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What is wrong with very long-run economic modeling for climate change?

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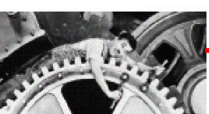

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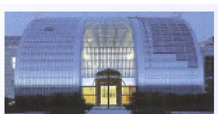

The Transition to Sustainable Economic Structures

My storyline
Reflecting on economic modeling for climate change

- **Obvious failures of economists in dealing with climate change**
- **Some reasons for that**
- **There are grounds for hope**

„Economics is the only field in which two people can share a Nobel Price for saying the opposite thing“

Sea level rise
according to Richard Tol

England and Wales today

... and after sea level rise

Floods of 2002 in AT
Are there any economic impacts?

Damage about 1% G

But:
Positive (?!) impacts on GDP

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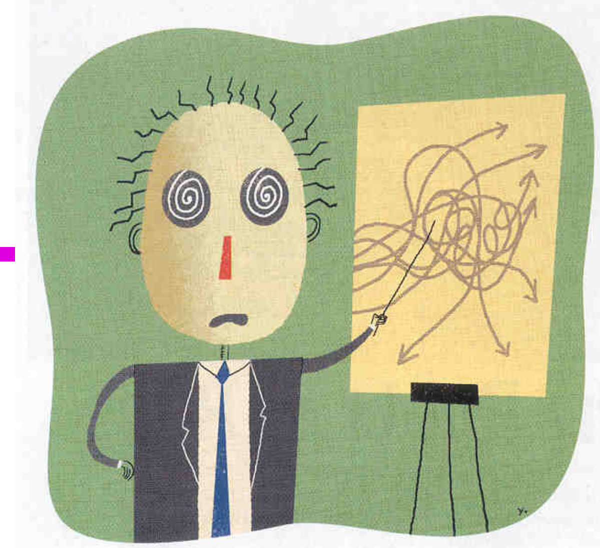
Extreme events in DCs
No impacts on economic activity?

Tsunami 2005

„... no impact on stock market since no major production facilities were affected“.

What went wrong?
Modeling the very long-run

- **Economic modeling has been fundamentally challenged when asked to deal with a time horizon of at least 100 years**
- **This means modeling the very long-run**
- **The first generation of models used was just not adequate**



The Nordhaus paradigm
for economic modeling of climate change

Production – Potential output
Factors of production

Q production is determined by

A technical progress

K produced capital

L human capital

I investments

$$Q = A(t)K(t)^{\gamma} L(t)^{1-\gamma}$$

$$A(t) \quad exogenous$$

$$K(t) = K(t-1)(1-\delta_K) + I(t-1)$$

$$L(t) \quad exogenous$$

Emissions
Abatement efforts

E emissions are determined by

μ abatement effort

σ abatement effort

Q output

$$E(t) = (1 - \mu(t))\sigma(t)Q(t)$$

Actual output

Impact of emissions damages and abatements

Q actual output is lower than potential output because of

Ω damages from emissions

μ abatement efforts

$$Q(t) = \Omega(t)\left(1 - b_1(t)\mu(t)^{b_2}\right)A(t)K(t)^{\gamma}L(t)^{1-\gamma}$$

$$\Omega(t) = \Omega(E)$$

E emissions

Consumption and investment
Limited by actual output

Q actual output is available for

C consumption

I investment

$$Q(t) = C(t) + I(t)$$

The fundamental interactions
Policy variables determine consumption

Control variables

μ abatement efforts

I investment

$$\Omega(t)\left(1-b_1(t)\mu(t)^{b_2}\right)A(t)K(t)^{\gamma}L(t)^{1-\gamma}=C(t)+I(t)$$

C consumption

Key output variables

Searching for "optimal" policies
Evaluating policies

W welfare measured by

C/L per capita consumption

ρ discount rate

$$\max W(t) = \sum U\left(\frac{C(t)}{L(t)}\right)(1+\rho_t)^{-t}$$

Controversies within the Nordhaus paradigm
Why economists disagree on climate change

- **Doubling of atmospheric concentrations of CO_2 would cost between 1% and 2,5% of global GDP**

- **But:**
  - costs of abatement today
  - benefits after decades or centuries

- **The crucial role of discounting**

  1,00 € in 50 years
  0,61 € if 1% discount rate
  0,23 € if 3% discount rate
  0,05 € if 6% discount rate

