“Two principles of international cooperation to control greenhouse gas emissions”

by

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Cooperation is key

- It might appear obvious, but international cooperation is the key to limiting greenhouse gas (GHG) emissions, to control global warming
- The standard concept of Nash equilibrium is *non-cooperative*, and would lead to a disastrous outcome. It would result in the 'tragedy of the commons,' the commons of a cool biosphere
- Economic theory has paid little attention to recipes for cooperation, and so some conceptual innovation is required

The 2015 Paris Agreement

- The Paris Agreement, drafted in December 2015, an exercise in cooperation. Roughly 190 nations agreed to 'intended nationally determined contributions (INDCs)' to restrict GHG emissions
- Many have noted the lack of enforcement mechanism. And even if met, the INDCs are insufficient to keep global temperature down.
- Main purpose of meeting was to build trust and solidarity, without which cooperation is not possible

The Trump sabotage

- D. Trump announced shortly after his election that he would withdraw the US from the Paris Agreement. Since then, at a national level, the US has taken no initiative. We can only hope that Trump is replaced by the electorate and a more cooperative president is installed
- How other nations should deal with a continuing belligerent US leadership, should it persist beyond 2020, is a topic for another time

How to allocate regionally GHG emissions

- Wish to focus here on a big question: How should permits to emit GHGs be assigned to different regions of the world (eventually, countries) in order to put our civilization on a path that would converge to a temperature increase of 1.5 or 2 degrees Celsius above pre-industrial levels?
- I am not here concerned with what the exact temperature goal should be – that is the job of natural scientists to explicate. I am here concerned with the *cooperative principles* that might guide the international negotiations

The First Principle: Maintain convergence

- Many large countries (China, India, Brazil, Indonesia) are growing, in GDP per capita, much faster than the developed countries (US, Europe, Australia). If this continues –- as we must all hope it does – then these countries will eventually *converge to Europe and North America* in their levels of GDP per capita.
- Such convergence would be a major accomplishment for mankind.
- The first principle is: Allocate GHG emission permits to regions in order to **preserve the dates** at which their economies will converge to the GDP/capita of the advanced world.

