Carbon Taxes vs. Carbon Trading

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INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Working Group III
Mitigation of Climate Change

WMO UNEP

P I K

Technische Universität Berlin

The Climate Change Problem

Market externality on the largest scale seen by humankind

- Long persistence (>1000 years) of warming & ocean acidification from anthropogenic CO_2 emissions
- Large-scale global impacts with possibility of abrupt climate change
- Mitigating CO_2 emissions requires innovation and restructuring of long-lived capital stocks ➔ long lead time for mitigation

Economic instruments to internalize „social costs of carbon“

Carbon tax vs. cap-and-trade of carbon emissions

Outline

1. **Putting a Price on Carbon: Carbon Tax vs. Cap & Trade**
   – *Price instruments and the Green Paradox*
   – *Quantity instruments and the Carbon Budget Approach*

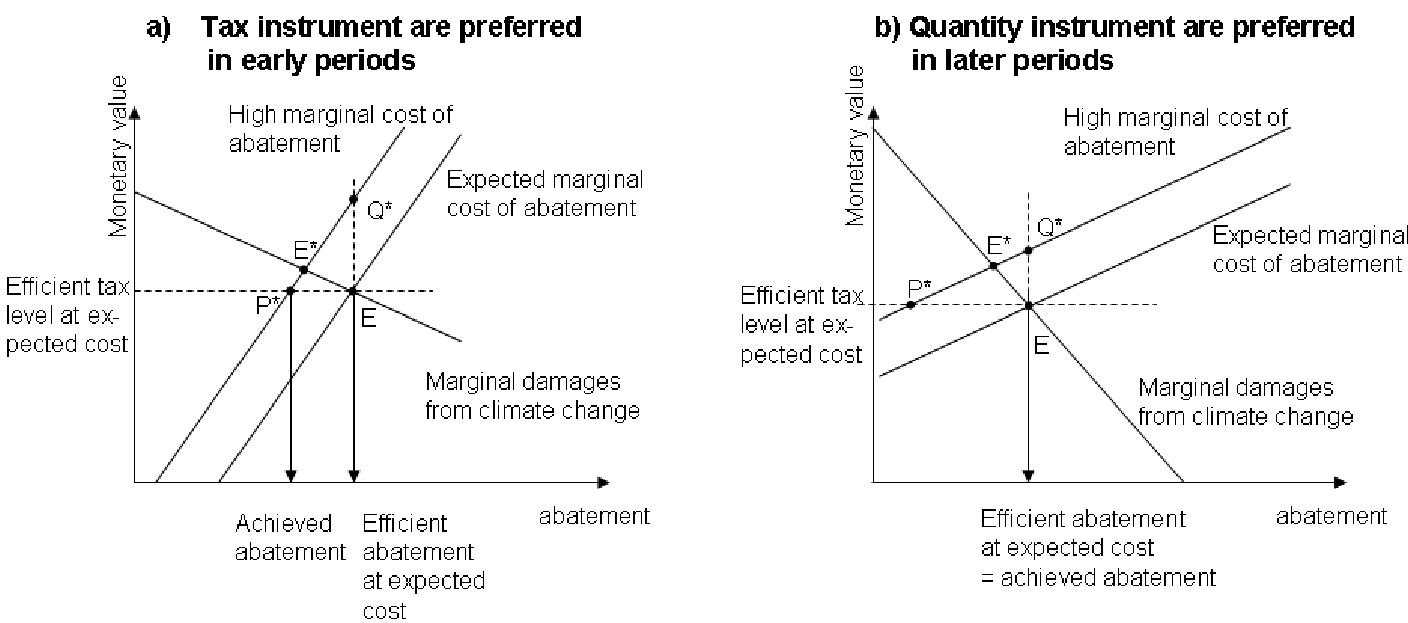
2. **International Carbon Markets and Lessons from EU ETS**

3. **Technology Policy**

4. **Options and Opportunities for China**

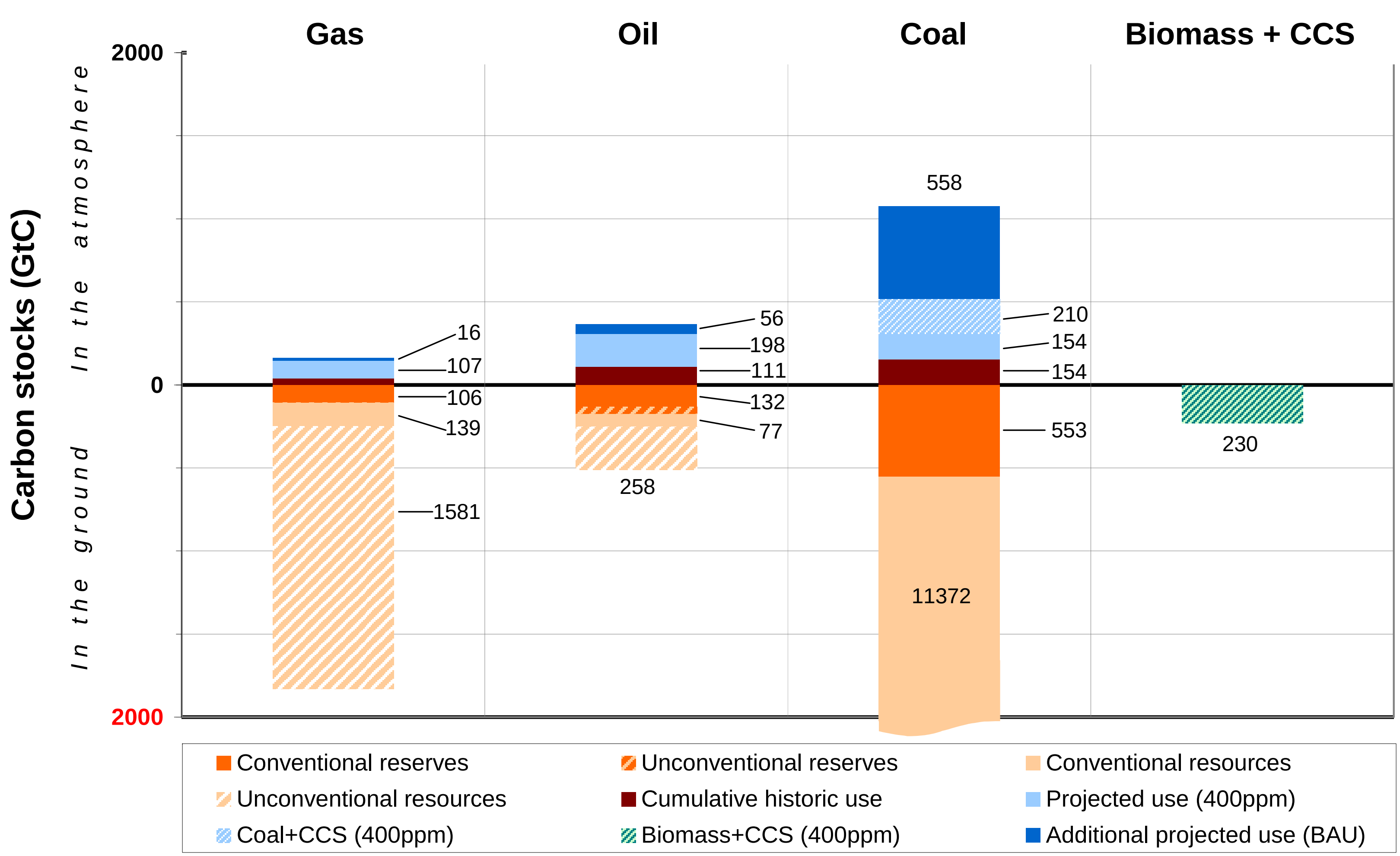
Why Weitzman is the Wrong Framework

- Weitzman criteria for static pollution problem
  - **Dynamic stock-pollutant** problem: Quantity instrument performs better in the long run (Newell and Pizer 2003)



- Weitzman does not consider **supply-side dynamics** and strategic behavior: Green paradox (Sinn 2008)

The Supply-Side of Global Warming



Cumulative historic carbon consumption (1750-2004), estimated carbon stocks in the ground, and estimated future consumption (2005-2100) for business-as-usual (BAU) and ambitious 400-ppm-CO2-eq. scenario.

