macroeconomic cost-benefit analysis of carbon dioxide emissions

@Klimarisikoutvalget, February 2018

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outline

- go through basic economic cost-benefit calculation for fossil fuel emissions
  - involves climate-model basics
  - and carbon-cycle basics
- discuss different policy options
- look at heterogeneous impacts – especially around the world
- conclude
- note: material here based primarily on research w John Hassler (IIES) and Tony Smith (Yale)

research background

- US-trained macroeconomist, tooled up to analyze this issue
- came into climate-economy field in 2007 “without prior”; learned basic mechanisms from natural scientists
- have built “integrated assessment models” to analyze optimal policy based on state-of-the-art global macroeconomics, climate modeling, and carbon-cycle modeling
- have conducted analysis on very different levels of aggregation: global (1 region in the world) and disaggregated (20,000 regions)

broad conclusions so far

- climate change likely leads to non-negligible global damages
- very uneven effects across regions of world
- for world as a whole, costs likely not catastrophically large
- a robust result (in Golosov, et al., 2013): optimal policy involves rather modest tax on CO_2 and would not pose threat to economic well-being
- some elements of analysis subject to substantial uncertainty

basic natural-science logic

- the burning of fossil fuel (oil, coal, natural gas) increases the CO_2 concentration in the atmosphere
- CO_2 in the atmosphere is a greenhouse gas: it lets solar radiation pass through but blocks heat radiation
- this leads to global warming; the logic is undisputed among scientists
- the direct warming effect is significant, but not catastrophic
- there are, however, feedback effects: creation of water vapor, melting of ice caps lowering solar reflection, cloud formation, …
- the quantitative magnitudes of feedback are disputed; the “average” view seems to be that feedbacks strengthen the direct warming effect considerably, but there is much uncertainty: cannot rule out really bad outcomes, but cannot rule out really innocent outcomes either

basic economic logic

- global warming affects economic activity; in many places, the effect is to cause damages (to agriculture, human health, and so on)
- this is an externality: those emitting carbon into the atmosphere are not charged for the costs
- thus, in classical economic terms, we have a failure of markets. The prescription is government intervention: we need to artificially raise the cost of emissions to its proper societal value
- main recipe: use a tax; well-known since Pigou (1920)
- the tax must be global: the externality is global
- what is the appropriate level of the tax? for this, we use standard cost-benefit analysis

