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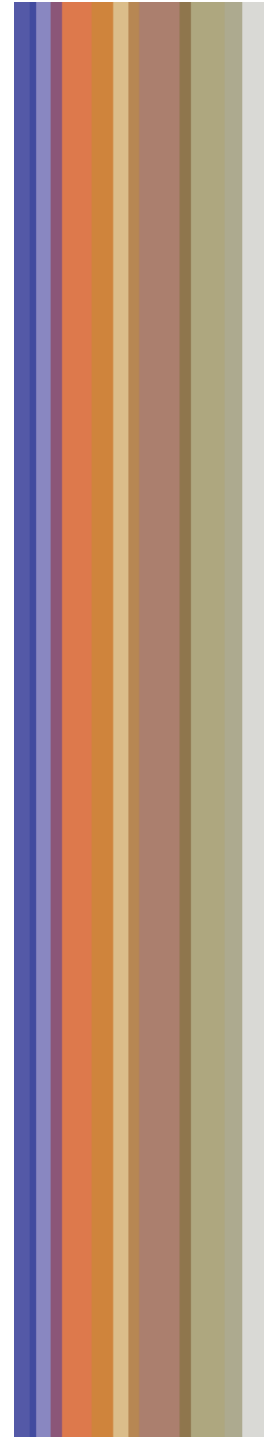
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Technology Deployment and Innovation”
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Economic and Environmental Effectiveness of a Technology- based Climate Protocol

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- **Current climate regime:**
 - **lack of several key players**
 - **low environmental effectiveness**
- **At the same time:**
 - **emergence of additional / parallel coalitions;**
 - **strong focus on technologies**

Where are we going to?

- Strengthened need to **increase environmental effectiveness** of international climate architecture
 - **2 main steps necessary:**
 - increase in **number of cooperating countries**
 - increase in **stringency of abatement target**
 - Number of recent proposals on climate change policy address both issue of **participation incentives** and issue of long-run **costs of effective abatement**
- ⇒ **Explore one of the proposals on a possible future scenario: a *technology-based climate protocol***

Main question:

Can a climate regime in which countries only cooperate on technological innovation and diffusion (thus, on a quasi-club good), without any binding emission targets, induce a higher environmental effectiveness?

Motivation

- **Policy proposals** suggest to replace international GHG cooperation with international cooperation on climate-related technological innovation and diffusion
- **Theoretical studies** show crucial role of R&D in the context of countries' preferences to cooperate
- **Importance in real world:**
 - US base their Kyoto alternative, the Climate Change Initiative, on technological innovation; bilateral initiatives
 - EU has signed science and technology cooperation agreements with almost 30 countries
 - Japan: several joint research initiatives
 - Asia-Pacific Partnership on Clean Development and Climate
 - **YOUR** experiences

Steps

➤ **Background:**

- Barrett (2001, 2002) and Benedick (2001) proposals
- Theory: cooperation on **private (quasi) club goods, as R&D or trade, induce excludable benefits**

➤ **Analysis of two possible scenarios:**

- technological cooperation among “traditional” Kyoto countries (US, EU, JPN and FSU)
- global technological cooperation

➤ **Strategy:**

empirical analysis of economic incentives (self-enforcing?) and environmental effectiveness related to a technology-based climate regime wrt current scenario

Methodology and main assumptions

- **Focus on Post Kyoto: 2010-2100; economic incentives**
- **Game-theoretic framework**; concept of profitability and stability (Carraro and Siniscalco, 1993)
- **Quantitative assessment** through simple **integrated model: FEEM-RICE** with endog./induced technical change
 - Players optimally set the intertemporal values of three strategic variables - investments, R&D expenditure and abatement rates - that maximise the present value of per capita consumption
 - version 1 (Nordhaus and Yang, 1996): stock of knowledge, cumulated through R&D investments, affects both factor productivity and the emission-output ratio (LbR); plus international spillovers
 - version 2 (Nordhaus and Boyer, 2000): TC more sophisticated (LbR, LbD) - emission reduction takes place through both energy-saving and fuel-switching effects

A technology-based climate regime

Proposal by Barrett (2001, 2002), Benedick (2001):

- **Kyoto Protocol:**
poor incentives for participation and compliance
- **Alternative climate regime:**
based on common incentives for climate-friendly R&D

In particular:

- co-operative funding of basic R&D with respect to energy-saving, environmental-friendly technologies
- implementation of standards directed towards the world-wide adoption & diffusion of new technologies
- global R&D fund

A technology-based climate regime (2)

➤ Advantages:

- “push” and “pull” incentives, affecting both supply of R&D and the demand for fruits of R&D
- open to all countries
- strategic advantage: the more countries adopt standard, the more attractive it becomes for others to adopt the same standard
- no need for strong enforcement and monitoring

➤ Weaknesses:

- choice of “best” standards
- lock-in to a particular standard

Question

**Basic trade-off related to implementation of a technology-based climate protocol:
emission reductions ⇔ stimulus to economic growth**

- ⇒ **Applied game theory analysis necessary to verify...**
- ...whether there are actually **economic incentives** for R&D cooperation to be implemented by countries, esp. all world countries including developing countries
- ...whether such a cooperation, without cooperation on GHG emission abatement, is also **environmental effective**

- **All world countries** find it **profitable to co-operate** if a global technology-based agreement is proposed and the differential spillover is above **20%**.

In addition, the coalition which co-operates in R&D **is stable (no free-riding incentives)**.

Reason: economic benefits (“ β ”) that can be appropriated only by coalition member

- ⇒ Therefore:

Crucial issue is the **environmental effectiveness** of a coalition on R&D only

Environmental effectiveness of technological cooperation among the Annex B

Technological cooperation between Annex B countries vs. environmental cooperation between EU, JPN, FSU				
	2010		2050	
β	Percentage change of global emissions	Percentage change of aggregate emission/output ratio	Percentage change of global emissions	Percentage change of aggregate emission/output ratio
0.20	+ 12.97%	+ 12.99%	+ 48.28%	+ 47.99%
0.33	+ 12.97%	+ 12.88%	+ 48.87%	+ 48.42%
0.66	+ 13.01%	+ 12.68%	+ 48.60%	+ 47.83%
1.00	+ 13.07%	+ 12.53%	+ 48.46%	+ 47.40%
1.50	+ 13.13%	+ 12.35%	+ 48.18%	+ 46.88%

Results

- Unfortunately, **both global emissions and the emission/output ratio increase** when Annex B countries cooperate only on R&D
- Indeed: **no** cases in which technological cooperation can induce a **reduction of global emissions and/or of the emission/output ratio**
- **Effects** are even **stronger in medium term**

1. The intensified R&D efforts induce a **higher production** which in turn leads to an increase in emissions of the cooperating countries.
The emissions/output increase because the overall **impact** of accumulated R&D expenditure **on economic growth** is larger than its impact on emission abatement.
2. R&D investments in Annex B have an **impact** also on the other (developing) countries **through technological spillovers that increase output**. Average global emission-output ratio increases.
3. In the **medium term, effects** of increased R&D investments **clearer**; technological spillovers have strong effect on growth rate of developing countries

Environmental effectiveness of global technological cooperation

Global technological cooperation vs. environmental cooperation among EU, JPN, FSU			
2010		2050	
Percentage change of global emissions	Percentage change of aggregate emission/output ratio	Percentage change of global emissions	Percentage change of aggregate emission/output ratio
+ 2.19%	- 0.27%	+ 9.73%	- 3.75%