Ottmar Edenhofer
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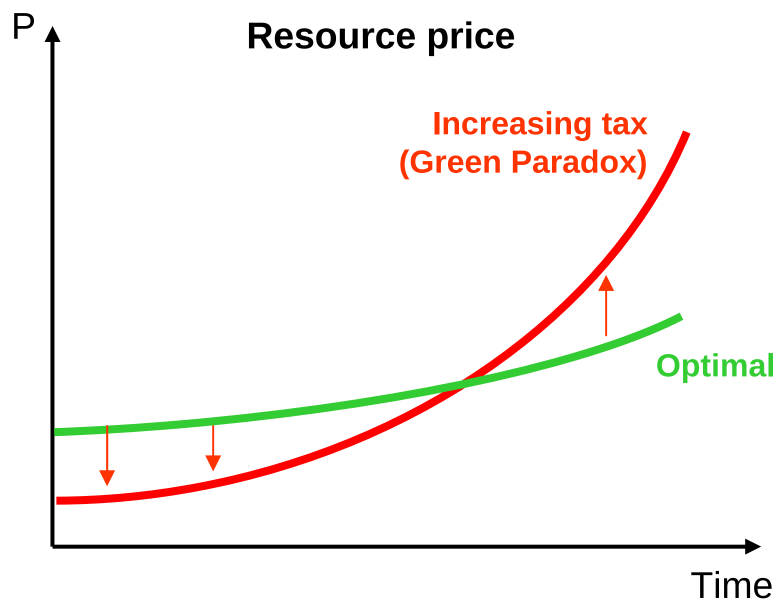
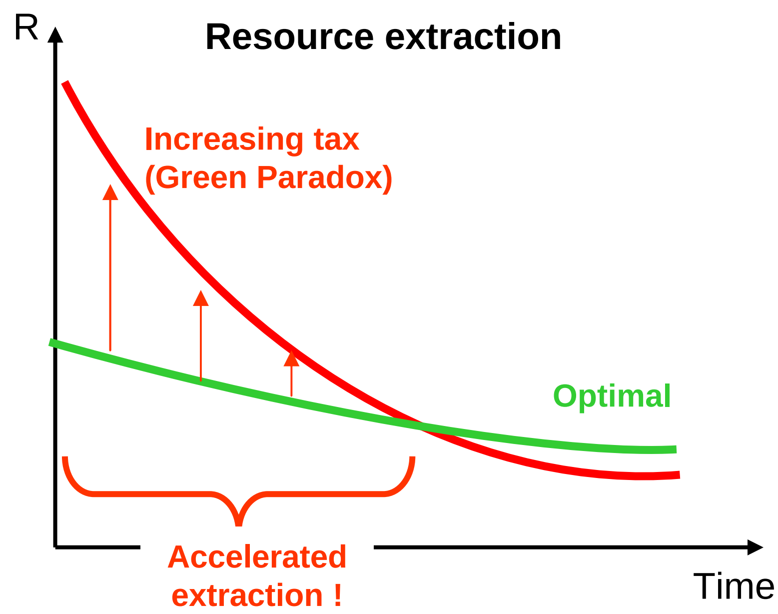
Source: Kalkuhl, Edenhofer and Lessmann 2009

Lessons from the “Green Paradox”

- Increasing resource taxes change time path of net resource price
  - time-path of extraction is changed
  - Pigouvian taxes on emissions work similar to resource taxes





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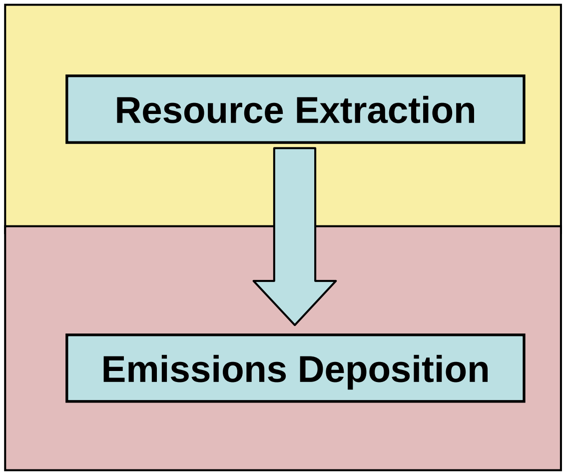


Conventional Pigouvian tax

Dynamic (non-linear) Pigouvian tax

Decreasing cash flow tax or subsidies on non-extraction

Capital source tax

Emissions trading scheme

Conventional Pigouvian tax cannot solve the incentive problem for stock-pollutant ➔ inefficient

***i*-th resource owner's problem:**

$$\max_{R_t^i} \int_0^\infty (p_t - g^i(S_t^i) - \tau_t) R_t^i e^{-rt} dt$$

p – resource price
R – fossil resources
S – resource stock
g – extraction costs
τ – unit tax

Pigouvian tax:

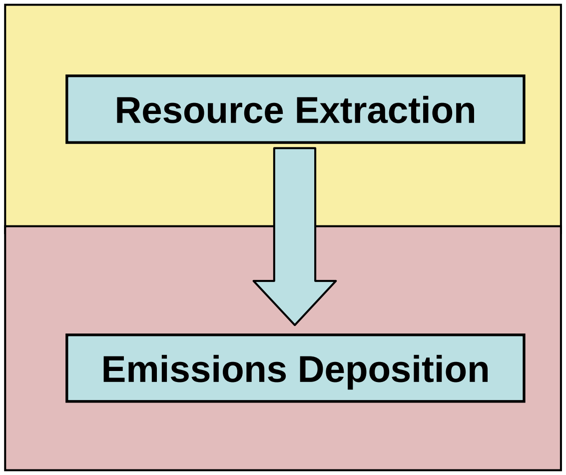
$$\tau_t = \tau(S_t) = \frac{f_S}{r}$$

How do resource owners anticipate the change of τ?

Pigouvian tax changes with aggregated, cumulative extraction!

But resource owners do only see a weak (or even no) relation between individual extraction and aggregated extraction

Lessons from the “Green Paradox“



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Hotelling rule for the *i*-th resource owner with *n* identical resource owners and conventional Pigouvian tax:

$$r = \frac{\dot{p} + f_S + \frac{f_{SS}}{r}\frac{n-1}{n}R}{p - g(S)}$$

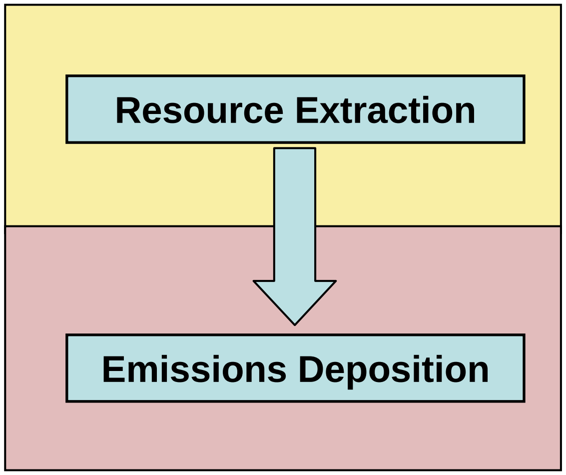
Suboptimal extraction path (“Green Paradox”)