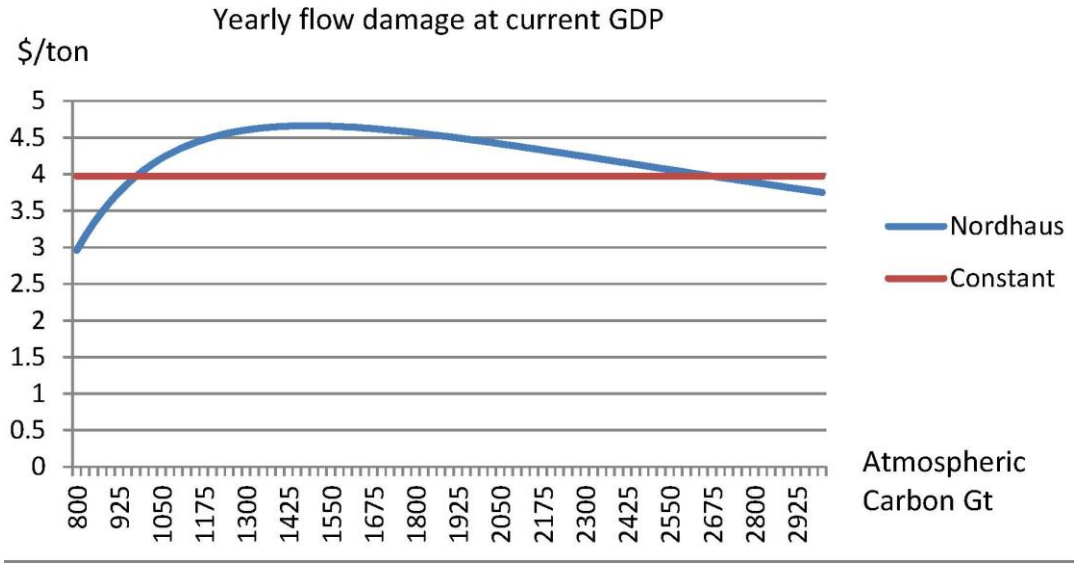
key steps in arriving at optimal tax: 1

- CO_2 contents in atmosphere causes temperature to increase (at lag)
- higher temperature causes economic damages (of variety of kinds)
- relation CO_2 → temperature known to be logarithmic (**concave**): smaller and smaller percentage effects as more emitted

- relation temperature → damages (% of gdp) believed to be **convex**: higher and higher percentage effects as temperature rises
- key insight: combined CO_2 → % damages link **nearly linear**!

numbers

1 GtC increase in atmospheric carbon concentration leads world GDP to fall by 0.0024% (from meta estimates in literature: Nordhaus and others, using “bottom-up” approach)



