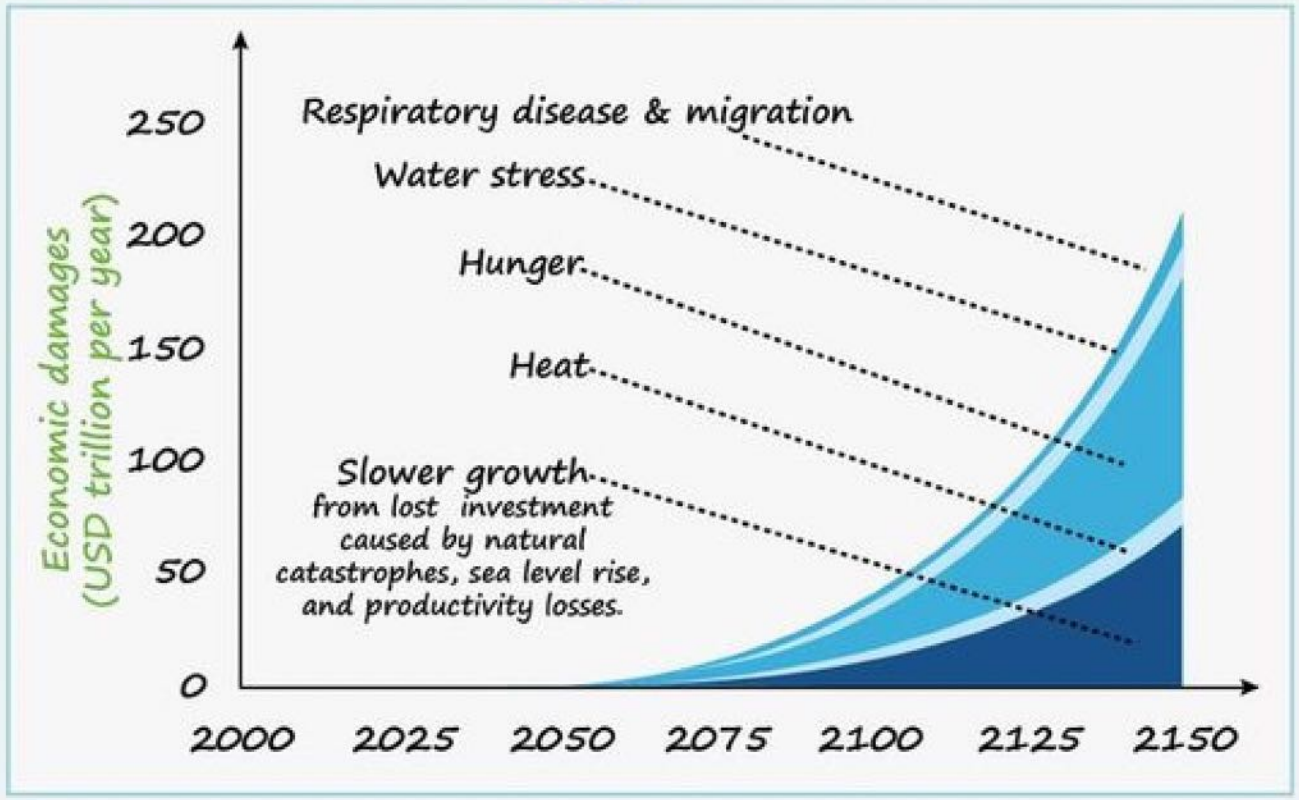
- **Assumptions about the discount rate are the master parameter in estimating the social cost of carbon**
- **It's so influential that other assumptions in the models hardly matter at all!**

**Nordhaus (2017) PNAS**

# Critiques of Climate Economics

See
“A Rant about Economist Pundits”
by David Roberts
@ volts.wtf

The damage to infrastructure, homes, and industry coupled with job losses, reduced productivity, and poor health will increase faster than incomes.