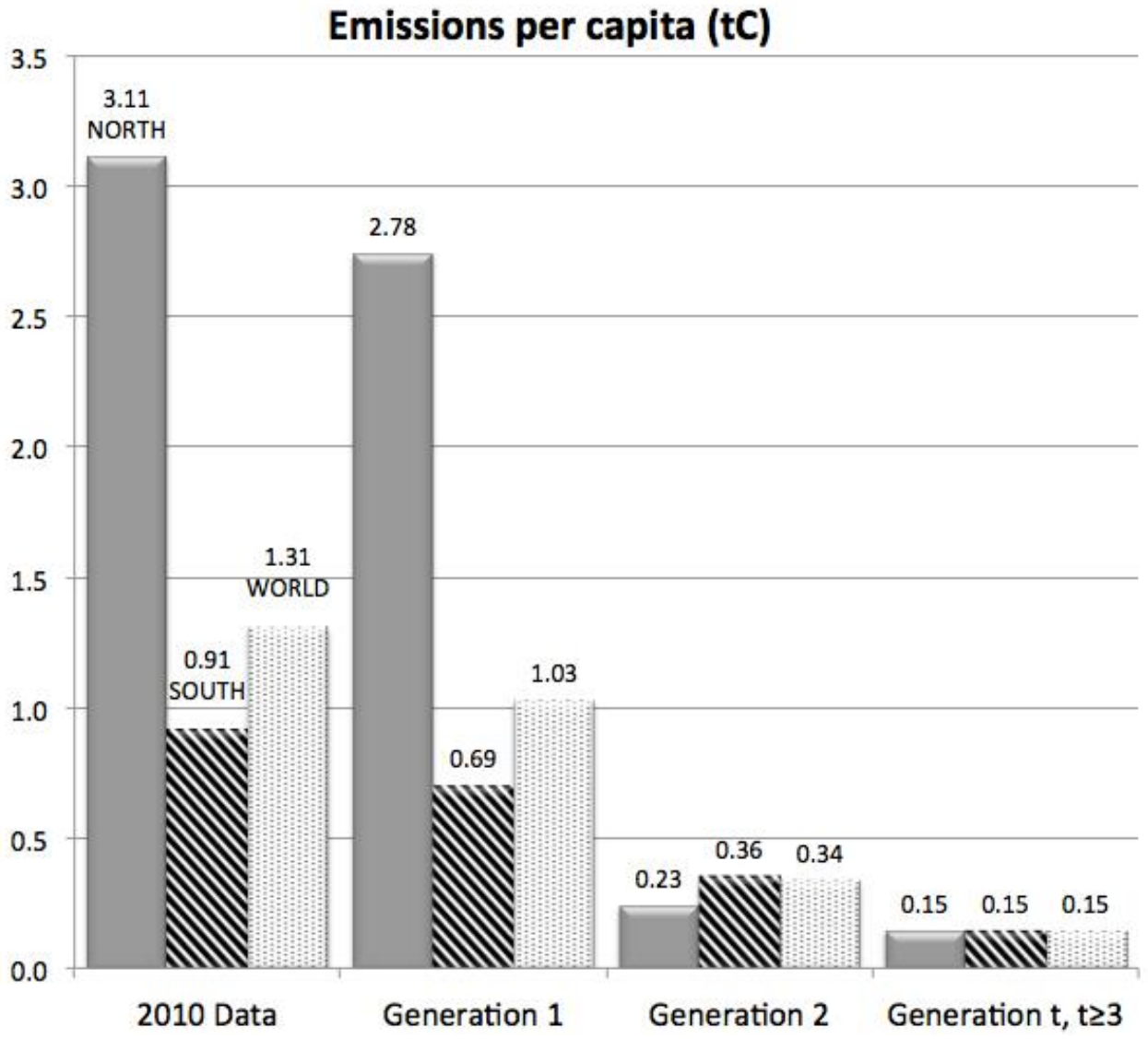
An Example: China-US convergence

- In 2017, US GDP was $60,000 per capita and China's GDP per capita was $8,800. Suppose the *average* rate of GDP growth in the US during the next 75 years, *absent the problem of global warming,* were to be 1.5% p.a., and Chinese average GDP growth were to be 4.5% p.a.
- Then **convergence of Chinese to US GDP per capita would occur in 66 years.**
- The first principle: *Allocate our remaining carbon budget between the advanced and developing world so that convergence will still occur in 66 years – but at slower growth rates for both China and the US.*

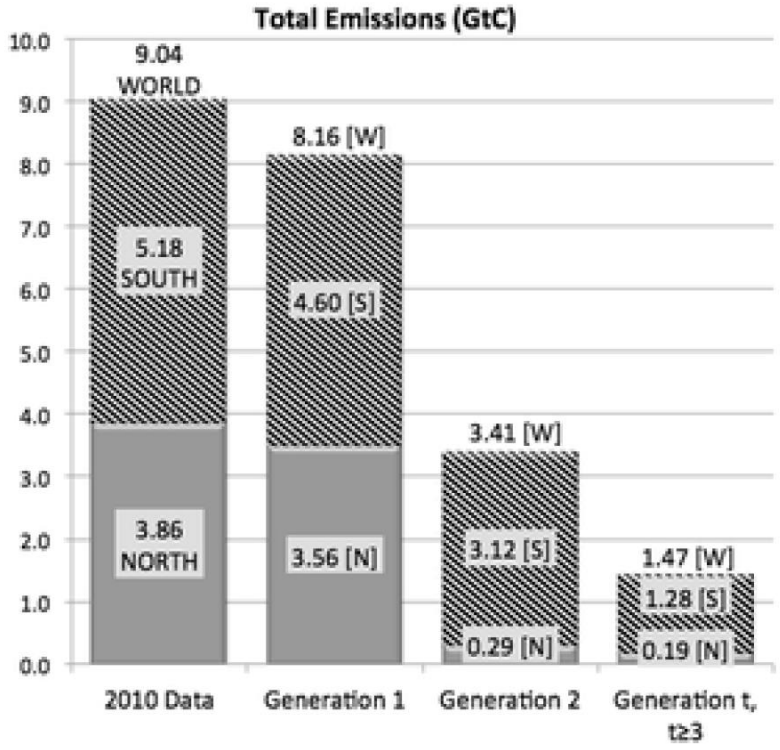
- In other words, if we restrict GHG emissions, growth will slow somewhat. With knowledge of how rapidly the carbon efficiency of production will increase with R&D, we can calculate how to allocate the carbon budget among countries to *maintain dates of convergence* to the advanced countries' standards of living
- What is the rationale? Would China accept an allocation of permits that would retard its convergence to the US in GDP per capita by ten years? Why should it? And conversely…..

