Global Warming

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Econ/Demog c175

Week 5, Lecture A

Spring 2017

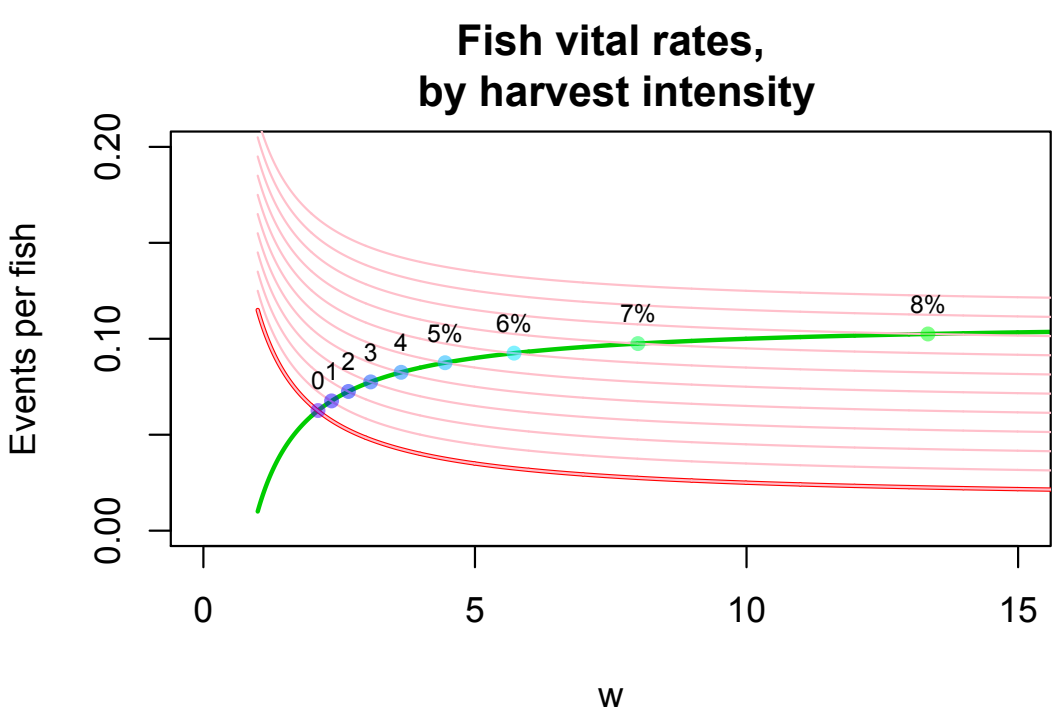
UC Berkeley

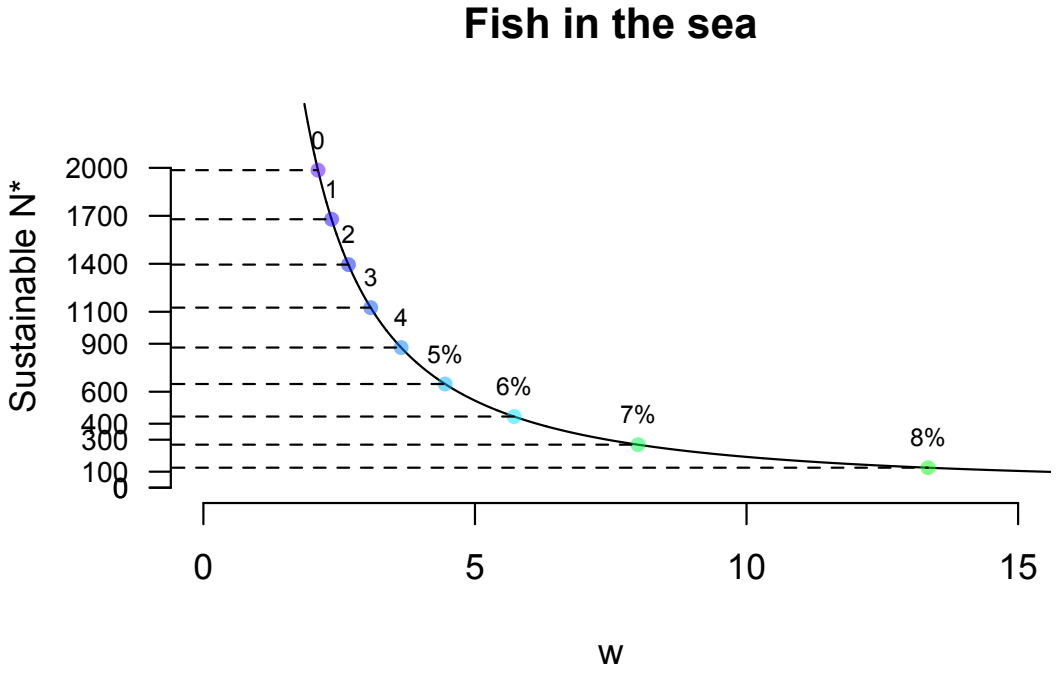
Agenda

- Tragedy of the commons : an iClicker fishing game
- The challenge of population increase and carbon emissions
- Strategies for controlling carbon emissions

Part 1
Fishing and the Tragedy of the Commons

Malthusian harvest simulation (review)





Sustainable fish population sizes

What is optimal harvest rate?

harvest *h* in percent	Sustainable pop N^* (*h*)	Total harvest H^*
0 %	2000	
1	1700	
2	1400	
3	1100	
4	900	
5	600	
6	400	
7	300	
8	100	
9	0	
10	0	

Our MMOG (Massively Multiplayer Online Game)

Your choice (eventually with iClickers, but not yet)

A. Abstemious fishing (h_i = 0%)
B. Moderate fishing (h_i = 5%)
C. Rapacious fishing (h_i = 10%)

We then compute h_{ave} = average(h_i) → to get sustainable equilibrium population N* of fish

The nature of the commons

- Sustainable fish population size depends on everyone's choices
- Your harvest depends mostly on your own choice
- What do I mean by "mostly"?

Let's play
(copy this table on a piece of paper)

Round	h_i	h_{ave}	$N^*(h_{ave})$	H_i (= $N^*(h_{ave}) \times h_i$)