- Acceleration of extraction due to $f_{SS}<0$
- Tax is inefficient and ineffective
- Resource sector suffers from internal public good problem with respect to $\tau(S_t)$

$$\tau(S_t) = \tau\left(\sum_{i=1}^{n} S_t^i\right) = \frac{f_S\left(\sum_{i=1}^{n} S_t^i\right)}{r}, \qquad \dot{S}_t^i = R_t^i$$

n=1	Correct anticipation of damages Tax as feedback instrument	$r = \frac{\dot{p} + f'_S}{p - g}$
n=∞	Only time-path is anticipated Tax as open-loop instrument	$r = \frac{\dot{p} + f_S + \frac{f_{SS}}{r}}{p - g(S)}$

Lessons from the "Green Paradox"



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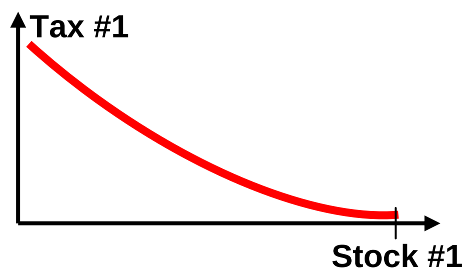
Dynamic (non-linear) Pigouvian tax is optimal, but difficult to implement

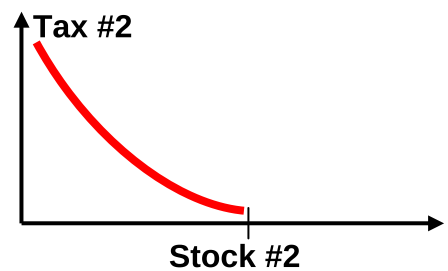
$$\tau(S_t^i) = \frac{f_S(nS_t^i)}{r}$$

Pigouvian tax for i-th resource owners
(*n* identical resource owners)

- Tax changes with individual cumulative extraction
- Resource owners have to anticipate dynamic tax rule

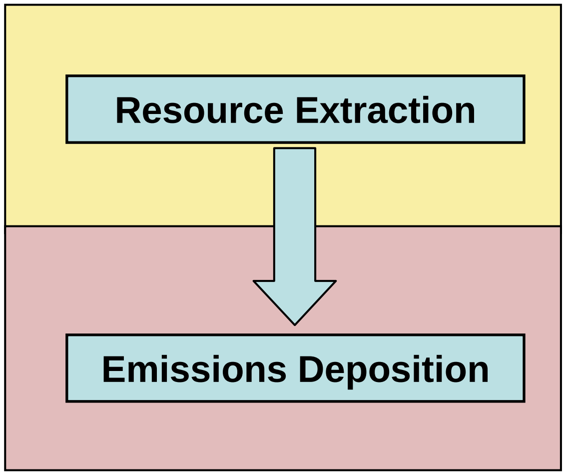


Resource owner #1:
Big resource stock



Resource owner #2:
Small resource stock

Lessons from the "Green Paradox"



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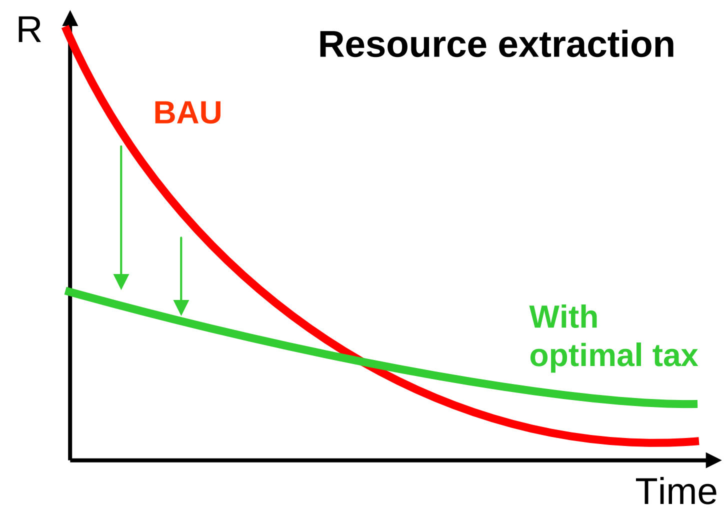
Decreasing cash flow tax or subsidies on non-extraction: Commitment and calculation problems

$$\dot{\theta}_t = \frac{-f_S^{*}}{p^{*} - g(S^{*})}(1-\theta_t) < 0$$

Capital source tax: Limited effectiveness and distortions on capital markets.

$$\upsilon_t = \frac{f_S}{r(p - g(S))}$$



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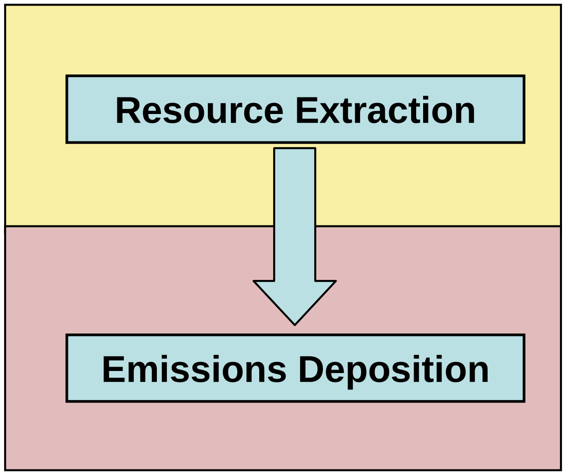

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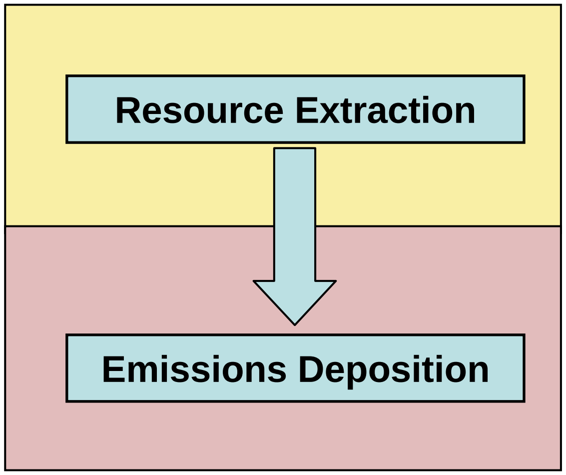
Emissions trading scheme

- Carbon price depends on strategic behavior of the fossil resource sector („Green Paradox“)
  - Resource owners anticipate tax path and change their extraction
  - Internalizing of damages is not feasible
  - Increasing taxes could lead to accelerated depletion (as future revenues are cut)

- Government would permanently have to modify the tax to account for economic and strategic uncertainties
  - Daunting informational requirements and reduced planning security for private sector

➔ Emissions trading scheme – an alternative ?

Lessons from the “Green Paradox“



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Emissions trading scheme (ETS):

- Determines aggregated extraction path
- But leaves freedom for resource owners:
  - Which resources to extract (coal, oil, gas, conventional/unconventional)?
  - When to extract (if intertemporal flexibility is implemented)?

➔ How to determine caps?