250 add’l GtC (current situation) → global GDP down 450 billion USD

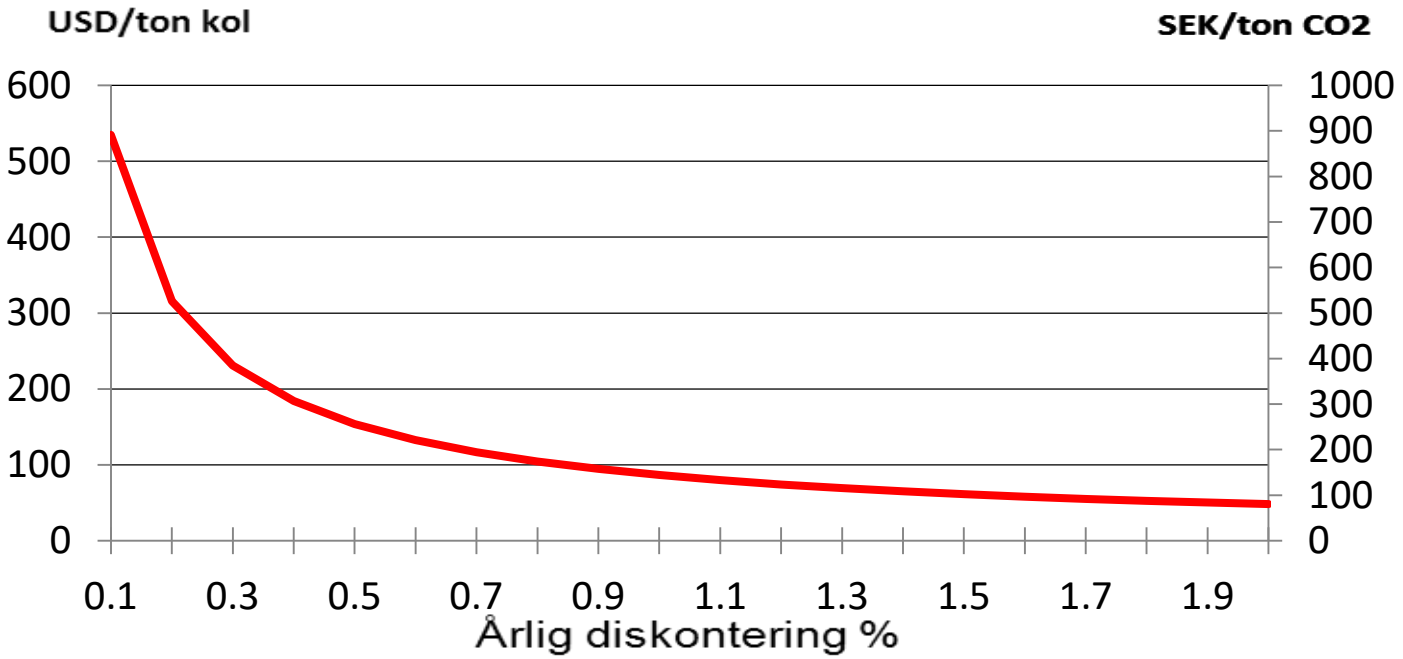
caveats

- as stated: feedback effects quite uncertain
- what about tipping points, i.e., nonlinearities? many (mostly local) examples discussed in literature, but very far from consensus; in particular, no known specific points (e.g., 2 degrees or some level of atmospheric carbon concentration)
- damage measurements: even less is known! methods employed:
  - bottom-up: add micro damages by type, sector, region, …
  - top-down: aggregate time-series correlations between temperature/climate and output, mortality, etc.; or ”Ricardian approach” – cross-sectional
  - costs and benefits of adapatation, e.g., in form of migration, poorly understood
- uncertainty, risk aversion: is there a tipping point here? not at a known level

step 2 (final): adding up over time

- previous damages: only flow (annual)
- emissions stay very long in atmosphere
- carbon cycle: roughly 20% stays ”forever”, 50% disappears ”immediately”, rest slowly disappear (few % per decade)
- also need: weights on future generations
- two components to weights on future generations:
  - to the extent future generations richer than we are, they care less about losses, roughly in proportion to gdp
    conclusion: future GDP not key for calculation, since losses are in % of gdp but the valuation is inversely proportional to gdp!
  - welfare of future generations ”discounted”: care less about them than about ourselves; used in all governmental infrastructure evaluation but ultimately a philosophical issue (Stern: 0.1%, Nordhaus: 1.5% annual)

sum damages over time => ”optimal” tax!



Sweden has carbon tax ~ 600 USD/tC!

what if we don't use the optimal tax?

- let's use a recent (natural science-based) approximation of the effects on global temperature of fossil-fuel emissions
- "Carbon Climate Response" (CCR): for each 1,000GtC in cumulative historic emissions, global temperature rises by 1-2.1 degrees Celsius
- we've emitted about 550GtC so far (since industrial revolution)
- remaining (conventional) oil+gas: about 300GtC... simited warming if we use it up!
- remaining coal: much more, possibly over 3,000GtC
- => coal is the main threat!

what would the optimal tax do?

- wouldn't affect (conventional) oil and gas use
  - a tax on oil and gas makes little difference: these fuels are so cheap to produce that markets will keep using them despite the tax
  - it is indeed efficient from an economic perspective to use them up!
- a different story for coal:
  - coal doesn't give a big profit per unit so a tax would make us stop using most of the coal
  - taking the climate damage into account, using coal simply isn't worth it.
- so: bad for the coal industry (the world over), no big deal otherwise

how costly is the optimal tax for us?

- suppose we use “very cautious” discounting of 0.1%, implying a tax of $600/tC
- turns out Sweden has had that tax for over a decade. We did better than average during the Great Recession, no noticeable “leakage” of firms abroad
- significant scope for
  - energy saving
  - alternative technology