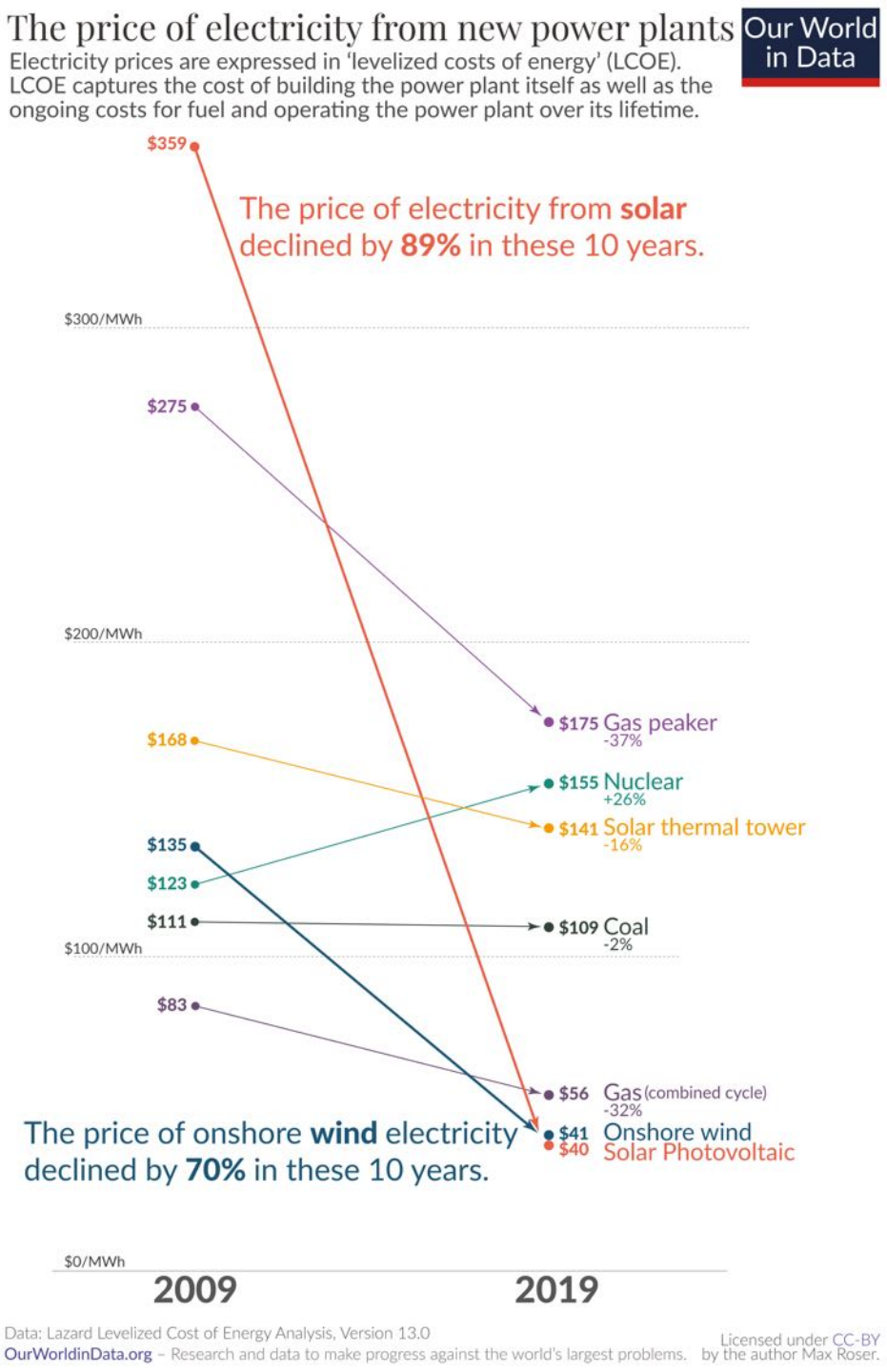



# Damages Badly Underestimated

- Damages may rise faster than income
- Climate change could bring about the end of the unprecedented rise in prosperity that began with the industrial revolution

# Technologically Naive

- Economists assume clean energy is extremely expensive
- They treat technology as an exogenous variable, something external that just happens, applied to models at a set rate
- The real world of energy costs today bears no resemblance to that of a decade ago.
- Clean energy is now the cheapest energy



# Intergenerational Discounting

- **Discount rates derived from short-term market** contexts are inappropriate to calculate the value of inter-generational goods.
- Fossil $CO_2$ and warming will persist for thousands of years
- **Trillions of people will be harmed** by emitting $CO_2$!