Why the Nordhaus paradigm is not adequate for modeling the very long-run

- **Problems with impacts of climate change**
  - Extreme events
  - Sea level rise
  - Loss of natural capital
  - Loss of human lives
- **Problems with analyzing abatement policies**
  - Low energy technologies
  - Low carbon technologies

$$\Omega(t)\left(1-b_1(t)\mu(t)^{b_2}\right)A(t)K(t)^{\gamma}L(t)^{1-\gamma}=C(t)+I(t)$$

$$\max W(t)=\sum U\left(\frac{C(t)}{L(t)}\right)(1+\rho_t)^{-t}$$

The deficiencies of the Nordhaus paradigm when used for modeling the very long-run

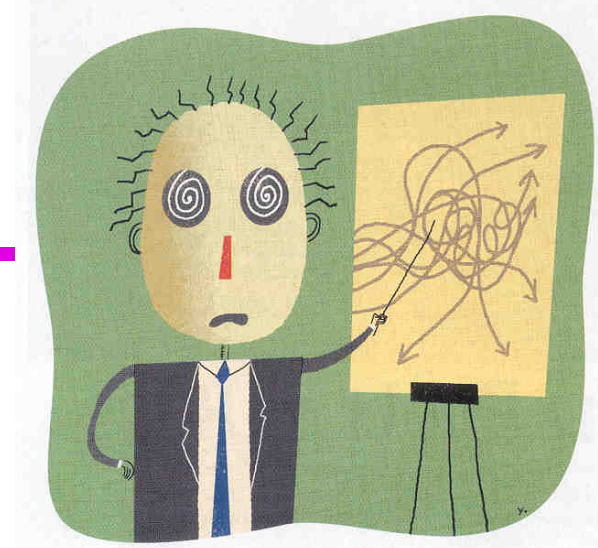
Damage and abatement are extremely difficult to evaluate

Technological change is the issue

Welfare results also from stocks

$$\Omega(t)\left(1-b_1(t)\mu(t)^{b_2}\right)A(t)K(t)^{\gamma}L(t)^{1-\gamma}=C(t)+I(t)$$

$$\max W(t)=\sum U\left(\frac{C(t)}{L(t)}\right)(1+\rho_t)^{-t}$$



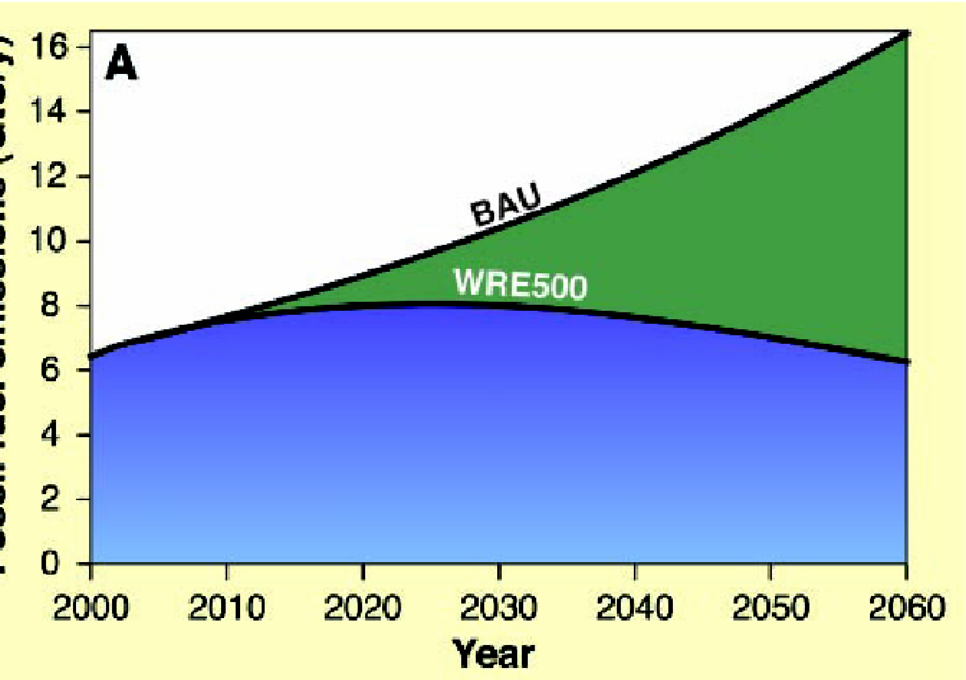
A stimulus from outside
The Pacala-Socolow paradigm