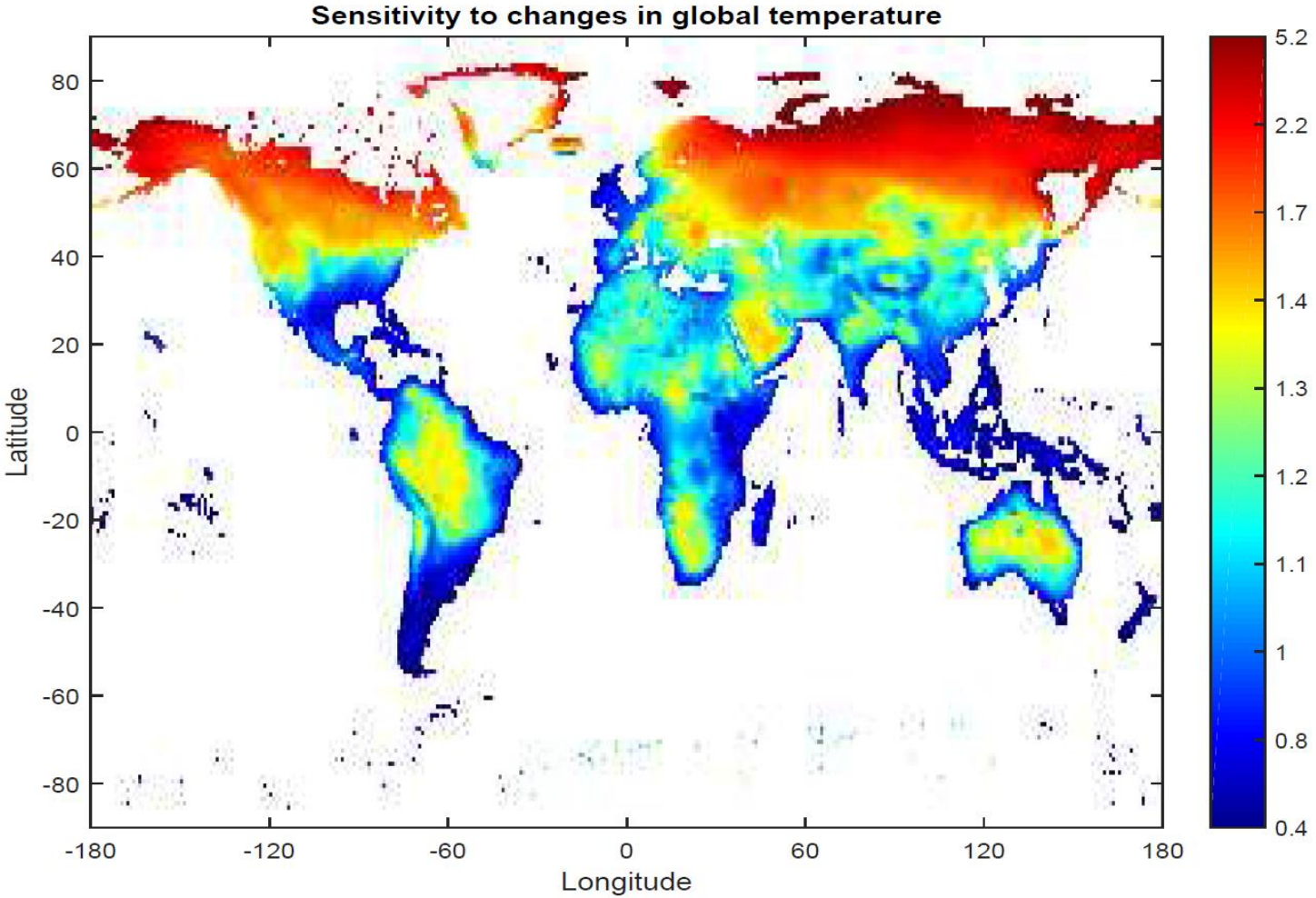
policy instruments

- baseline recommendation:
  - tax carbon, world-wide
  - required rate will not be a big blow to our global economy, but will (must) shake up coal industries
- what about alternatives, like cap-and-trade?
  - if managed so that the emission rights are as expensive as the carbon tax, ok!
  - in Europe, this is not the case – low world demand and high caps culprits
- do we need green subsidies?
  - under an optimal carbon tax, maybe not; otherwise, yes
- should all countries mainly reduce emissions at home?
  - no: reduce them where they are least needed/least efficient (help reduce the internationally most inefficient emissions, pay to keep forests, …)

