Fondazione
Eni
Enrico Mattei

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Climate Change Policy

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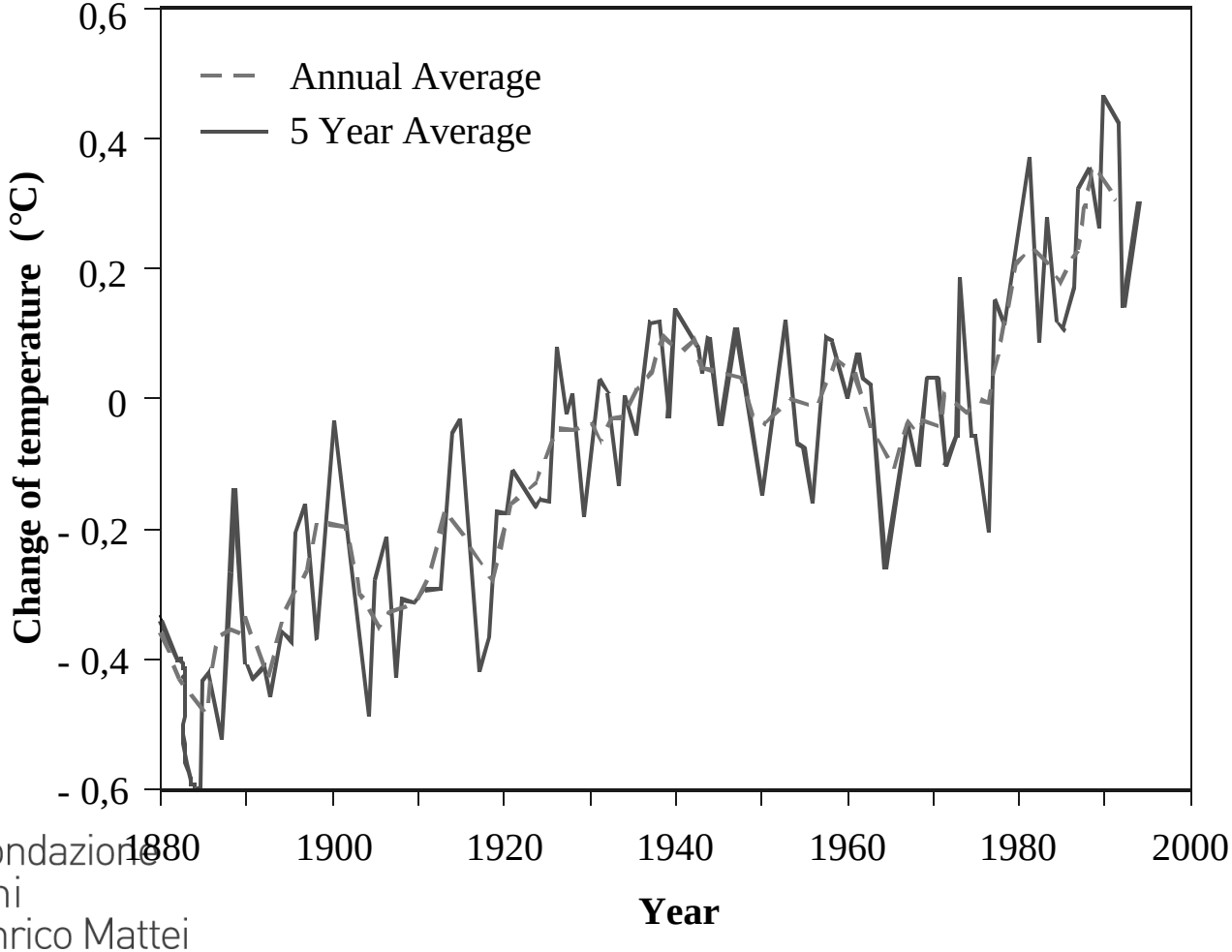
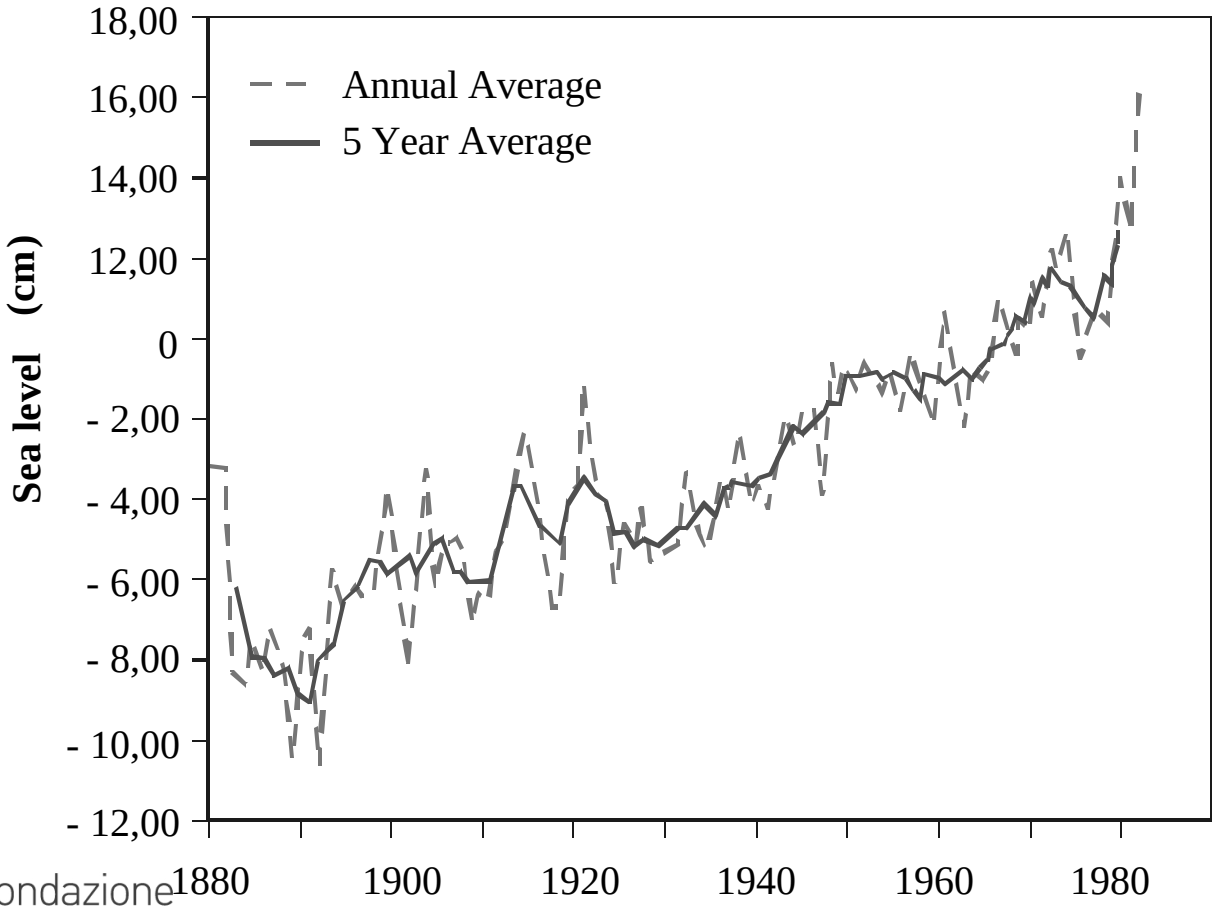
THE GLOBAL WARMING PROBLEM