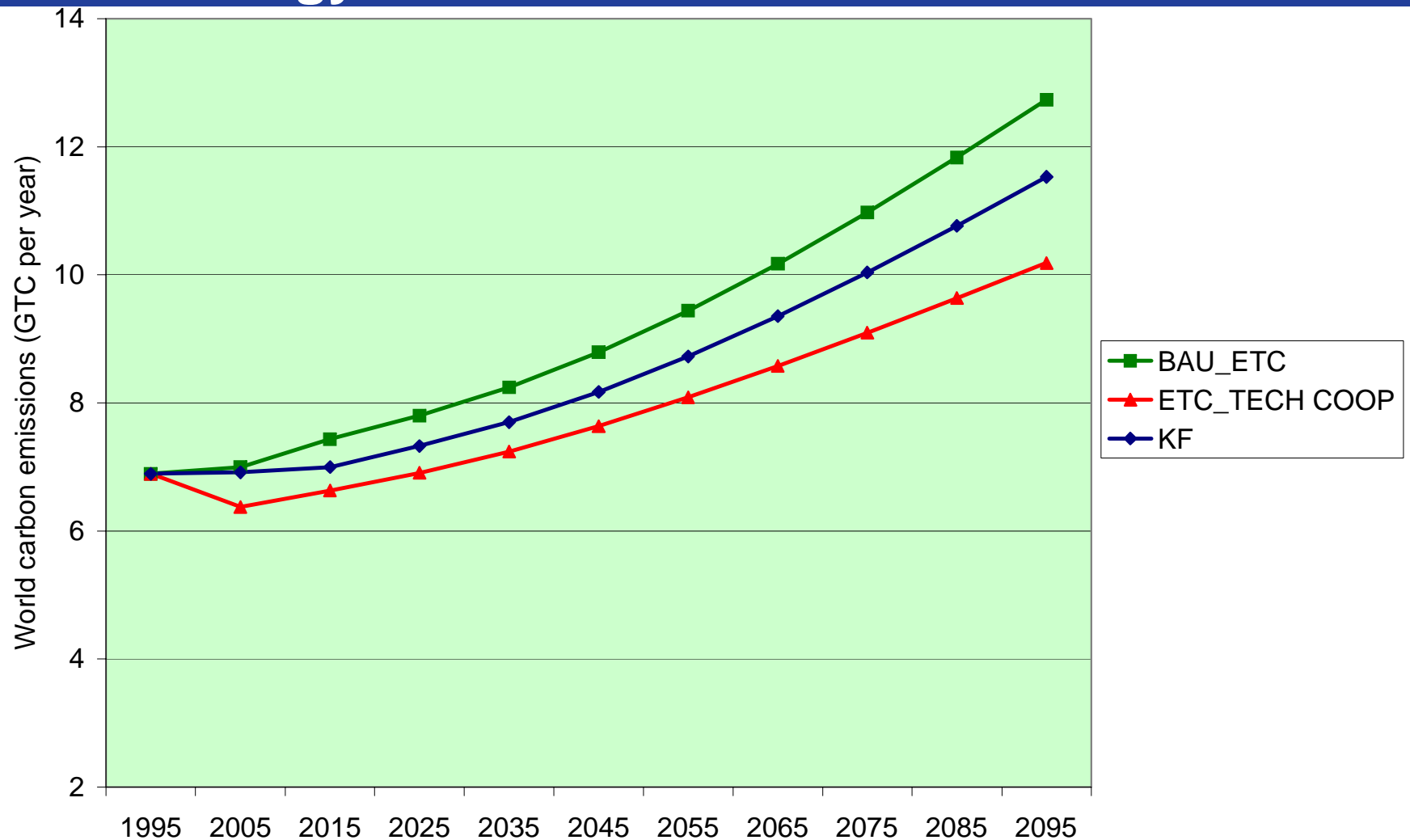
- ⇒ **Global cooperation increases the economic benefits and the environmental effectiveness of the agreement**
- ⇒ **But: total emissions in the technology-based protocol increase with respect to situation in current climate regime (less than without developing countries).**