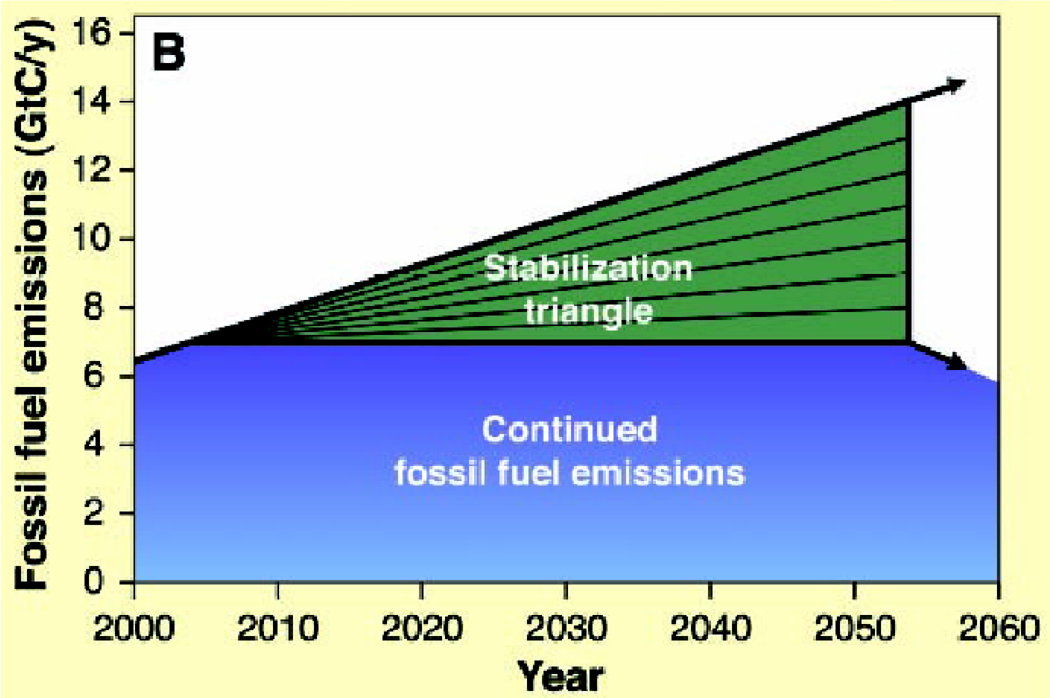
A paradigm shift
The Pacala-Socolow proposal

"Humanity already possesses the fundamental scientific, technical, and industrial know-how to solve the carbon and climate problem for the next half-century and climate problem over the next half-century."

S. Pacala and R. Socolow
Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies
Science, Vol. 305, August 13, 2004.

Current technologies for GHG stabilization in 50 years





Current technologies for GHG stabilization in 50 years

- **Efficiency and conservation**
  - Cars (4x -> 2 billion cars)
    60 instead 30 miles/gallon
    5000 instead 10000 miles per year
  - Buildings
    -25% energy
  - Power plants
    from 40 to 60% efficiency

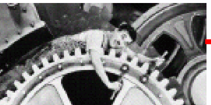
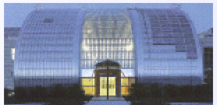
Current technologies for GHG stabilization in 50 years

- **Decarbonization**
  - Electric power plants
    gas substitutes coal
  - New renewables
    wind, thermal and photovoltaic solar
- **Carbon capture and hydrogen storage**
  - Post-combustion carbon capture and storage in electricity generation
  - Pre-combustion carbon separation and hydrogen storage
    as substitute for fossil fuels
- **Carbon sinks**

Searching for the next generation of economic models for the very long-run

Key issues for next generation of long-term models

- **Structure**
  - **Additions**
    - Extended concept of production
      Recycling and production in households
    - Extended list of capital stocks
      Reproducible capital in firms and households
      Exhaustible, knowledge and natural capital
  - **Links**
    - Stock-flow relationships
    - Endogenous technical change
- **Measuring welfare**
  - From stocks and flows
- **Mechanisms**
  - Price (market based) mechanism
  - Non-price mechanisms