- **Climate is actually changing**….
  - Temperature increases
  - Sea level rises
  - Precipitation patterns change and extreme events (hurricanes, floods, droughts,…) are more frequent
  - Ice cover is smaller and smaller...

Average temperature: 1880 - 2000



Sea level rise: 1880 - 2000



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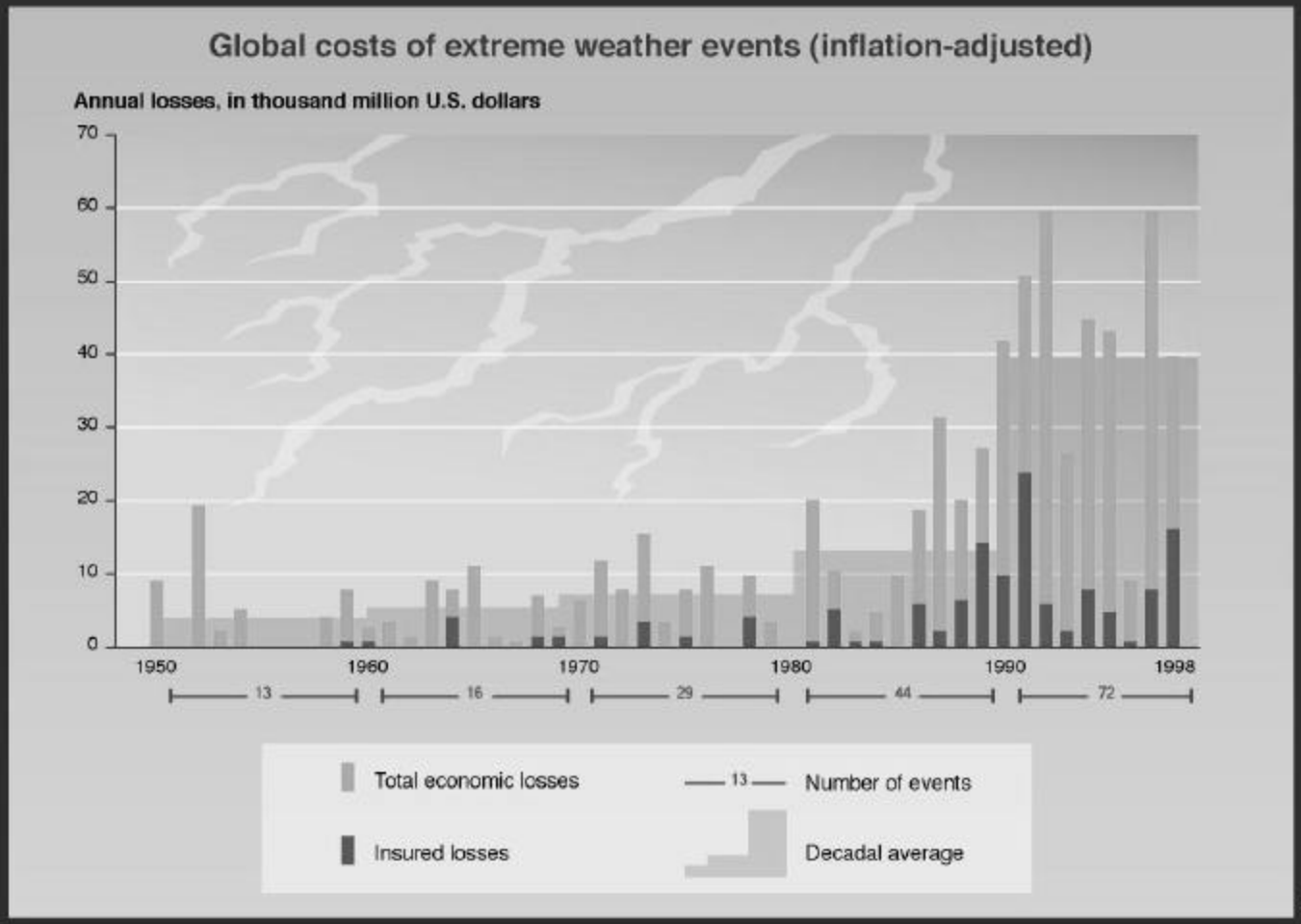
CLIMATE IS CHANGING ...



SYR - FIGURE 2-7

CLIMATE CHANGE IS A COMPLEX PROBLEM

Two basic questions:

- Do we actually need a climate policy ?
- If yes, how should it be designed ?

DO WE ACTUALLY NEED A CLIMATE POLICY?

Usual questions:

- Does climate change exists?
- If yes, is there a human influence on climate change?
- If yes, are there market failures?
- If yes, do we need a global climate regime?

BIASED APPROACH TO CLIMATE POLICY

Climate policy has two components:

– Mitigation

– Adaptation

- Above questions refer to mitigation. Biased approach.
- What about adaptation? Adaptation can be necessary even in the absence of human influence on climate.