1				
2				
3				
4				
5				

Round 1: Everyone choose

A. Abstemious fishing (h_i = 0%)
B. Moderate fishing (h_i = 5%)
C. Rapacious fishing (h_i = 10%)

Let's use iClicker results to calculate h_{ave}
and then look up sustainable fish pop $N^*(h_{ave})$

Now calculate your own "catch", H_i
(who won?)

sustainable fish population sizes

h_{ave} in percent	$N^*(h_{ave})$ available per fisher
0 %	2000
1	1700
2	1400
3	1100
4	900
5	600
6	400
7	300
8	100
9	0
10	0

Round 2: Let’s repeat and see if we get same result

Round 3: Live tally

Round 4
(act as if you were going to be graded on your catch)

Round 5: Social Planner

- Choose whatever you want
- Then I will regulate fishing so that average is about 4%
- Who is better off?

Summing it up

- Tragedy of the commons: individual incentives not compatible with sustainability
- We can impose a solution (via institutions and regulation)
- Why is market solution of “privatization” not practical here?

Hardin's language

"Mutual Coercion,
Mutually Agreed Upon"

Part 2
Population growth and global warming

The role of population

- Population as a “cause” of global warming

- Ehrlich’s formulation: “I-PAT”

Impact = Pop * Affluence * Technology

- What is effect of changing Pop on impact?