Our calculation

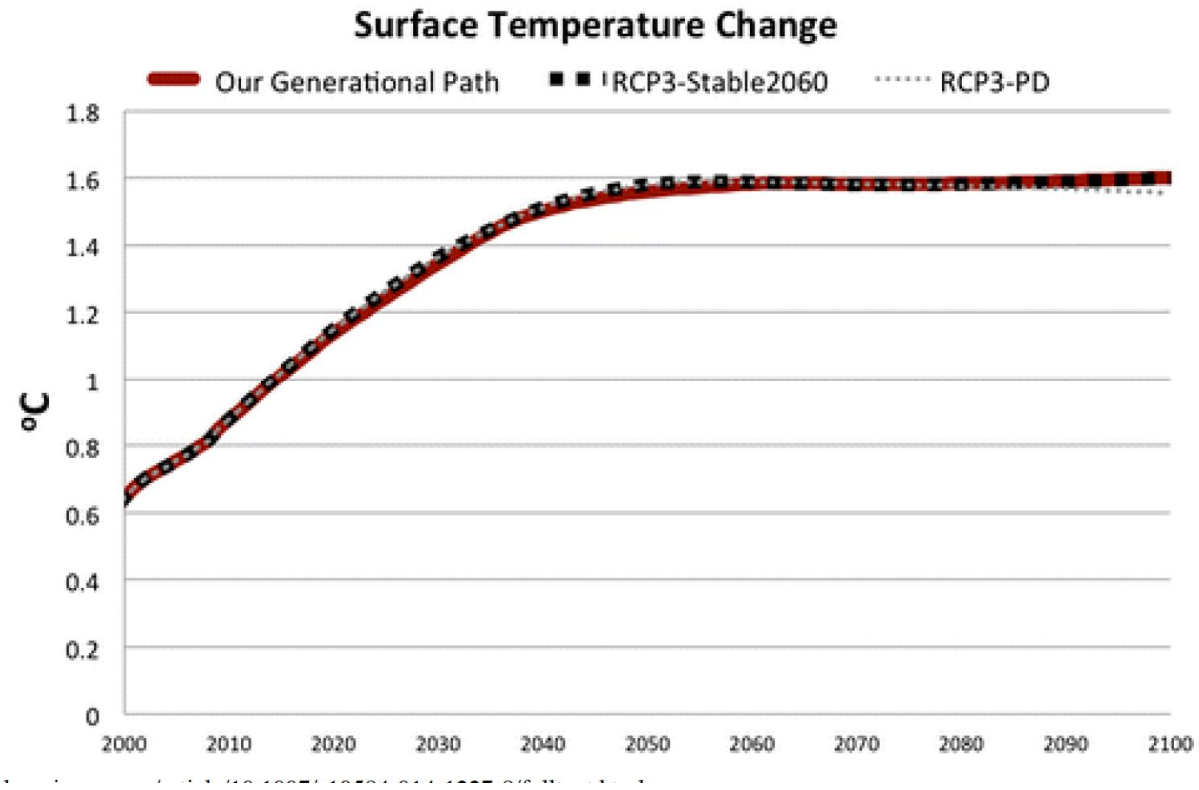
- We (Llavador,Roemer & Silvestre, *Sustainability for a Warming Planet,* 2015, Harvard UP) made this calculation several years ago, with the following assumptions:
  - A world consisting of two regions, North and South (US-Europe, and China)
  - A carbon budget implying convergence of temperature to below 2^0 C. above 1850 levels
  - Regional population growth as estimated by the UN
  - Convergence in three 25-year generations from 2010 (by 2085)
- Here are the results:


Emissions per capita (tC)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
3.11
NORTH
0.91
SOUTH
1.31
WORLD
2.78
0.69
1.03
0.23
0.36
0.34
0.15
0.15
0.15
2010 Data
Generation 1
Generation 2
Generation t, t≥3

Here are the total emissions along this path



And here is the projected temperature path



- Thus per capita carbon emissions are reduced to 11% of 2010 levels.
- Given the recent IPCC report arguing for 1.5^0 C., this is almost sufficient.
- I present these calculations to illustrate the principle.

- Unlike many proposals that stress historical contributions of regions, this proposal is *forward-looking*, not *backward-looking.* We do not think it is politically realistic to hope for a backward-looking solution.
- In game-theoretic language, our proposal is a *focal point* of the bargaining game between the global North and South

ÅAlong the path, US utility per capita grows at approximately 1% per annum. China's GDP grows faster. Consumption grows at the same rate. This rate is lower than growth in recent years, but it is *much higher* than the growth of income per capita of the bottom half of the US population, which *stagnated completely* between 1980 and 2014. The *total real income growth* of the bottom half of the income distribution was 1% over this 40 year period (Piketty, Saez and Zucman, 2016).