IN THIS LECTURE ….

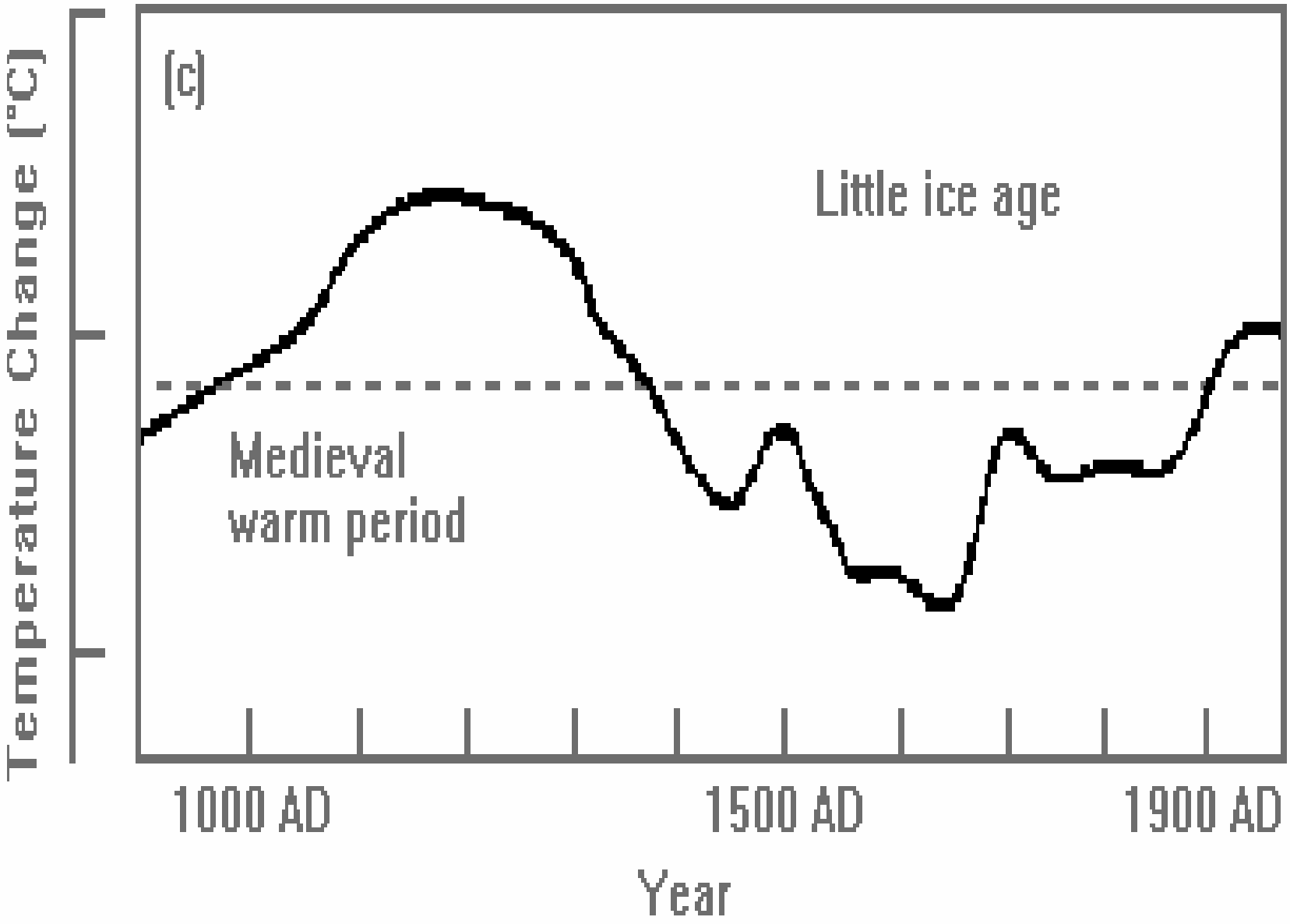
- Different mitigation options
- Incentives for global and sub-global coordination
- New policy architectures
- Modelling issues for mitigation policy …

- … however, main point will be the necessity to improve modelling of adaptation strategies and of their economic implications.