(Take the derivative)

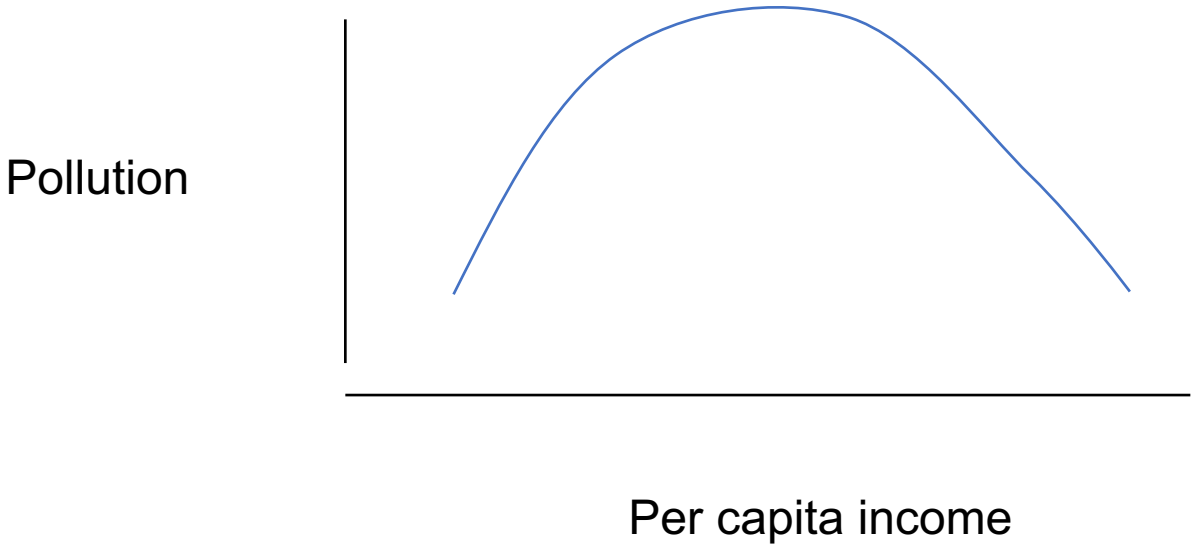
- Indirect effects? Malthus, Boserup

Population as a cause

- Changing population may also change other factors …

- For Malthus increase P, decreases A
- For Boserup increase P, improves T
- (Kuznitz sees increasing A eventually improving T)

Kuznitz curve (in theory)



At lower income people would rather produce and consume more, so pollution rises with income. At higher incomes they are willing to pay to have cleaner environment