Tentative conclusions

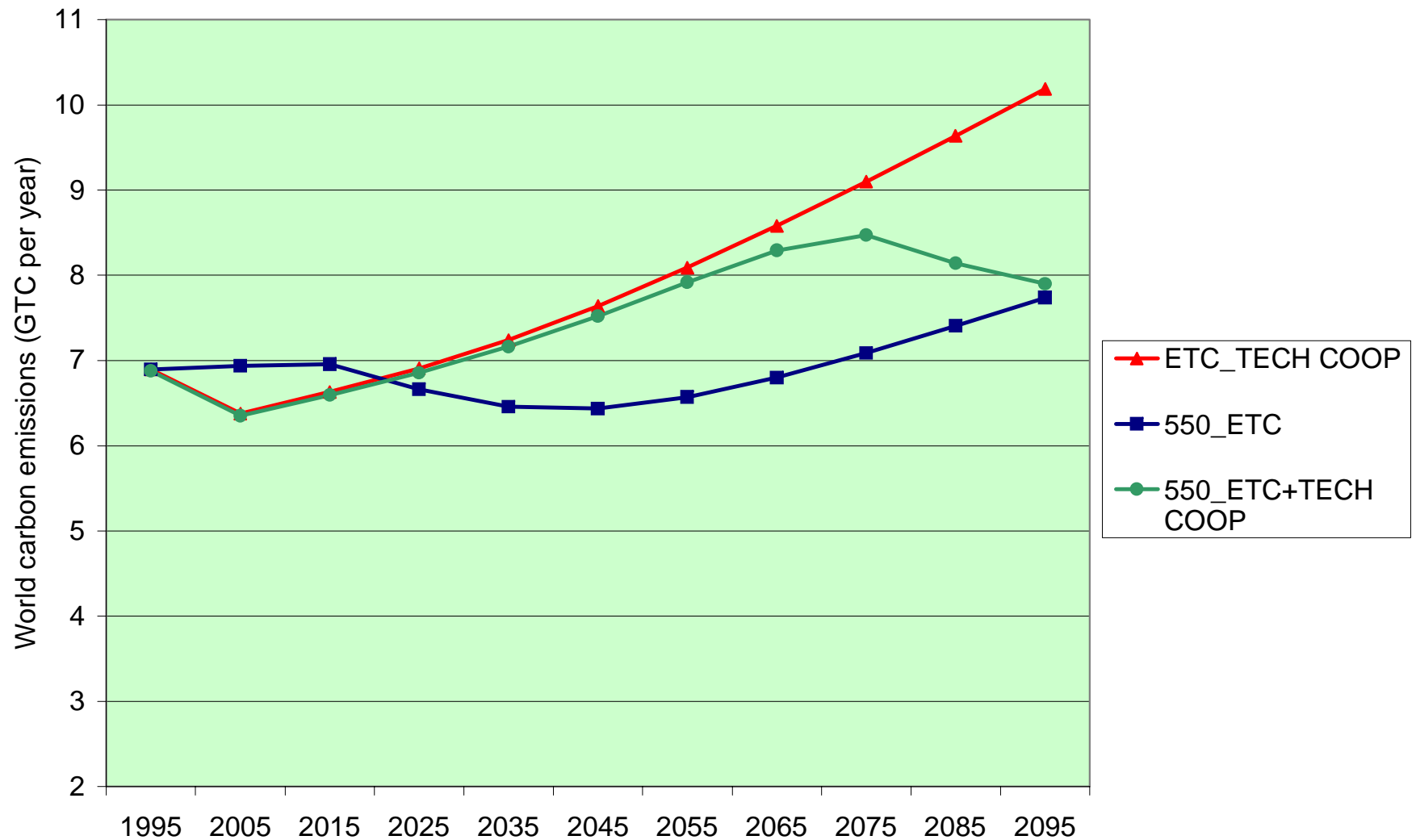
Technological cooperation cannot replace environmental cooperation.

- **Technological cooperation appears to increase R&D, growth and welfare, but also emissions.**
- **As a consequence, some environmental policy measures, to be coupled with technological cooperation, seem to be necessary to achieve an environmentally satisfactory regime.**

Further analysis: the dynamics of carbon emissions in the technology-based scenario