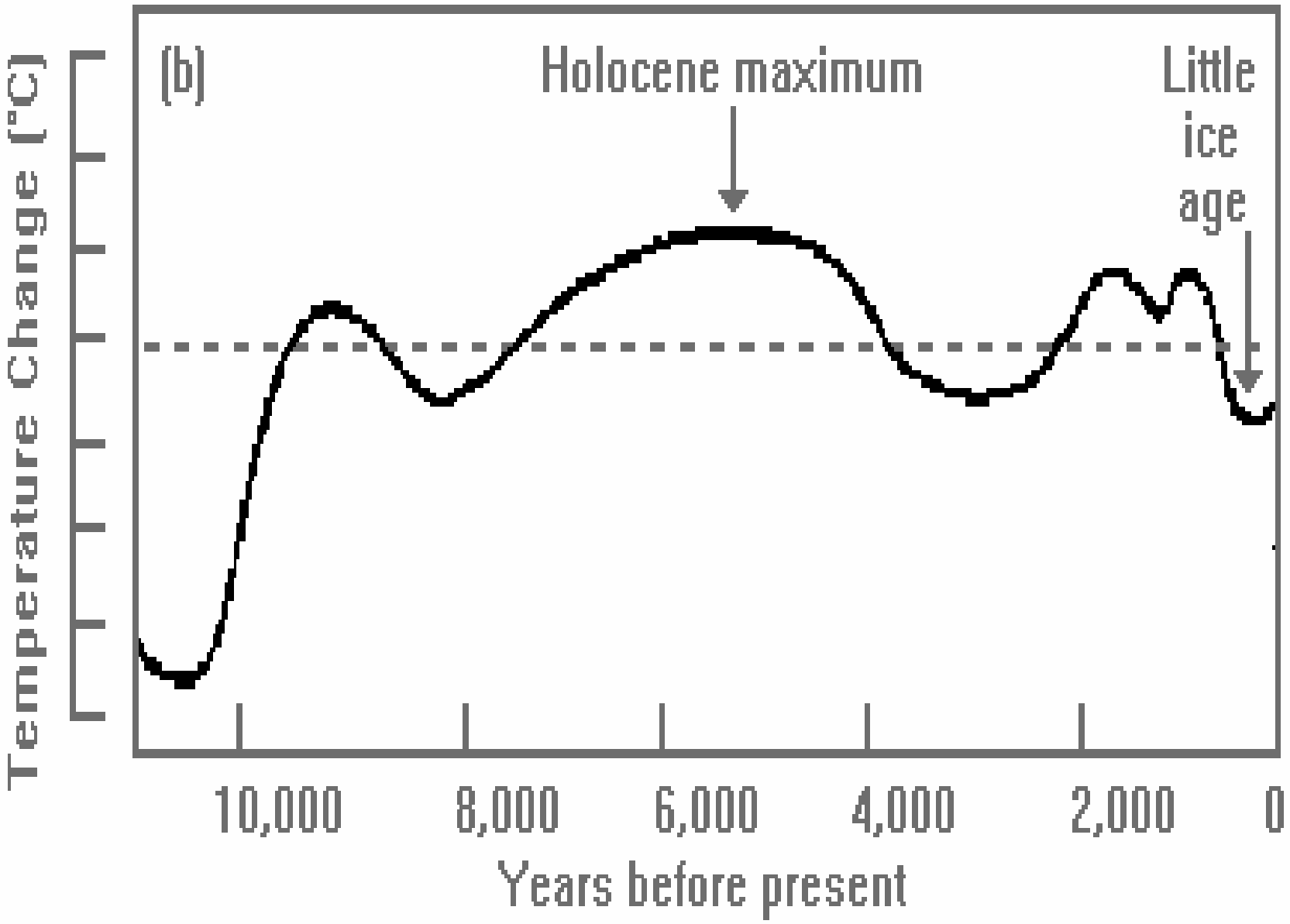
IS THERE A HUMAN INFLUENCE ON CLIMATE?