In practice

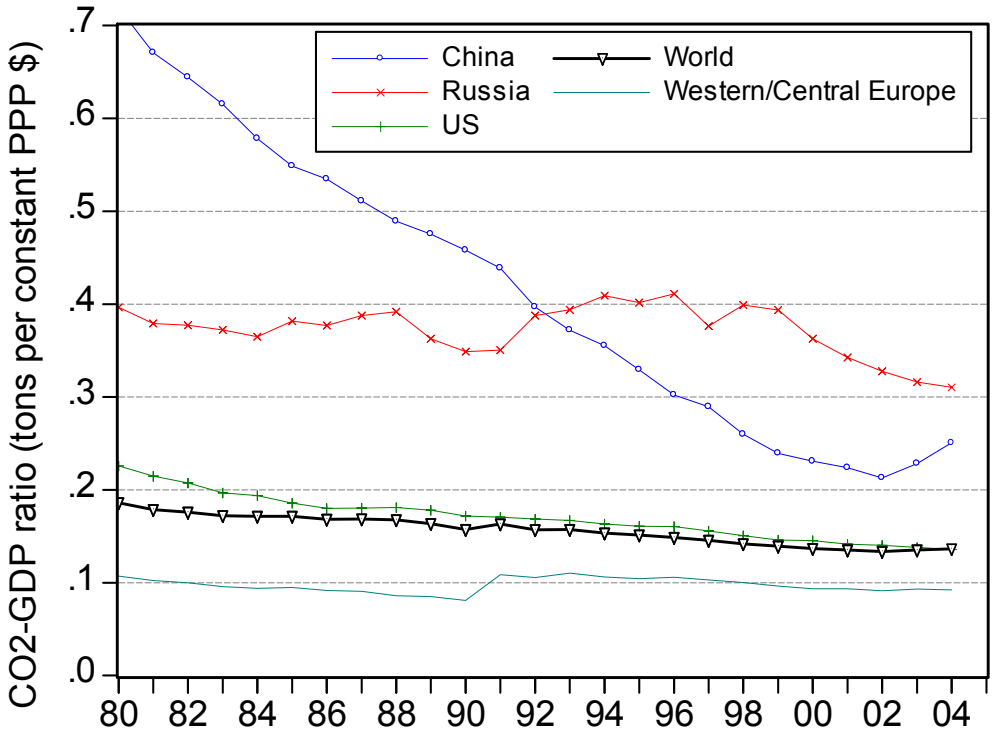


Figure III-1. Historical ratios of CO_2 emissions to GDP for major regions and globe

Source: Nordhaus

Transitions

- Energy transition

  "organic" economy to "carbon" economy to "low-carbon" economy

- Demographic transition

  Still many decades of growth, primarily in developing world

- Political transition

  Nations have regulated individuals but who will regulate nations?

Accounting rather than causality

Carbon emissions =

carbon/ person * number of people

We know what's happening over time to population.

Dyson looks at how emissions need to change

Dyson's business-as-usual scenario

Region	Population N(2000)	N(2050)	c(2000) Tons of carbon per capita	c(2050)	C(2000) Billion tons of carbon	C(2050)
Developing	5 billion	8 billion	2	2	10	16
Developed	1.1 billion	1.1 billion	12	12	13	13
Total	6.1	9.1			23	29

With your partner,

- What percent does population increase
- What percent does carbon emissions increase
- Are these numbers the same? If not, why?

Dyson's optimistic scenario

Region	Population N(2000)	N(2050)	c(2000) Tons of carbon per capita	c(2050)	C(2000) Billion tons of carbon	C(2050)
Developing	5 billion	8 billion	2	2	10	16
Developed	1.1 billion	1.1 billion	12	12 * .6 = 7.2	13	7.5
Total	6.1	9.1			23	23.5

Assume rich countries can reduce per capita C02 by 40%
Result is roughly constant global emissions.

Note: Obama agreement with China has US reducing total emissions by 26-28 % by 2025, so 40% reduction by 2050 not implausible.

Dyson's realistic scenario

Region	Population N(2000)	N(2050)	c(2000) Tons of carbon per capita	c(2050)	C(2000) Billion tons of carbon	C(2050)
Developing	5 billion	8 billion	2	2* 2 = 4	10	32
Developed	1.1 billion	1.1 billion	12	12 * .6 = 7.2	13	7.5
Total	6.1	9.1			23	~ 40

Assume rich countries can reduce per capita C02 by 40%
Developing countries double C02 per capita
Result is that global emissions nearly double (close to 40 rather than close to 20).

Dyson's conclusions

- Pop growth puts upward pressure on global emissions
- Increase in emissions in developing world easily overwhelms savings in rich world
- Hard to imagine a global reduction

Part 3
Strategies for controlling carbon

Strategies for controlling carbon

1. Let each country decide on its own

2. Global agreements

3. Climate clubs?

Letting each country decide on its own

- Decision is on carbon tax
- But tax is costly in terms consumption
- Incentive is to have low or no tax
  → Tragedy of the Commons
- Best outcome for a country: don't tax yourself, but gain from low emissions by others ("free riding")

Global Agreements

1. Kyoto 1997
   (everyone agreed to keep Carbon emissions at 5% below 1990 level)
   → But USA pulled out
2. Copenhagen 2009 (also non-binding, no penalties)
3. Paris 2015 (also non-binding, no penalties)

- Problem is that there is little or no sanction
- First free rider does little harm to world, gets huge benefit (but this snowballs)

Climate Clubs?

- An example is USA-China agreement under Obama (in 2014)
- They both agree to reduce emissions, with tacit improvement in mutual relationship (e.g. trade)
- Now imagine that we have “clubs”
  - “dues” are limiting carbon
  - benefit is tariff-free trade within the club

Are clubs “stable”

- If someone defects, what happens?