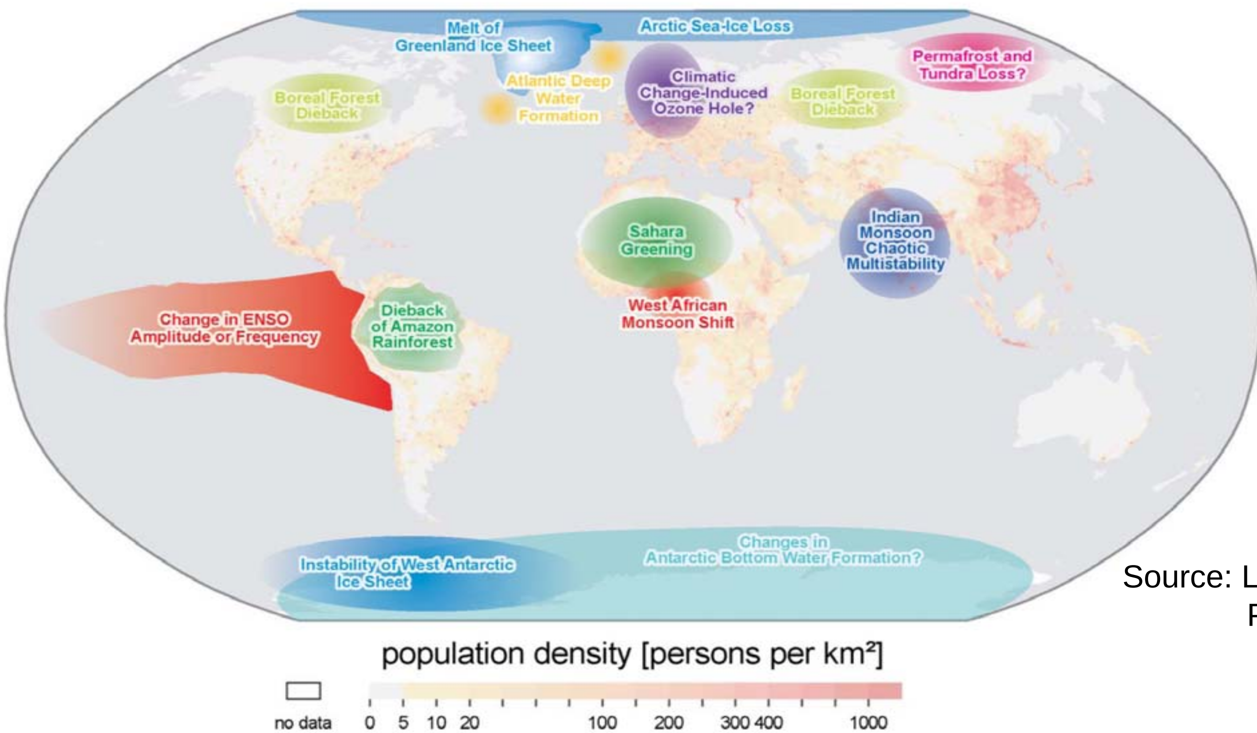
➔ How to organize intertemporal permit trade?

➔ What happens to the resource rents?

... to be explored in the following

Can We Assess the Social Cost of Carbon?

- Monetary valuation of benefits often unfeasible
- High uncertainties which are very difficult to quantify
- Possibility of tipping elements

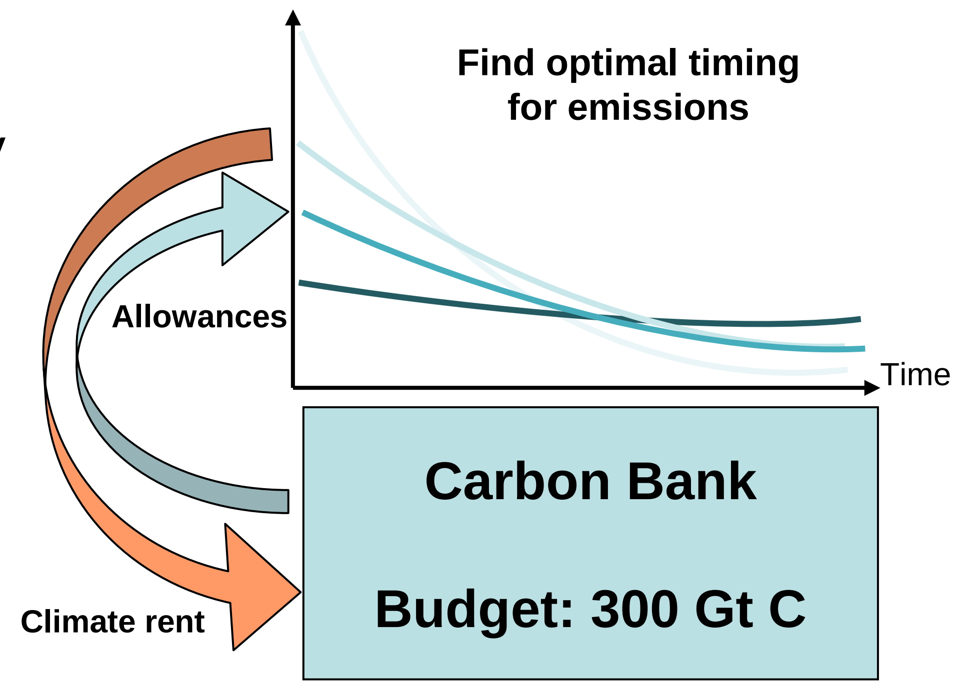


Source: Lenton et al., 2008, PNAS 105(6)

➔ Cost-benefit-analysis (or „social cost of carbon“) is not well-suited for climate change problem.

Emissions Trading for Optimal Depletion of Carbon Budgets

- National „Carbon bank“:
  - guarantees long-term credibility of the budget
  - provides public information
  - regulates timing of permit use
  - manages climate rent



- Banking and borrowing allows for time-flexibility
  - hedge against uncertainties by establishing futures markets
  - reduce volatility in permit markets
  - capital source taxes flatten the permit price path (Hotelling)

The Carbon Budget Approach

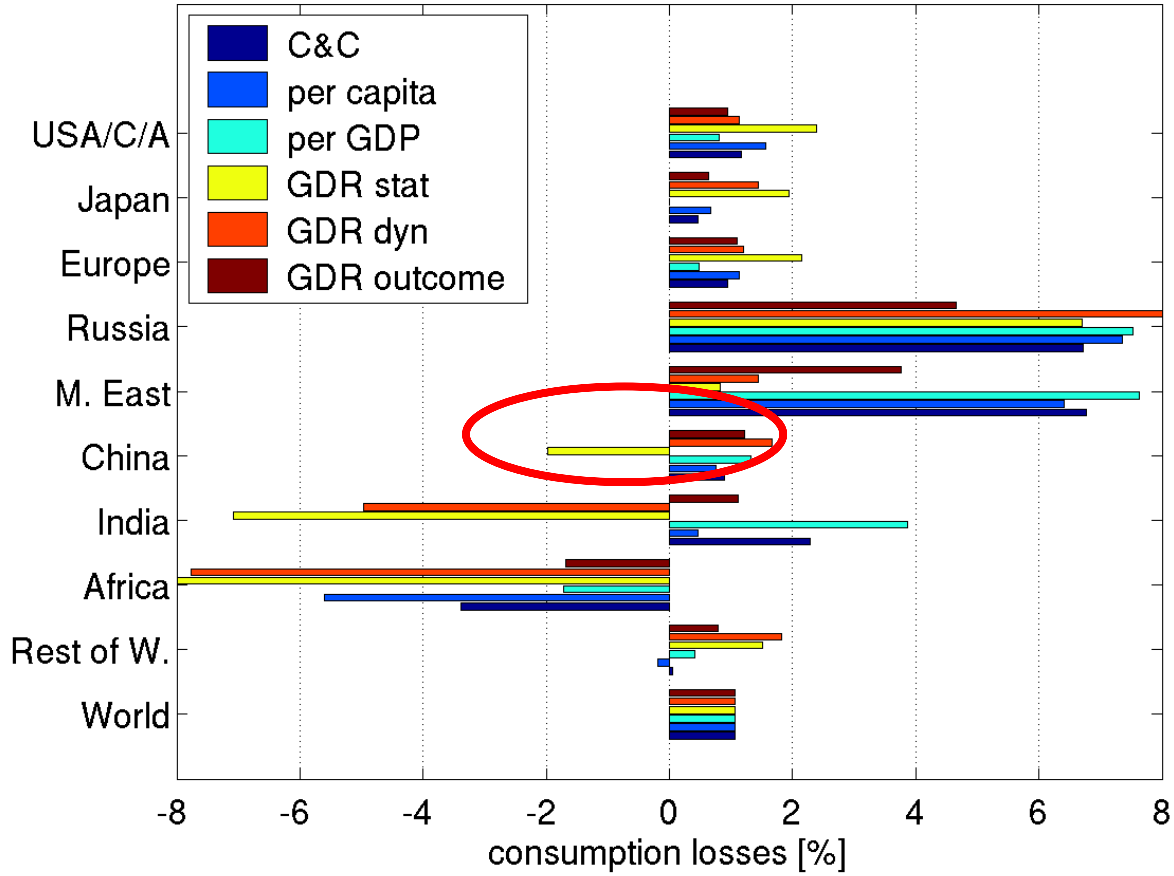
Global budget: 850 $GtCO_2$ for the rest of the 21st century (*in order to achieve the 2℃ target*)