- Climate has always been changing
- Therefore, uncertainty is not about whether there is climate change, but about how much climate change is induced by human activities … i.e. whether there is a human influence on the speed of climate change.

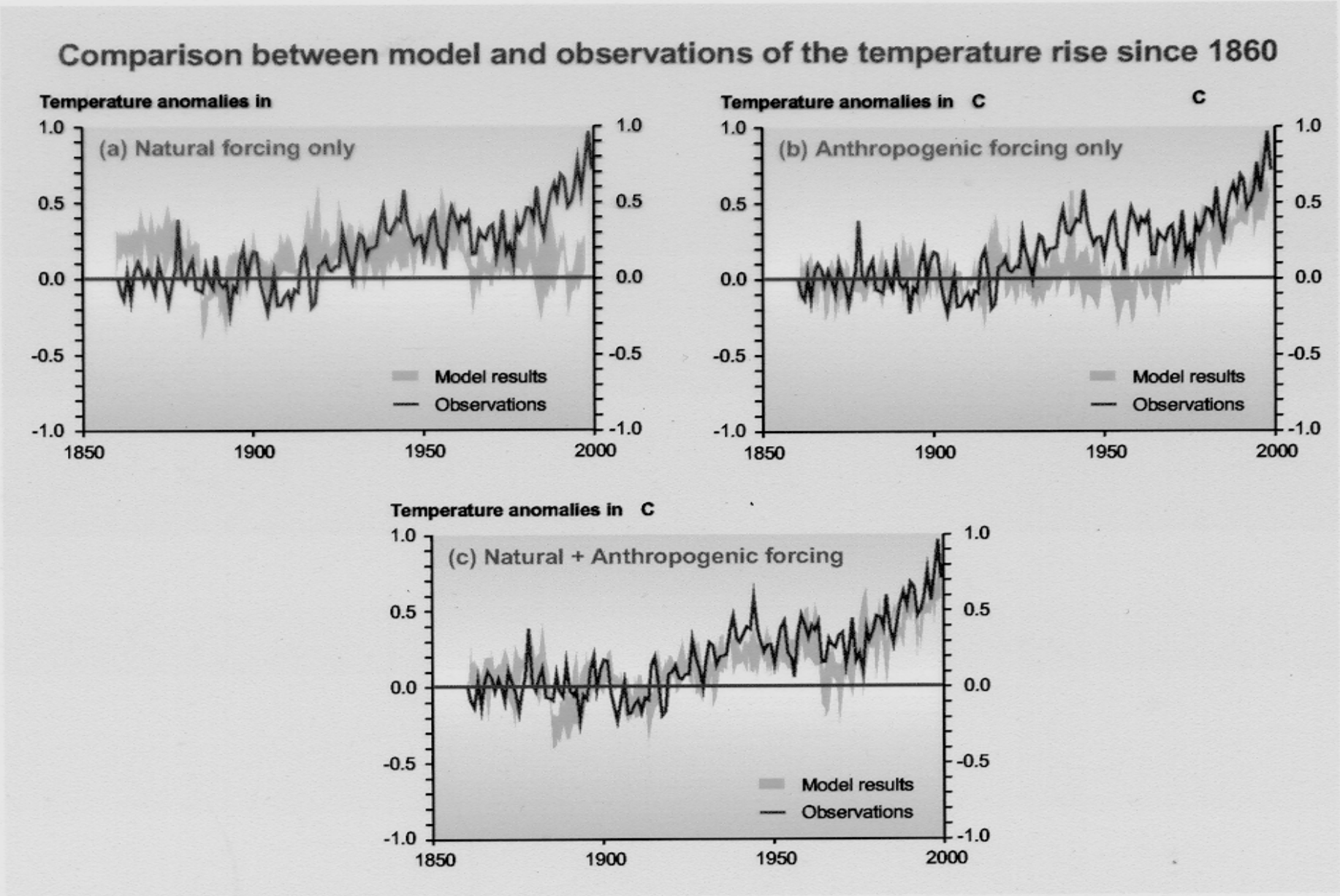
HUMAN INFLUENCE ON CLIMATE CHANGE ?