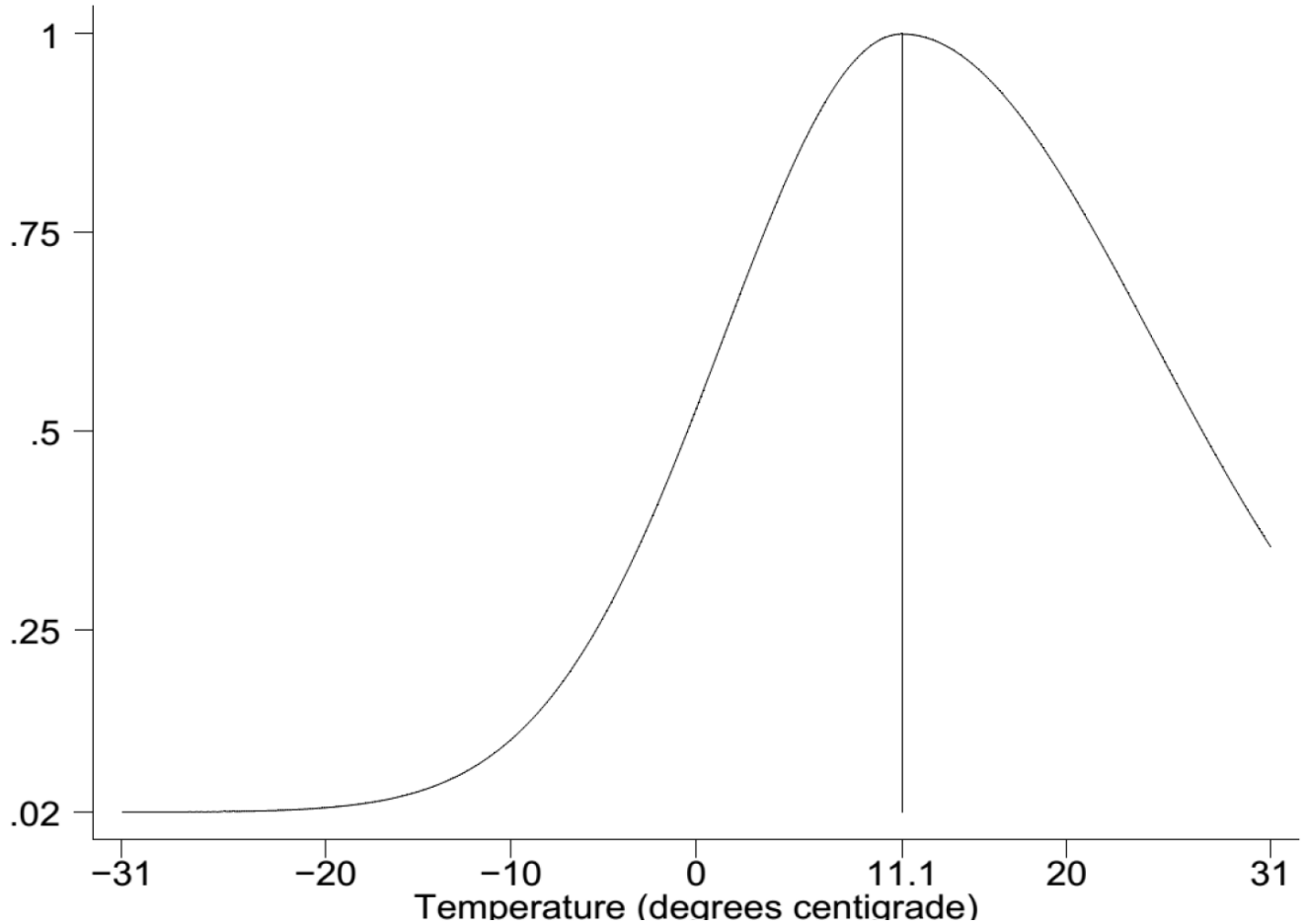
effects of climate change around the globe

- the average cost of carbon emissions is sizeable but not catastophically large
- however, the costs are VERY different in different regions: recent estimates suggest the average cost of carbon is swamped by its variation across regions
- thus:
  - for some regions, climate change will likely be very, very costly…
  - and yet for other regions climate change is very good!!!
- also, local temperatures react differently to a global temperature rise