- ETS with full coverage guarantees environmental target and cost-efficiency
- Permit prices reflect “depletion” of the budget (Hotelling price)
- Resource rent is transformed into a climate rent
- There is no room left for strategic resource extraction (no „Green Paradox“)

Global budget can be divided into **national budgets**

The Carbon Budget Approach

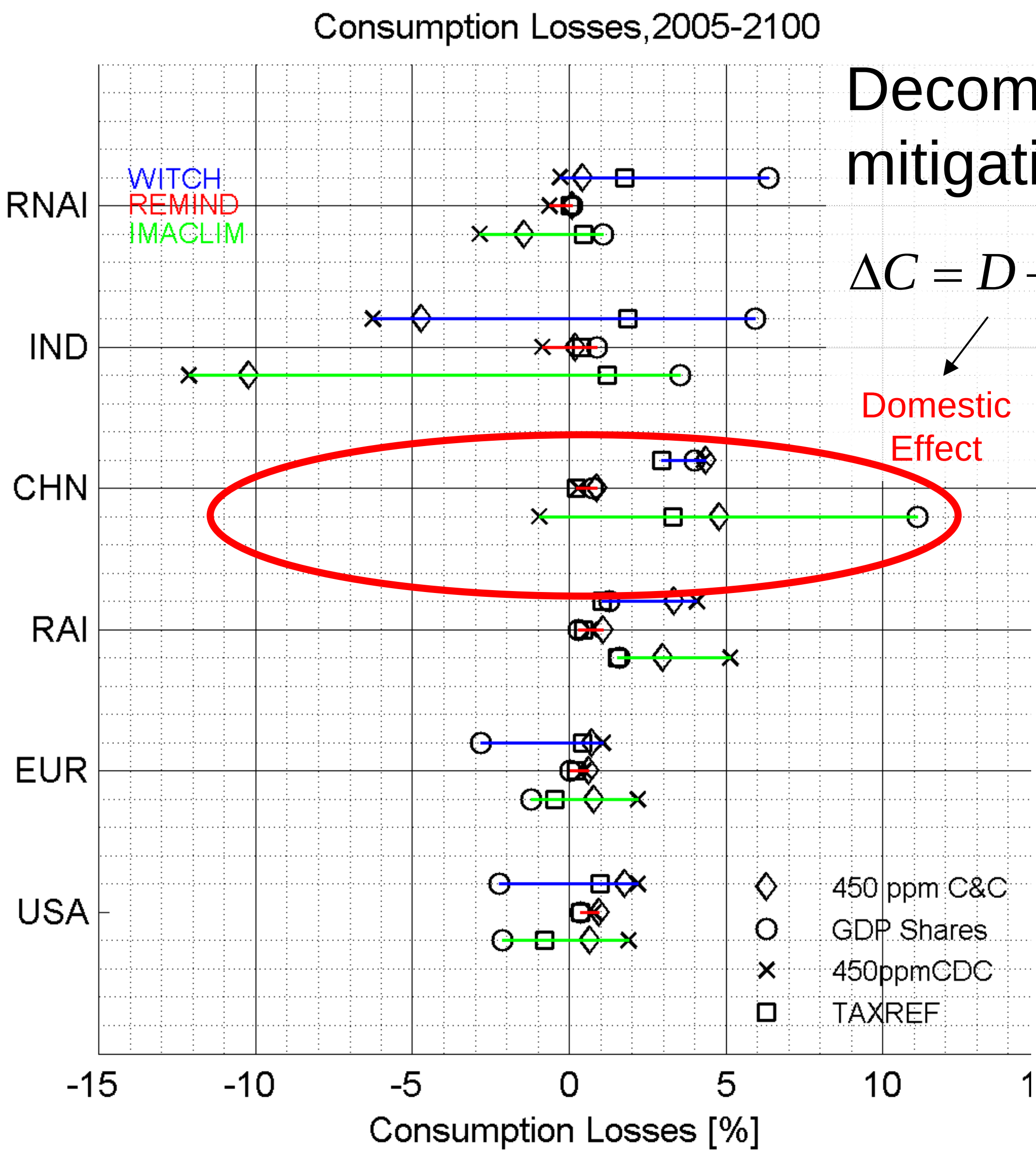
- **National budgets:** distribute mitigation costs



2005-2100, discounted at 5%

Source: Flachsland et al. 2009

Allocation rules and regional distribution of mitigation costs



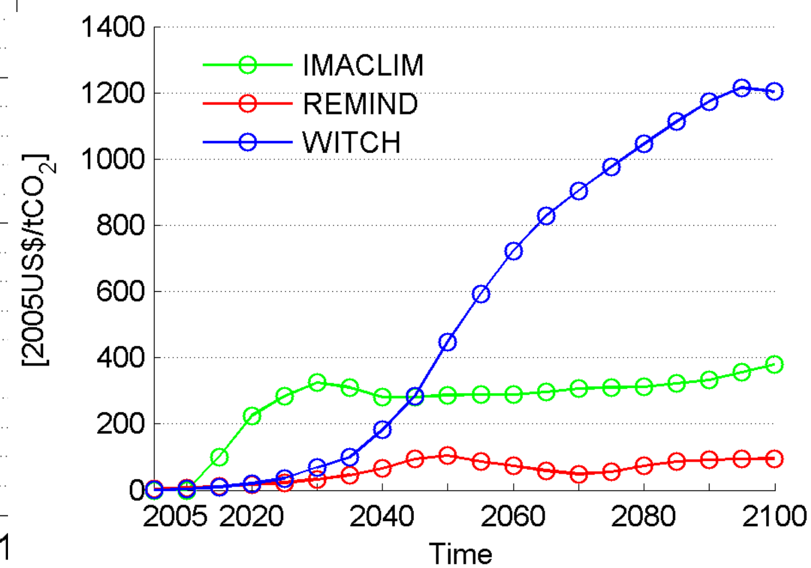
Decomposition of regional mitigation costs:

$$\Delta C = D + T + \int_{t0}^{T} \exp(-\rho t)(A(t) - E(t))\, p(t)\, dt$$

Domestic Effect

Energy Trade Effect

Carbon trade balance



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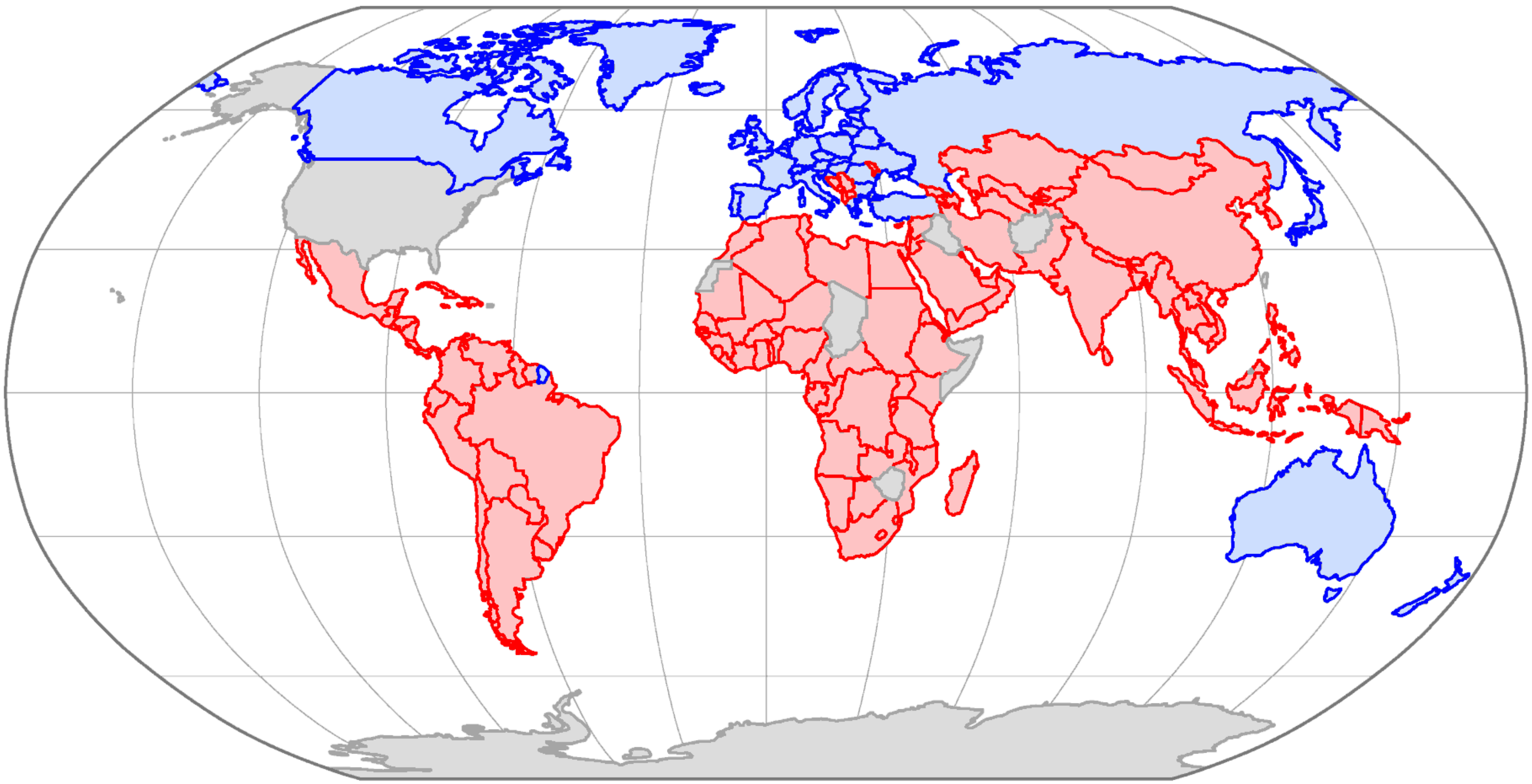
Top-down Emissions Trading: Kyoto Today