- Countries join because of self-interest, not altruism

  cost of belonging < cost of not
  carbon tax cost < tariff cost

- Challenge is getting a critical mass to start the clubs (e.g., China + USA +Germany)

Nordhaus's model

- A climate model:

  emissions → warming

- An economic model for

  warming → economic costs

  carbon tax → emissions behavior

  carbon tax → loss of consumption

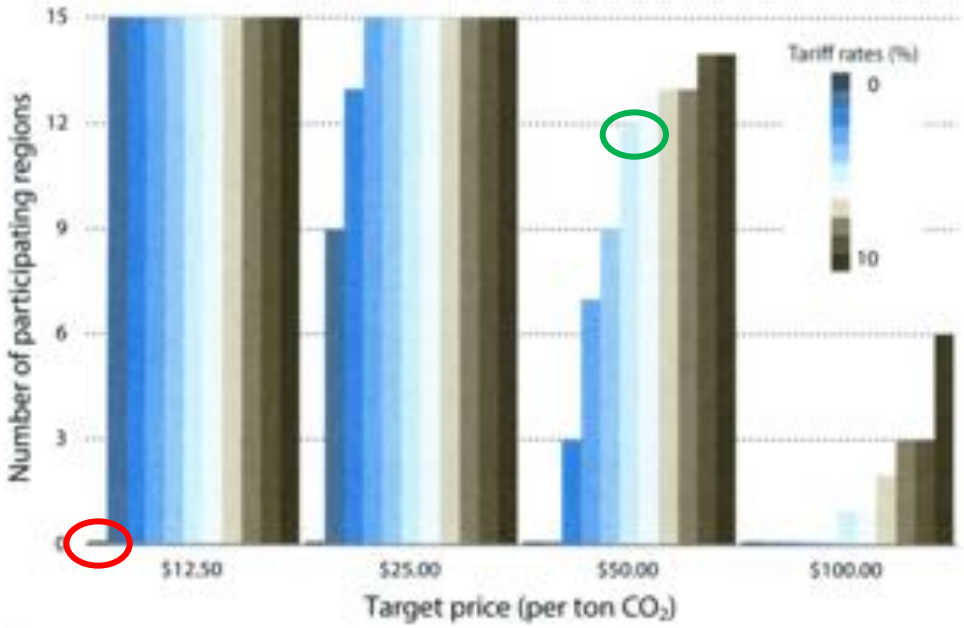
- A game-theory model for

  strategic tit-for-tat of club-membership

Nordhaus's results

FIGURE 1

Number of participating regions by international target carbon price and tariff rate



This and Figure 2 have the following structure: The four sets of bars are the model results for four different international target carbon prices, running from left to right as shown on the bottom. The eleven bars within each set are the penalty tariff rates, running from 0% to 10%. Note that each set has zero participants for a 0% tariff. The vertical scale here is the number of participants. These results are based on the author's C-DICE (Coalition-DICE) model. For the source, see Nordhaus, "Climate Clubs" in the recommended reading.

What would happen to the climate?