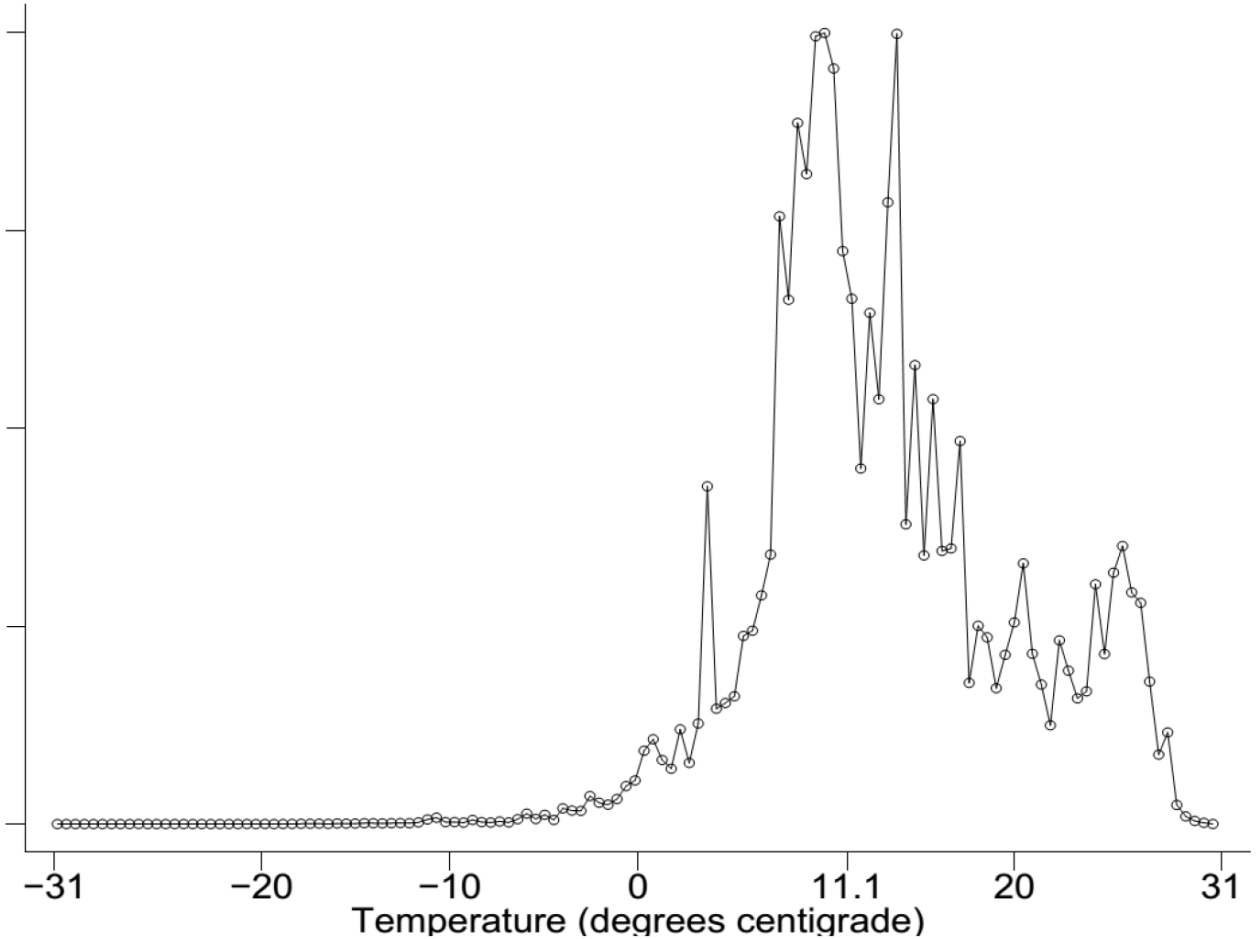
how much each region warms when world warms by 1 degree C