# Existential Risk

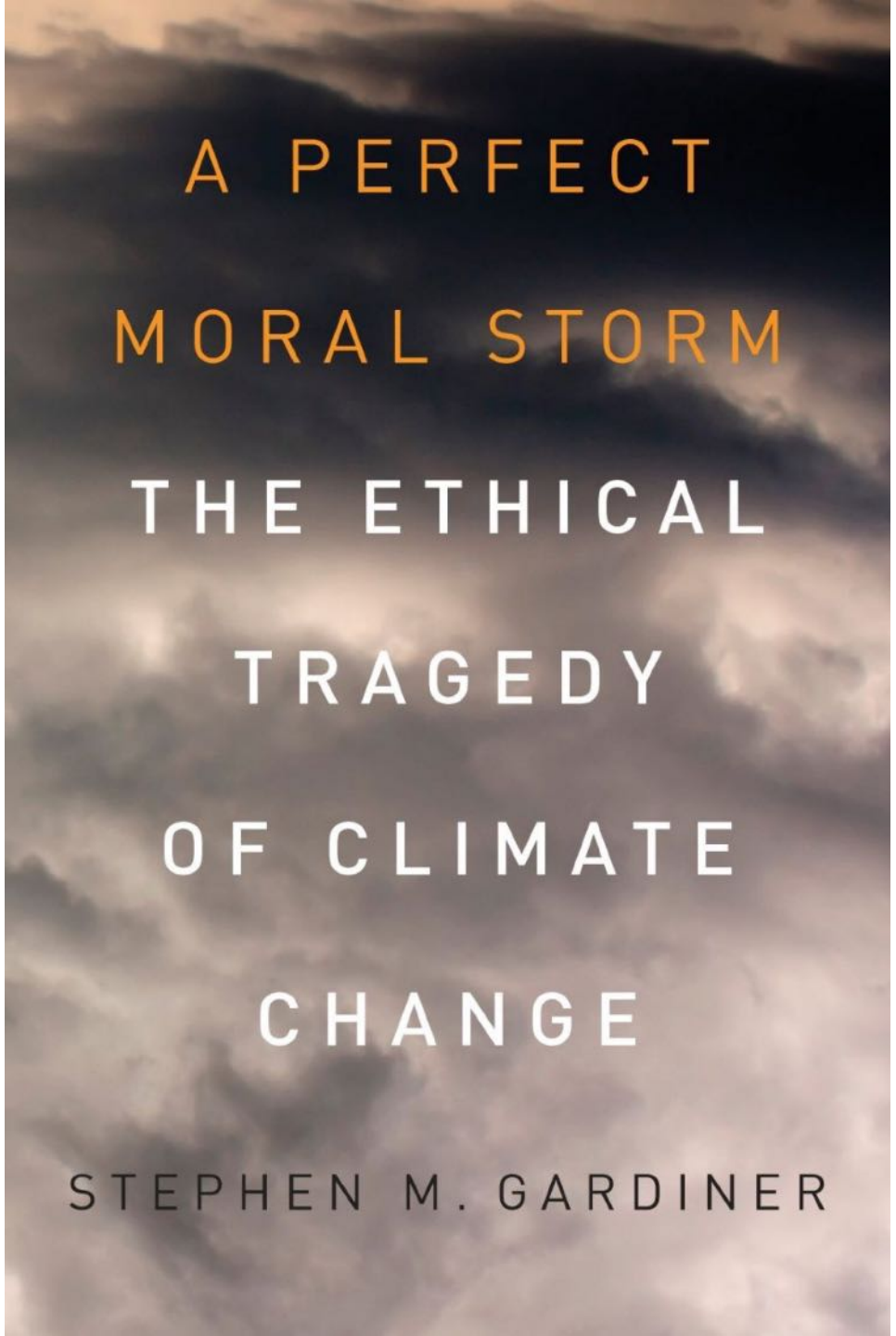
Nearly all economic analyses of climate change have failed to account properly for risk and uncertainty, especially for “long-tail risks:” low-probability outcomes with catastrophic consequences