Extended production activities
Re-generated and knowledge goods

Production and investment activities

q	**reproducible goods**
g	**re-generated goods (recycling)**
k	**knowledge goods**

Extended capital stocks
Reproducible and non-reproducible

Reproducible capital stocks

K^q	**reproducible goods – production**
K^g	**re-generated goods - recycling**
K^c	**reproducible goods – consumption**

Other (capital) stocks

E	**emissions (concentration)**
N	**natural capital**
R^r	**renewables resources**
R^e	**exhaustible resources**

(Technological) Knowledge stocks

Stocks of (technological) knowledge

T^q	**reproducible goods – production**
T^g	**re-generated goods - recycling**
T^c	**reproducible goods – consumption**
T^e	**emissions**

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Investment activities

Investment activities

i^q	**reproducible goods – production**
i^g	**re-generated goods - recycling**
i^c	**reproducible goods – consumption**
i^k	**knowledge goods**

Production in companies

Production in companies

q	**reproducible goods – production**
g	**re-generated goods - recycling**

$$q = q(K^q, L^q, T^q, e^q)$$

$$g = g(K^g, L^g, T^g, e^q)$$

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Production in households

Production in households

s **consumer services – household production function (housing, nutrition, mobiity, information)**

$$s = s(c, K^c, L^c, T^c, e^c)$$

Investment activitites

Investment activities

i^q	**reproducible goods – production**
i^g	**re-generated goods - recycling**
i^c	**reproducible goods – consumption**
i^k	**knowledge goods**

Flow equilibria

Flow equilibrium

Flows of demand and supply include recycling

$$c + i^q + i^g + i^c + i^k = q + g$$

Stock equilibria (1)

Reproducible capital

$$K^q = K^q(K^q_{-1}, i^q)$$

$$K^g = K^g(K^g_{-1}, i^g)$$

$$K^c = K^c(K^c_{-1}, i^c)$$

Stock equilibria (2)

(Technological) Knowledge capital

$$i^{k} = i^{kq} + i^{kg} + i^{kc}$$

$$T^{q} = T^{q}(T^{q}_{-1}, i^{kq})$$

$$T^{g} = T^{g}(T^{g}_{-1}, i^{kg})$$

$$T^{c} = T^{c}(T^{c}_{-1}, i^{kc})$$

Stock equilibria (3)

Stock of emissions (concentrations)

$$e = e^{q} + e^{g} + e^{c}$$

$$E = E(E_{-1}, e)$$

Measuring welfare

Welfare from flows and stocks

s	**consumer services (flows)**
E	**emissions (concentrations – stock)**
N	**natural capital (stock)**