- I do not mean to trivialize the problem of computing this allocation of GHG permits. An international team of economists would have to work together closely to do so.
- Must underscore the importance of establishing the goal that would guide the team. To agree upon the goal would itself require careful international negotiations.
- Implementation would require a system of monitoring and penalties.
- I do not think this goal is achievable with the present US administration.

The second principle: International unanimity in a cap and trade system

- The second proposal is quite different from the first one. It proposes a way to decide upon what global emissions should be by *international unanimity*: that is, every major region of the world would come to agree on what global GHG emissions should be over the next 75 or so years, and regional emissions would not be assigned, but decentralized in such a way that the agreed-upon global emissions limit would be satisfied.
- We will present a calculation for what the solution would be for a world partitioned into 12 regions

- Think of a world partitioned into regions, each of which operates a market economy. As well the usual prices – of output, of wages, of capital – there will be a price *c* that each firm must pay for each ton of carbon that it emits.
- Firms in the regions will set their production plans in the usual way, to maximize profits – and one of the costs they must sustain is the cost of carbon emissions associated with production. These carbon fees are paid into an international account.
- The revenues in this account will be returned to each region according in proportions that will be fixed in a way to be described below.

- It is assumed that each country will be interested in maximizing the following welfare function:
  - GDP per capita minus the damages implied by the global emissions of carbon,
  - i.e., $x^i - h^i(E^{total})$ where x^i is the GDP per capita, E^{total} is global emissions, and h^i is the damage function for region *i*
- Given prices, including the price *c* for carbon emissions, there is a way of setting proportion of the global emissions fund, α^i that is returned to region *i,* so that the amount that the world's firms plan to emit in toto equals the amount that the citizens in each region would desire total emissions to be.

- That is the citizenry of each region will have a *optimal level* of total emissions – in which it trades off the damage from emissions for the benefits it receives from the demogrant and the production in their own country. The proportions $\{a^i\}$ can always be calculated so that, at the market prices for output and carbon, regions *unanimously agree* on what level of global carbon emissions is optimal.
- At the solution, the proportion a^i is equal to the marginal damages the region experiences, $\frac{dh^i(E^{total})}{dE}$.

- The solution entails a decentralized allocation of regional carbon emissions – the result of firm profit-maximization in each region– which matches the citizenries' agreed-upon global total, and the result is *Pareto efficient*: that is, there is no feasible allocation of goods and emissions that can make any region better off, in welfare terms, without reducing the welfare of some other region.
- Again, this solution – in particular, the shares of the global carbon revenues that are returned to each region – must be calculated by an international team of economists. This necessitates that the team have good estimates of the macroeconomic production function in each region, and the damage function for each region.

ÅHere are our latest calculations of what emissions and revenues would be with this proposal.

Allocation of permits' claims and revenues

Region	*a*	a/Pop.share	*a* per million person	REVENUES billion $	REVENUES $ p.c.	REVENUES %GDP
US	0.077	1.70	0.21	168.5	458.63	0.66
EU	0.112	1.60	0.20	246.6	431.60	0.91
Japan	0.015	1.07	0.13	32.7	288.18	0.57
Russia	0.006	0.43	0.05	14.4	114.71	0.45
Eurasia	0.010	0.43	0.05	22.3	114.70	0.74
China	0.182	1.05	0.13	402.4	283.22	1.80
India	0.130	0.74	0.09	287.8	199.45	2.47
MiddEast	0.056	1.60	0.19	124.1	428.27	1.82
Africa	0.220	1.15	0.14	483.9	309.36	3.99
LatAme	0.063	0.74	0.09	138.3	201.10	0.96
OHI	0.030	1.86	0.23	66.9	500.47	0.96
OthAsia	0.099	0.63	0.08	220.7	169.91	1.93

Consumption and net cost of emissions

Region	consumption trillion $	consumption thoushand $ per capita	net payment billion(10^9) $
US	25.53	69.48	175.2
EU	27.04	47.33	14.7
Japan	5.720	50.43	19.8
Russia	3.15	25.10	64.1
Eurasia	2.97	15.25	46.6
China	22.22	15.64	136.9
India	11.77	8.16	-121.5
MiddEast	6.79	23.45	18.5
Africa	12.45	7.96	-331.2
LatAme	14.42	20.96	4.4
OHI	6.94	51.93	52.3
OthAsia	11.55	8.89	-79.9