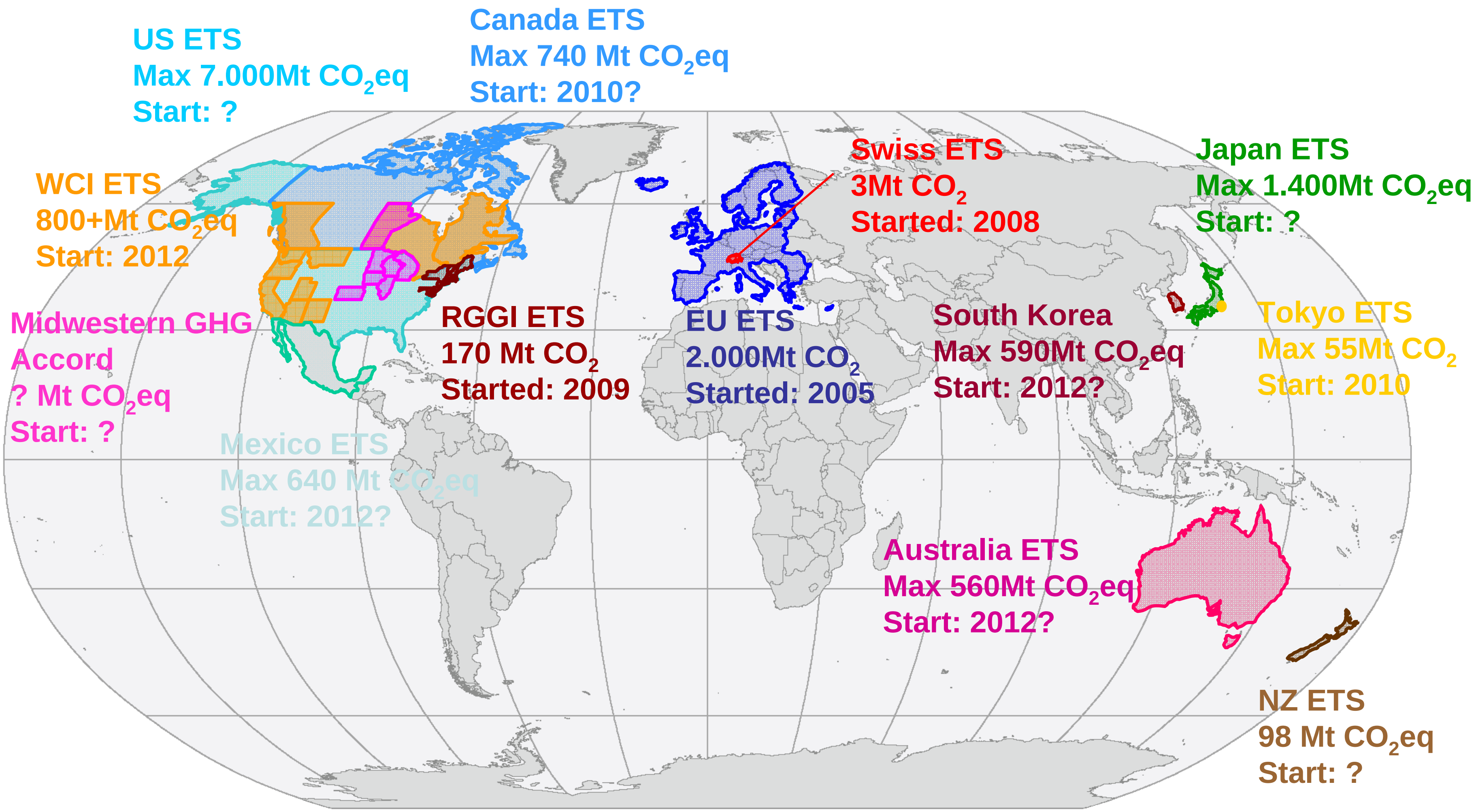
Annex-I: economy-wide cap and trade

Non Annex-I: no caps, CDM



Source: Flachsland 2009

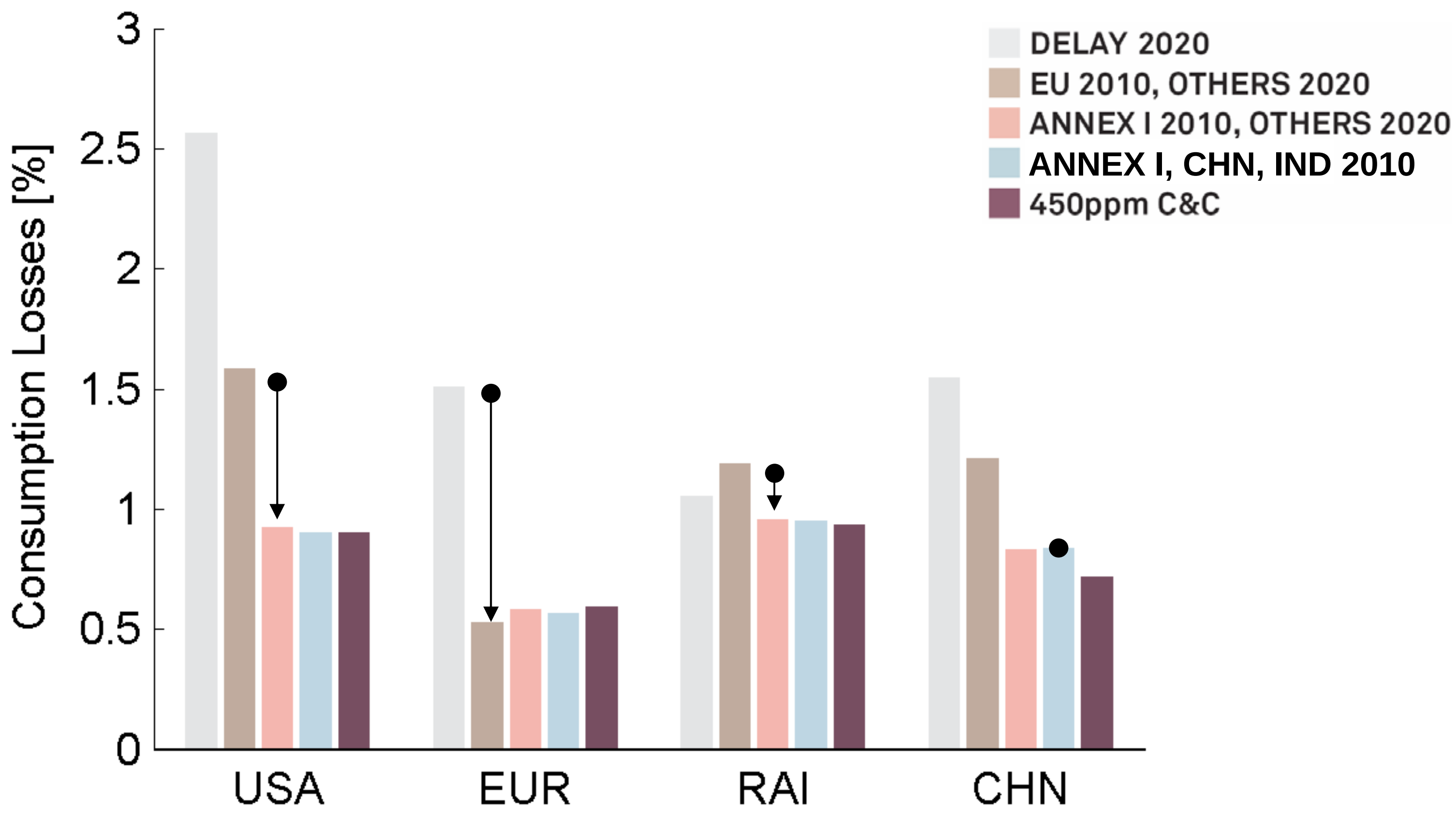
Bottom-up: Regional Cap & Trade Systems



Source: Flachsland 2009

The Value of Early Action

- In a world serious about achieving 2°C, early action is beneficial to China:



EU ETS 2013 - 2020

EU-wide cap

- 21% below 2005 levels by 2020
- Linear reduction of 1.74% annually
- Credible long-term trajectory still lacking

Auctioning principal allocation method

- 100% for West-European power sector, increasing shares for industry
- Redistribution of auctioning quotas to poorer member states
- Harmonized rules for benchmarking

Coverage extended to include

- Aviation, petrochemicals, ammonia, and aluminum
- 2 additional GHGs
- Around 50% of all EU GHG emissions

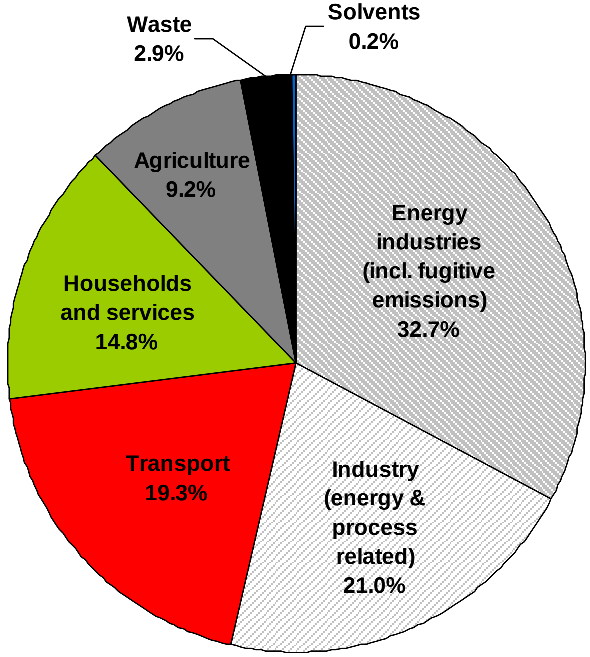
Non-trading sectors

- Road transport, buildings, agriculture, and waste still excluded from ETS
- Sectors required to reduce emissions by 10% by 2020

EU ETS 2013 - 2020

Total EU-27 greenhouse gas emissions by sector, 2006

(Source: European Environment Agency)



EU ETS covers 2.02 GtCO2 or ~40% of total

Coverage extended to include

- Aviation, petrochemicals, ammonia, and aluminum
- 2 additional GHGs
- Around 50% of all EU GHG emissions

Non-trading sectors

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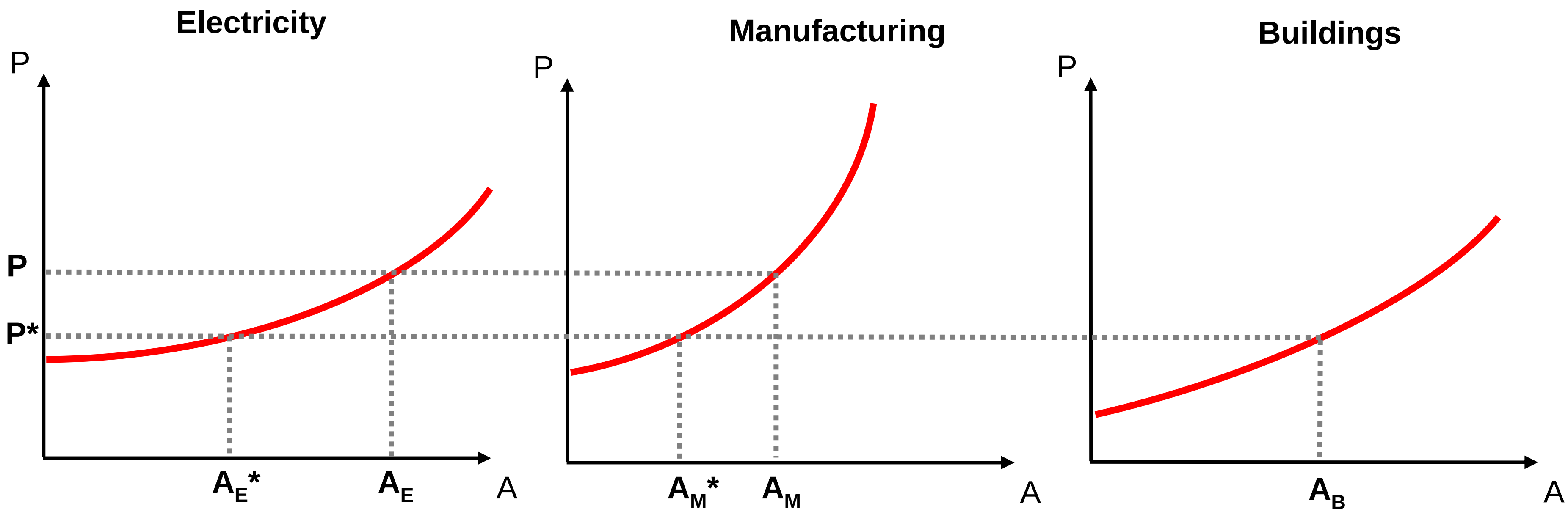
- Sectors required to reduce emissions by 10% by 2020