$$W = W(s, E, N)$$

Indicators

E	**emissions**
N	**natural capital**

Modeling decision mechanisms

Mechanism

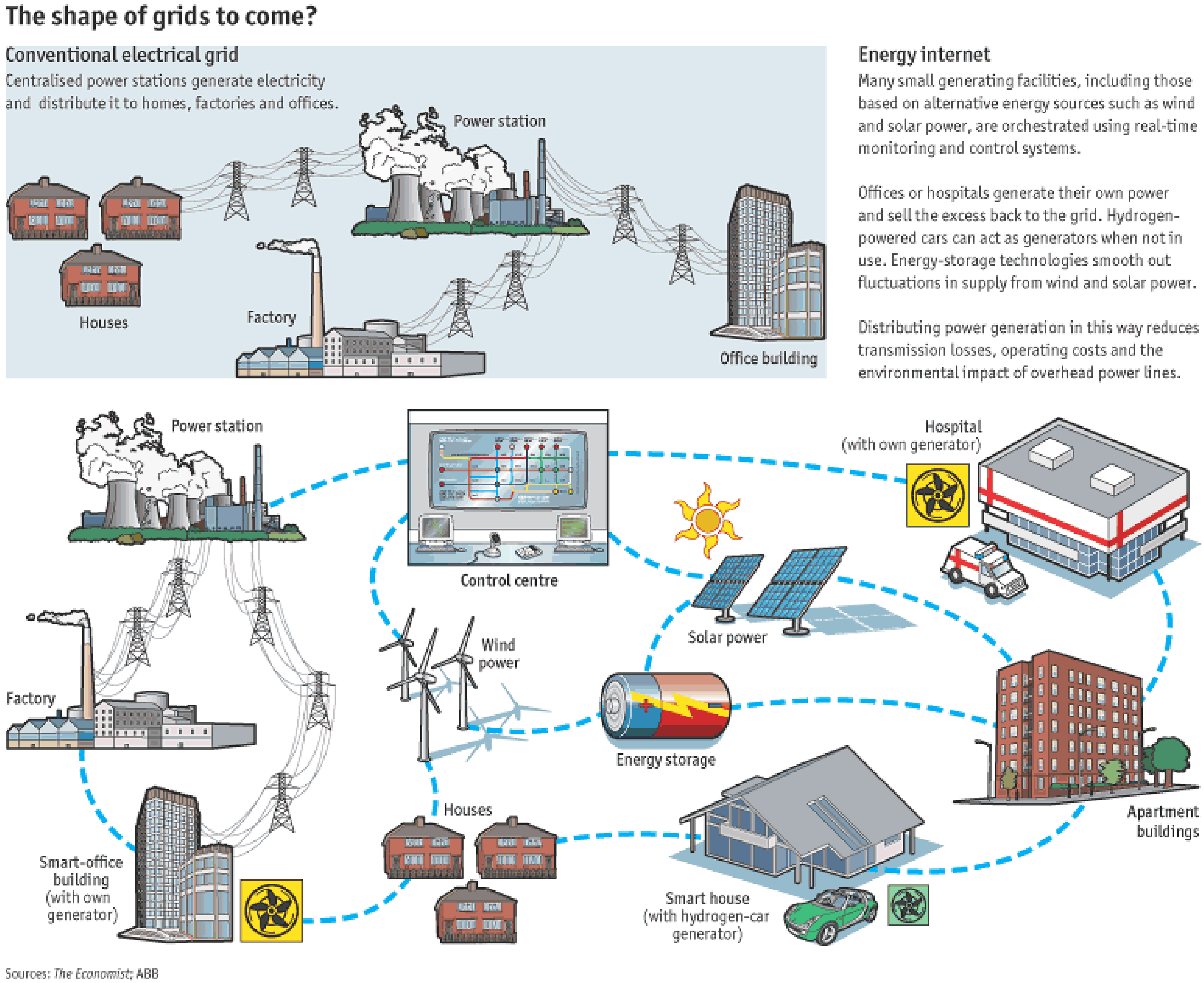
- Price decisions
- Non-price decisions

Decisions

- Consumption
- Investment
- Production

An example

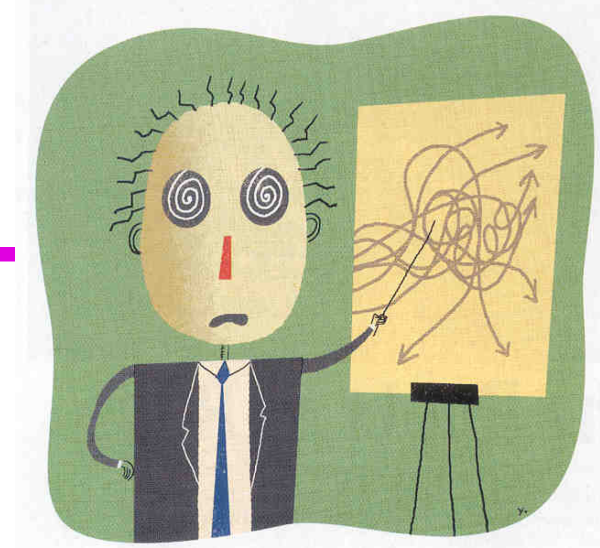
An internet structure for electricity and heat



Lessons to be learnt
How to deal with the “very long” run

- **Forward-looking perspective for technological change**
  - **What are the feasible paths for the penetration of certain technologies?**
  - **Which path should be chosen?**
  - **What are the the adequate instruments?**

- **Structures before strategies**
  - **There are no markets for the “very long” run**
  - **Innovative instruments are needed**



An economics limerick

Folks came from afar just to see
Two economists who'd agreed to agree.
While the event did take place.
It proved a disgrace;
They agreed one plus one adds to three.

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“Practical men … are usually the slaves of some defunct economist.”

John Maynard Keynes (1936)

Thank you.

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