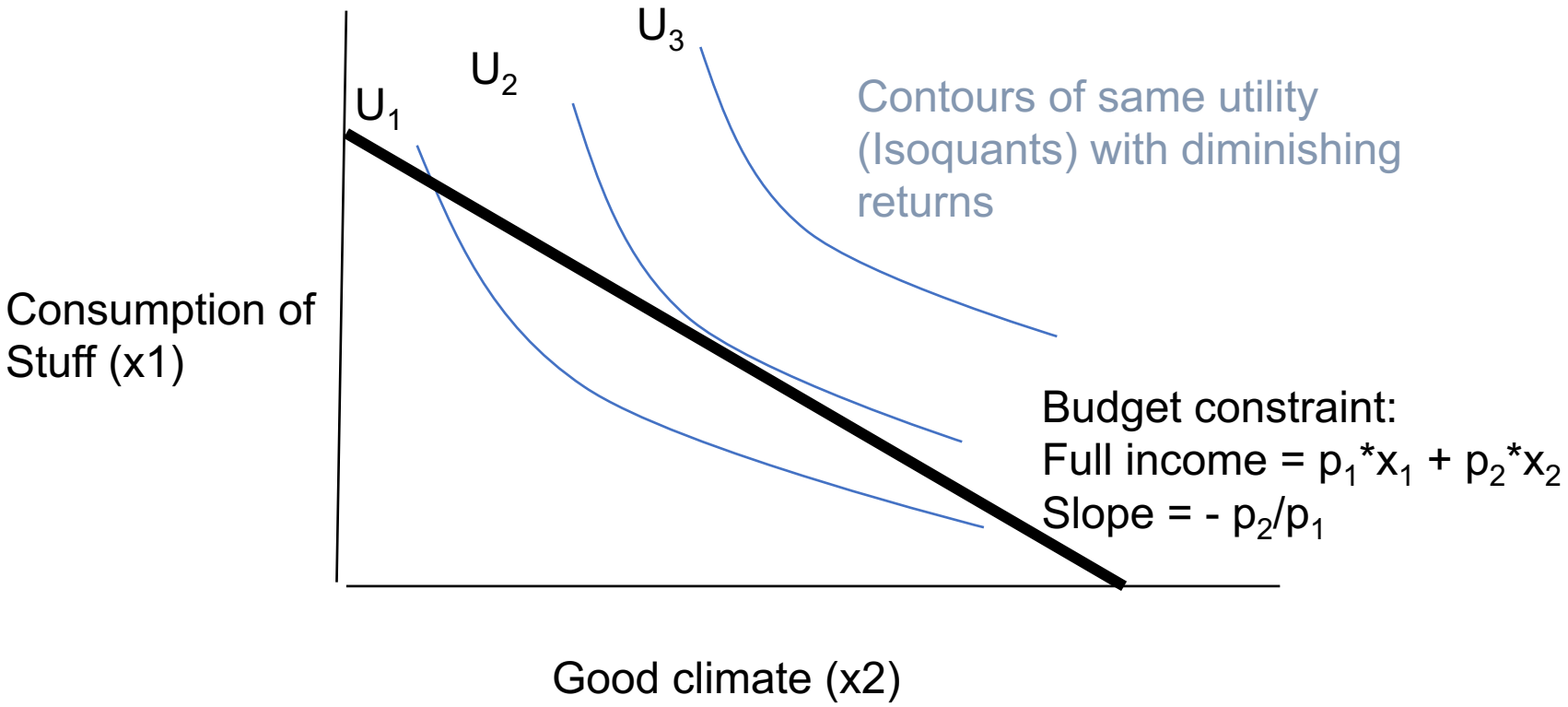
- Nordhaus estimates that $25-50 is right carbon price to put us on “optimal emissions path”

- A tradeoff: if we consume less “stuff”, we can buy better climate (and vice versa)