Broadening Sectoral Coverage Lowers Abatement Costs



Goal: Achieve a given abatement level A

- If coverage is limited to electricity and manufacturing:

  $A = A_E + A_M$ *at price P*

- If coverage is extended to include buildings:

  $A = A_E^* + A_M^* + A_B$ *at* ***lower price P****

Lessons from EU ETS

Cap

credible long-term trajectory essential for guiding investor expectation

Coverage

'broad is beautiful', including additional sectors (e.g. transportation) enhances cost-effectiveness

Allocation

auctioning superior, avoids distortions related to free allocation, generates public revenues ('double dividend')

Intertemporal flexibility

banking/borrowing likely to smooth price volatility

Price bounds

use of price cap/floor still debated, hybrid model might have advantage over pure quantity-based ETS design

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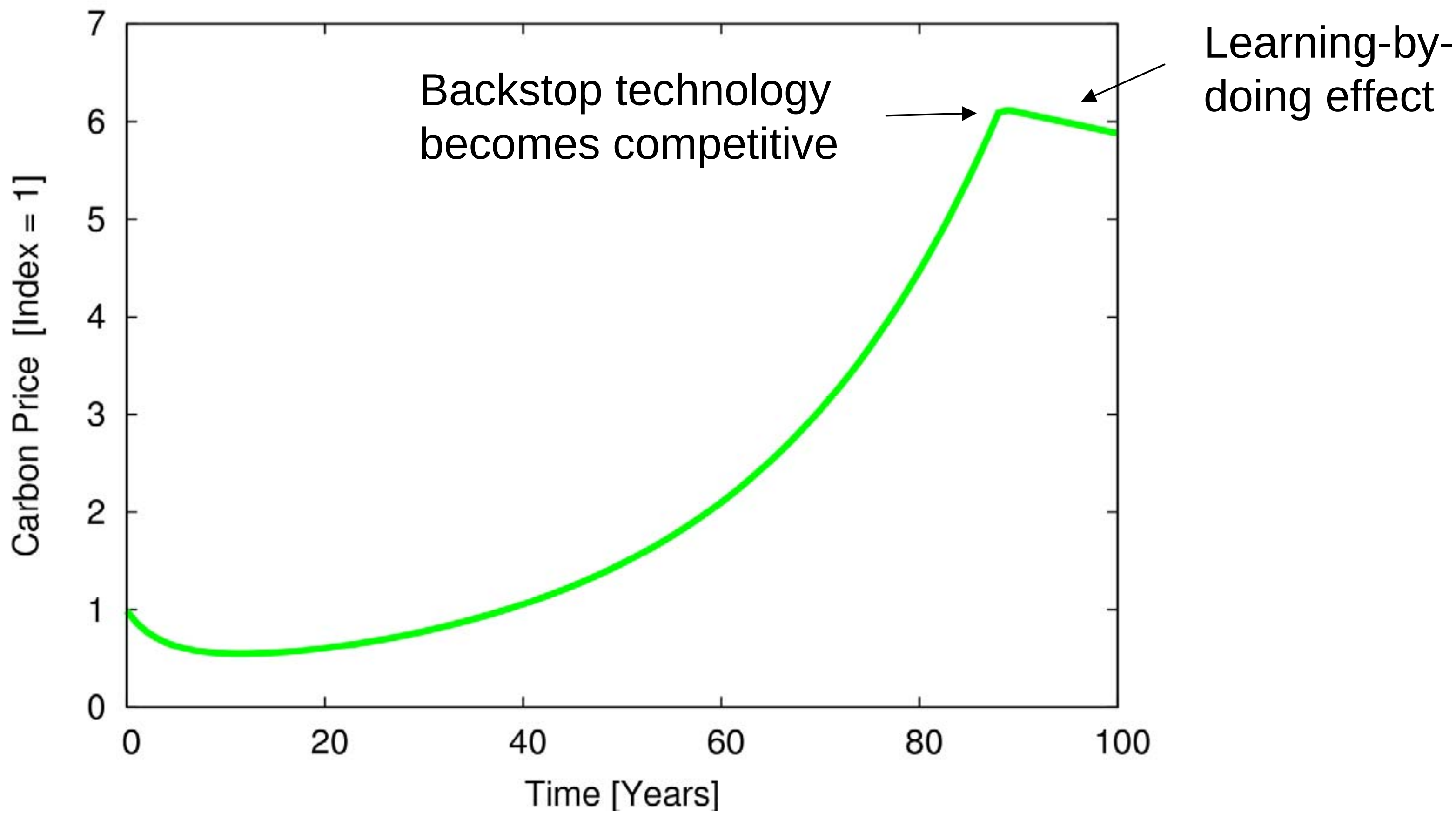
The Role of Backstop Technologies

Carbon budget approach: Increasing carbon price (Hotelling) until backstop technologies become competitive



The Need for Technology Policy

Invention

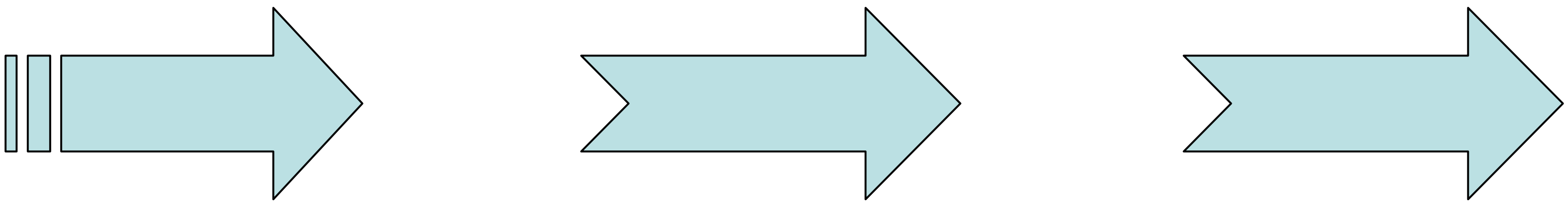
Invent new technology

Innovation

Make product competitive

Diffusion

Adoption by economy



Public R&D expenditures

stimulate inventions in new energy technologies

Production subsidies

quickly reap learning effects through capacity expansion

(e.g. feed-in-tariffs)

Information programs

promote information about mitigation technologies for consumers

Process of technological change by Schumpeter (1942)

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Emissions Trading: Major Options for China

Move beyond CDM!

(1) Economy-wide cap in global post-2012 regime (Joint Mitigation Plan)

→ Allocation determines distribution

→ Domestic policies required

(2) Domestic cap-and-trade for suited sectors

→ Ensure robust design

(3) Sectoral or economy-wide baseline-and-credit

→ Define reduction targets, profitable international sales of excess reductions

→ First step to cap-and-trade

Summary

- Credibility of commitment is of utmost importance to provoke long-term investments in low carbon technology
- Permit markets need to be regulated in order to establish stable carbon prices and long-term expectations; technology policy should complement permit markets
- Regulation should raise revenues for the state – this is automatically achieved by taxes; permits need to be auctioned
- No tax (or permit) exemptions for whole industries – this strongly reduces efficiency and raises costs
- Optimal tax is extremely difficult to calculate due to uncertainty about economic parameters and strategic behavior in the resource sector
- Emissions trading under a fixed carbon budget guarantees ecological integrity despite uncertainties in economic parameters and strategic behavior of resource owners

Conclusions

- Early action might be beneficial to China in a world which is serious about achieving ambitious emission reductions.
- Initiate model comparison project to systematically explore welfare impacts of economy-wide cap for China under different allowance allocation regimes
- Consider economy-wide, sectoral cap-and-trade and baseline-and-credit: emission targets and institutions