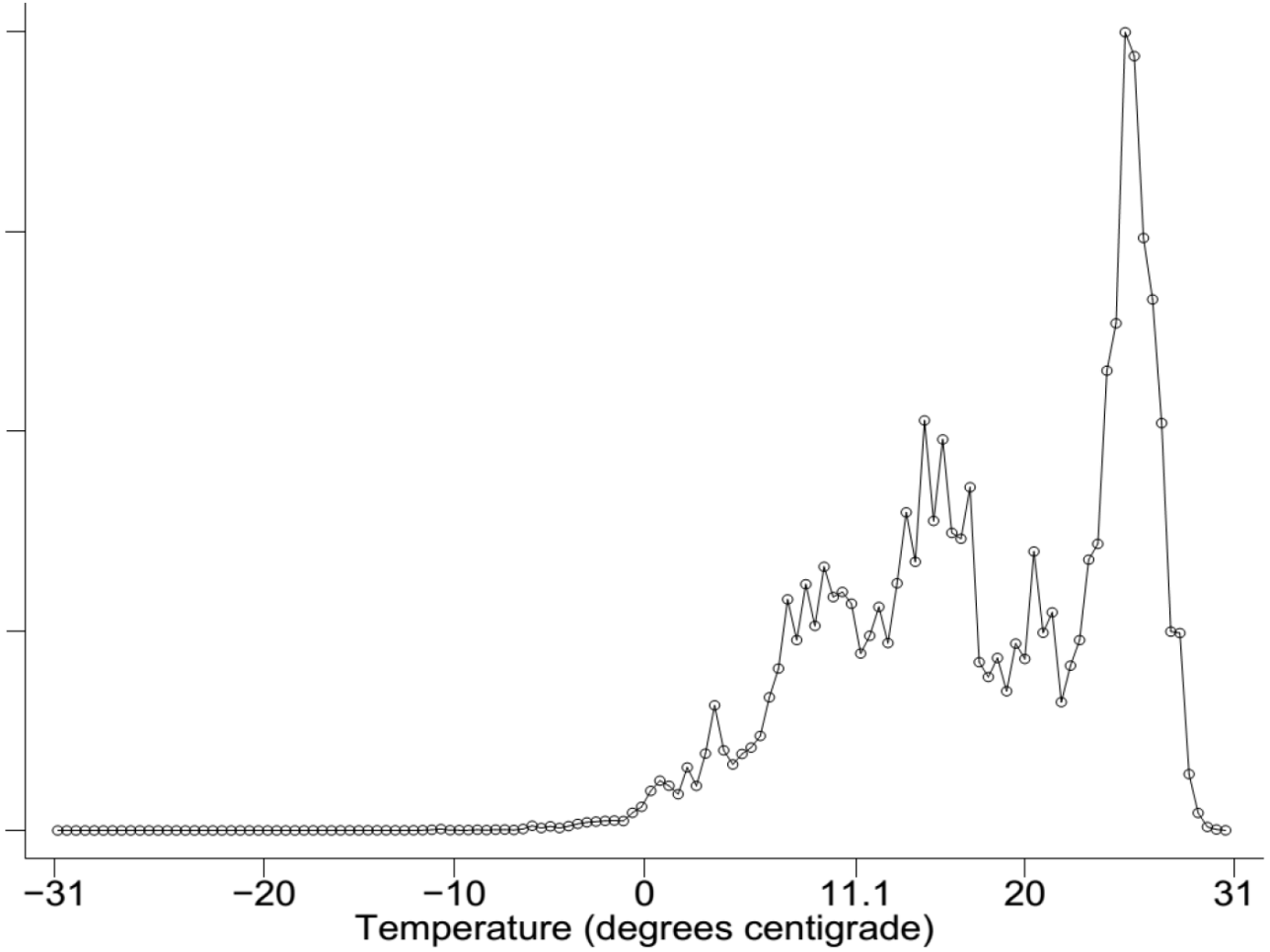
local production as function of local temperature