- Optimum maximizes

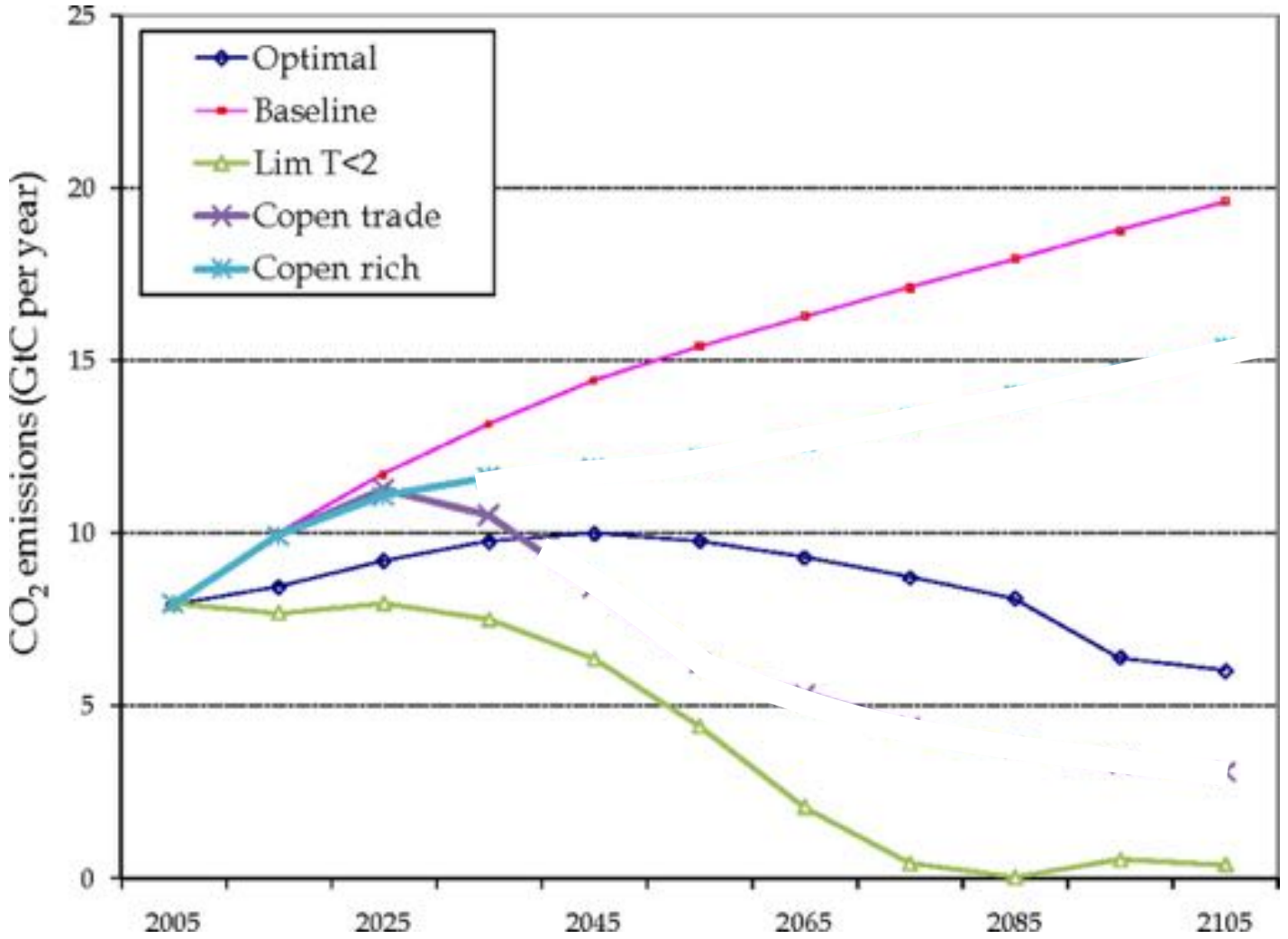
  Utility(consumption stuff, climate)