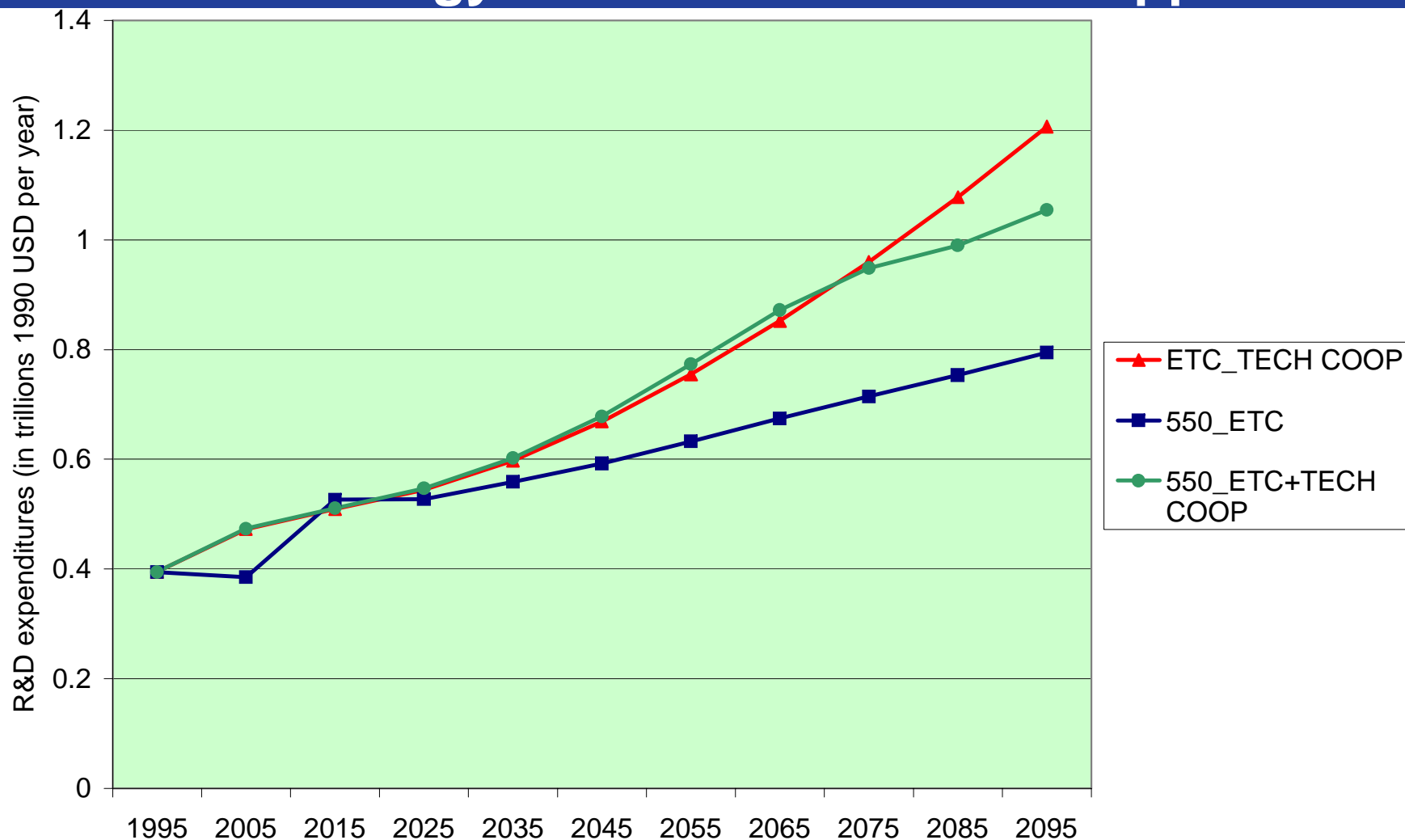
Further analysis: the dynamics of carbon emissions in the technology-based scenario wrt 550ppm case



Results

- **Technological cooperation** alone, without emission targets, **can stabilise concentrations at a level very close to 550 ppm**
- ⇒ **cooperative technology development** (independent of climate policies) drives the market in such a way as to **increase both GDP and reduce GHG intensities** (550ppm as a new reference case?)
- **Nonetheless**, in the presence of technological cooperation, **emissions are larger** than in the two cases in which an emission target is introduced.
- ⇒ presence of an **emission target lowers emissions more** than what technological cooperation alone would do
- ⇒ possible to achieve stabilisation target **with&without** technological cooperation. But: different **timing** of policy

Further analysis: the dynamics of R&D investments in the technology-based scenario wrt 550ppm case