# Marginal Analysis of a Transformational Problem

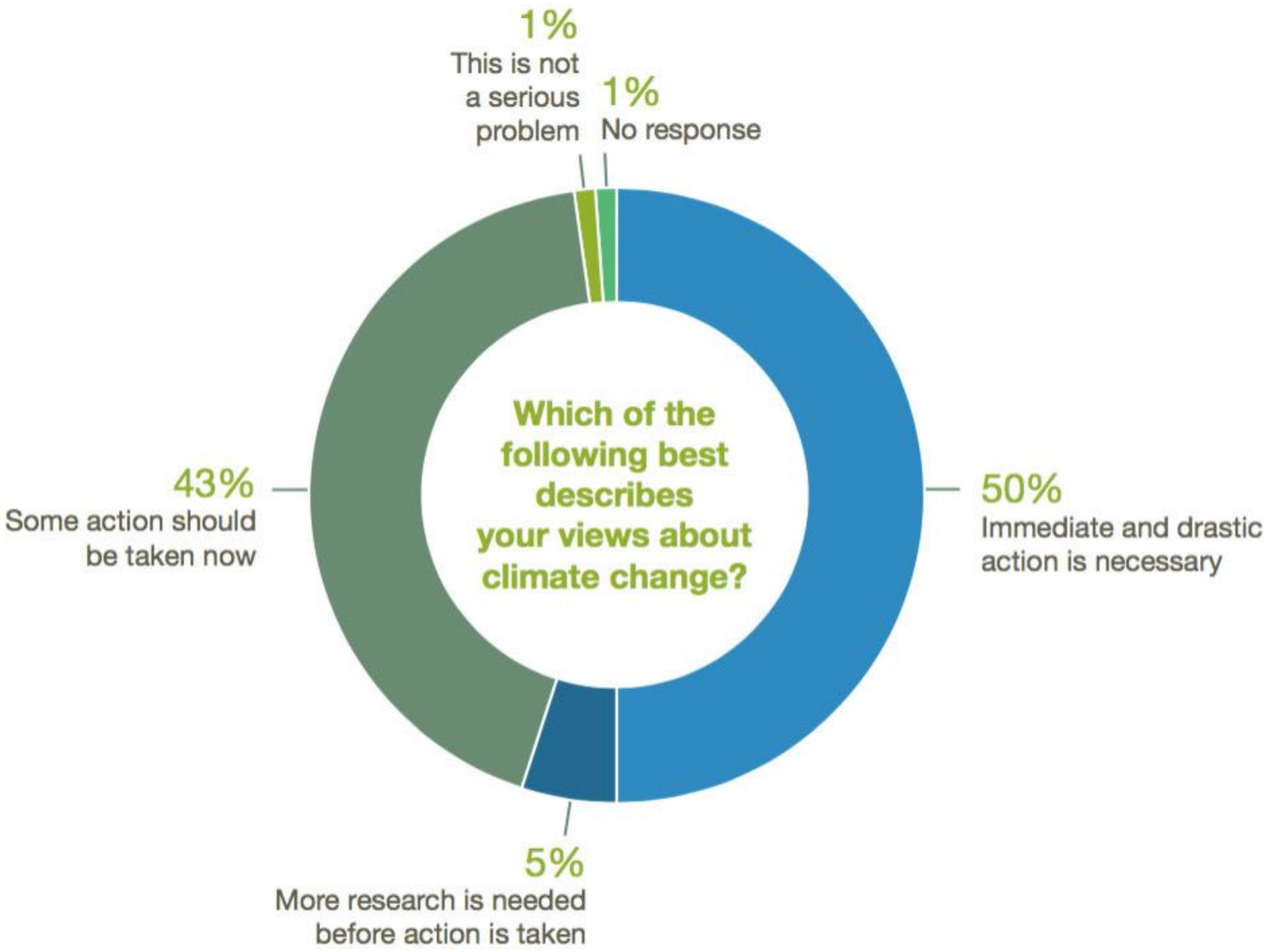
Economists assess the costs & benefits of wholesale sociotechnical transformation using utility functions designed to model changes at the margins of existing systems.

# Efficiency vs Ethics

- Obsession over optimally efficient policy in a way that ignores other values and trade-offs
- Climate econ offers radical value judgements disguised as calculations
- “Discounting” is a fancy way of saying “I don’t care about you”



# Do Something!




- Institute for Policy Integrity surveyed 365 economists who had published climate change research in top journals
- Nearly all of them prioritize climate solutions over inaction

Institute *for* Policy Integrity
NEW YORK UNIVERSITY SCHOOL OF LAW