Optimum policy



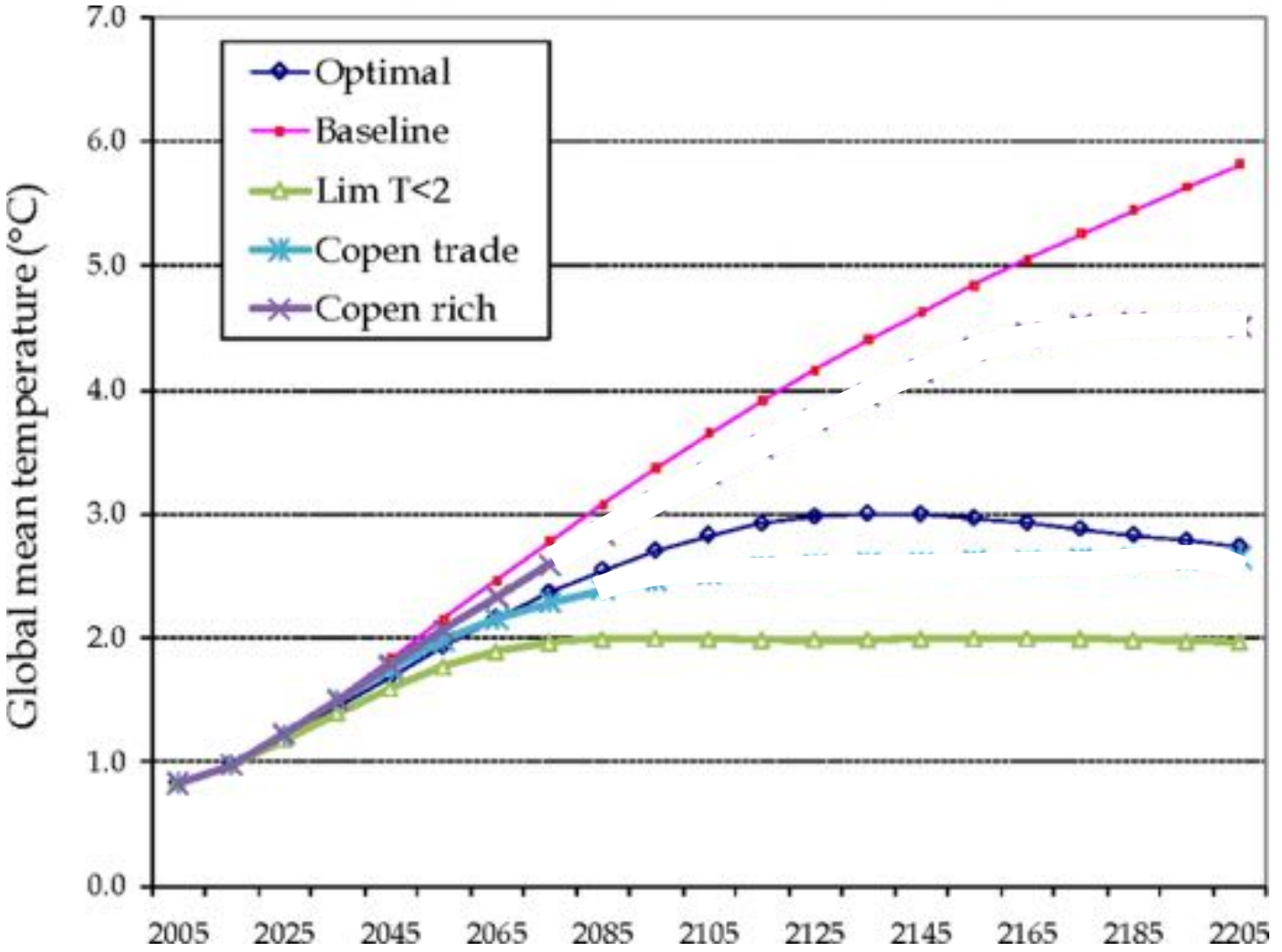
Details of this model of optimal choice later in course
For now, enough to see that a tradeoff leads to some optimum

Projected emissions of CO2 under alternative policies.



William D. Nordhaus PNAS 2010;107:11721-11726

Global temperature increase (° C from 1900) under alternative policies.



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A more optimistic perspective

- Enormous carbon reductions are not necessary to prevent catastrophic warming
- Need to weight benefits to costs of carbon reduction
- “Optimal” reductions can be gained by a moderate tax on carbon

What are we to conclude?

- Big efforts are needed
- Even with big efforts, expect climate change
- Challenges are
  1. Getting global agreement on carbon tax or equivalent
  2. Developing technology for abatement (particularly in developing world)
  3. Adapting to some inevitable warming

Role for many sciences

- Main economics narrative fairly clear
- Many technological challenges
- Big role for politics (game-theory, political science)

Role of population

- Faster fertility decline in developed world may ease challenge
- But, as we saw with Lam, development of institutions is the key

How does global warming differ from overfishing?

- Similarity : a commons that unregulated individuals will destroy
- A “public good” (see Nordhaus)
- Differences
  - Global, not local?
  - Delayed feedback
  - Lots of reliance on models (climate & economy)
  - Unimaginable downside