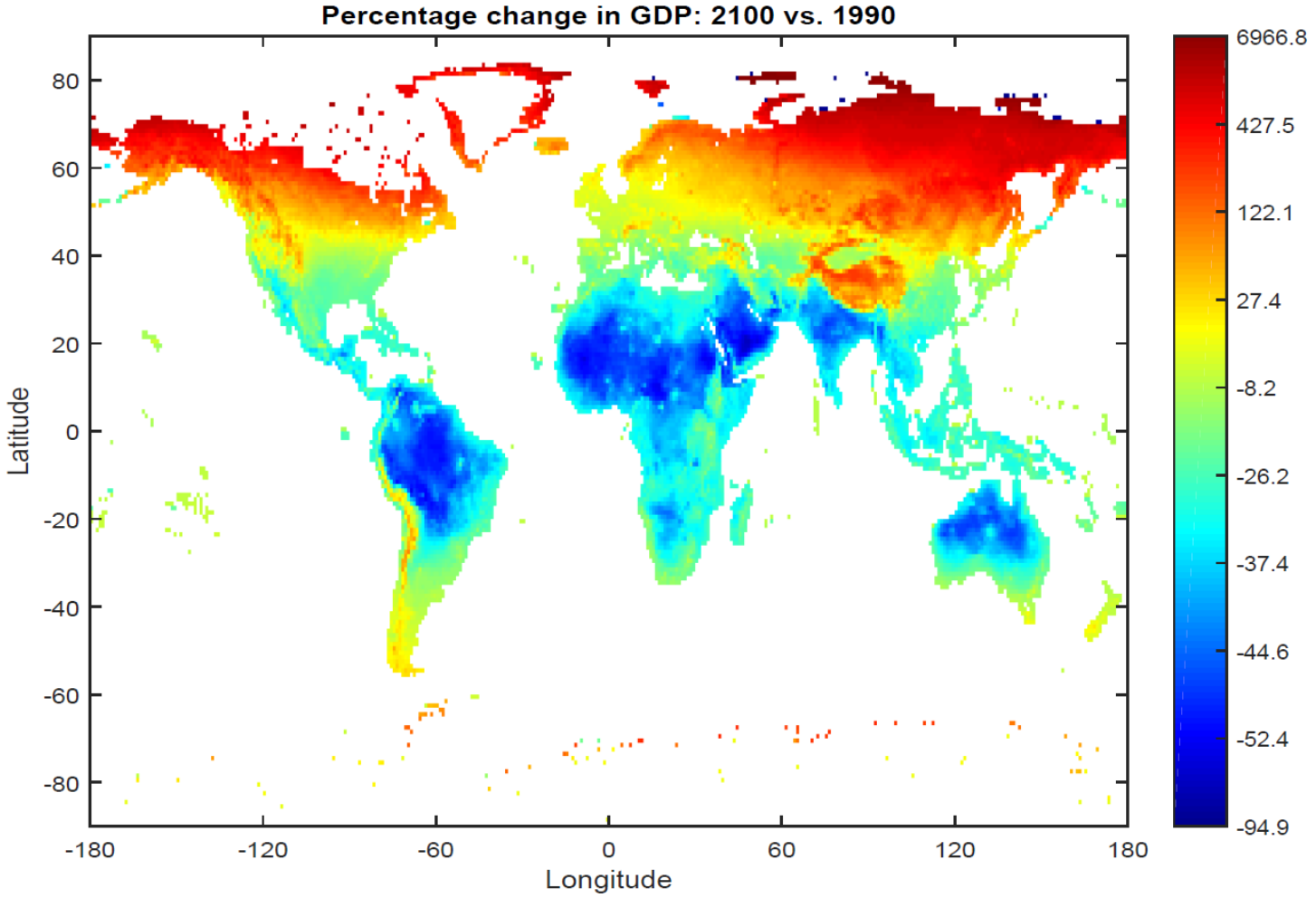
share of world GDP as function of local temperature



population as function of local temperature



highly heterogeneous impacts of business as usual!



concluding remarks

- must tax CO_2 emissions (and the required rate is not staggering)
- key challenge: global disagreement, lobbies against carbon tax
- taxing conventional oil is not crucial: little of it is left
- taxing coal and non-conventional oil (tar sand, fracking oil, ...) is crucial because there is a lot of it
- danger in this context: ”solution” by investing in green technology if green technology does not make coal and non-conventional oil unprofitable
- watch out for huge costs of climate change in some regions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