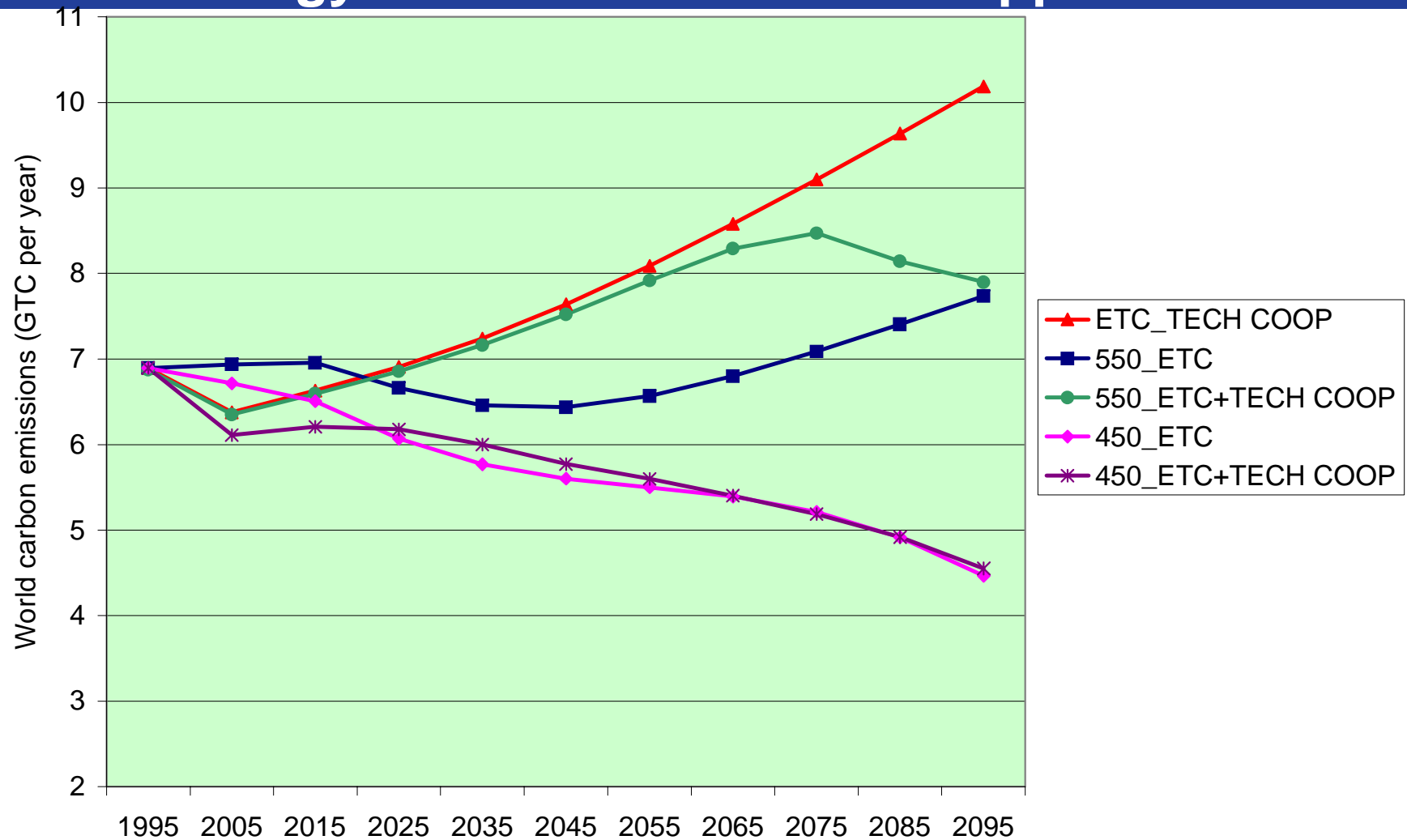


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profitable to invest in R&D and to abate early in order to exploit the benefits provided by R&D investments & related learning process

Further analysis: the dynamics of R&D investments in the technology-based scenario wrt 450ppm case



Conclusions

- 👉 A **technology- based regime is more stable** than an emission-based regime, i.e. more countries are likely to participate in such a climate regime.
- 👉 In addition, technological cooperation without emission abatement commitments **increases economic growth**.
- 👉 However, this strategy is unlikely to lower global GHG emissions, i.e. a technology-based protocol does **not** seem to be **environmentally effective**.
- 👉 Yet, using a more sophisticated model of TC, this conclusion becomes less cogent: **techn. cooperation** indeed can do **better than a “Kyoto forever” regime in reducing global carbon emissions**.
- 👉 In addition, techn. cooperation becomes less and **less important as the stringency of the stabilisation goal increases** (need for large R&D investments).

Final thoughts

- ⇒ **Measuring technological innovation is difficult ⇒ further research is needed.**
- ⇒ **Already now appears very clear:
Technological cooperation = crucial part of a successful strategy to control climate change (self-enforcing).**
- ⇒ **Environmental policies still needed.**
- ⇒ **At the same time, incentives for parallel regimes are existing.**

Final thoughts on a Technology-based Protocol

Input ⇔ Outcome?

⇒ **Both; long-term vision of where we want to go and short-term vision of which are the next promising technologies**

Push ⇔ Pull?

⇒ **Both; create supply and demand**

Cooperation ⇔ competition?

⇒ **Both; depends on specific technology field**

Evolutionary ⇔ revolutionary?

⇒ **Both; draw “constructive” lessons from past but urge people to start “fresh” thinking**

- ⇒ **Portfolio of players**
- ⇒ **Portfolio of policies**
- ⇒ **Portfolio of technologies**

Thank you for your attention!

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