HUMAN INFLUENCE ON CLIMATE CHANGE ?



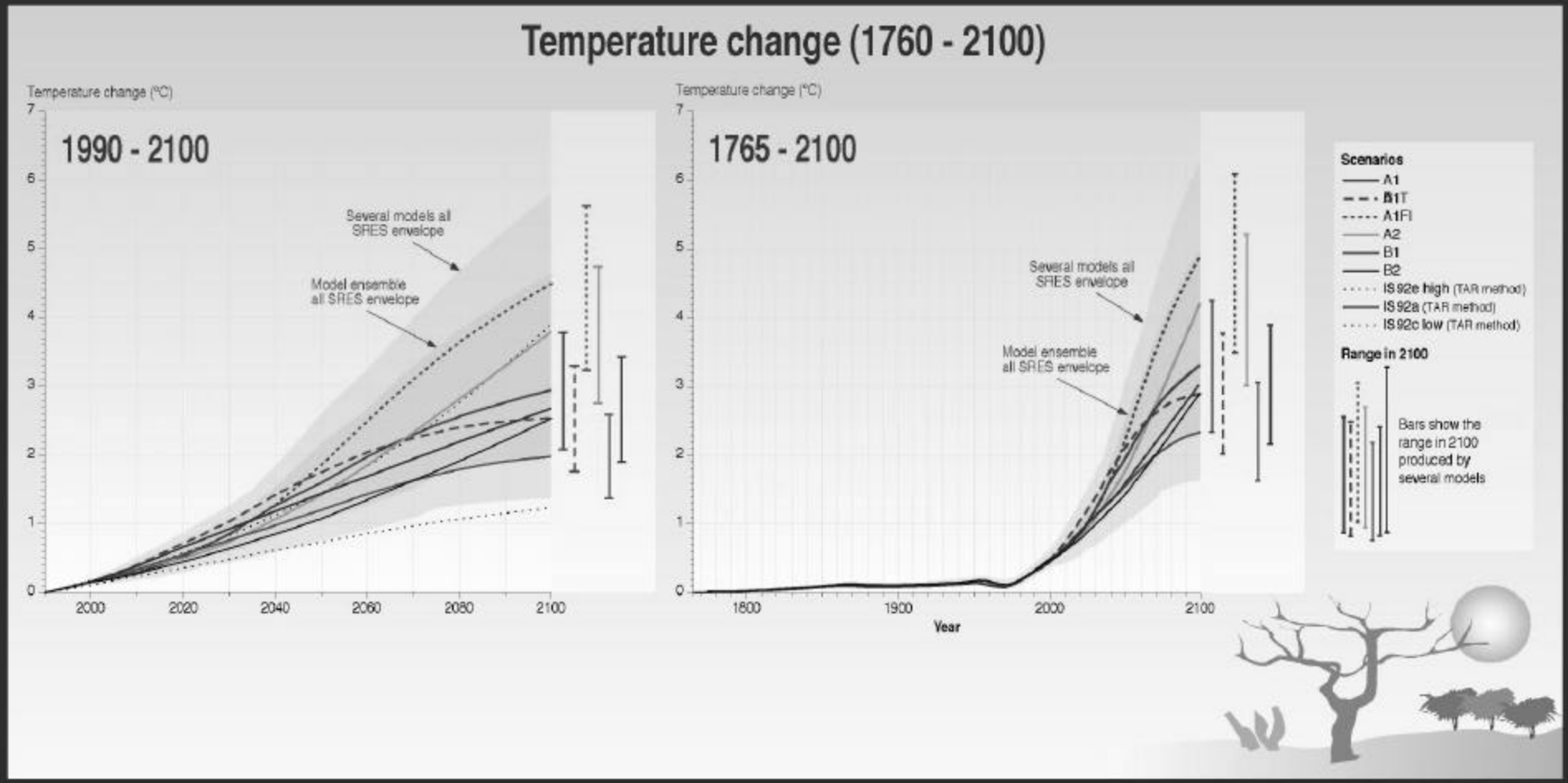
HUMAN INFLUENCE ON CLIMATE CHANGE ?



FUTURE CLIMATE

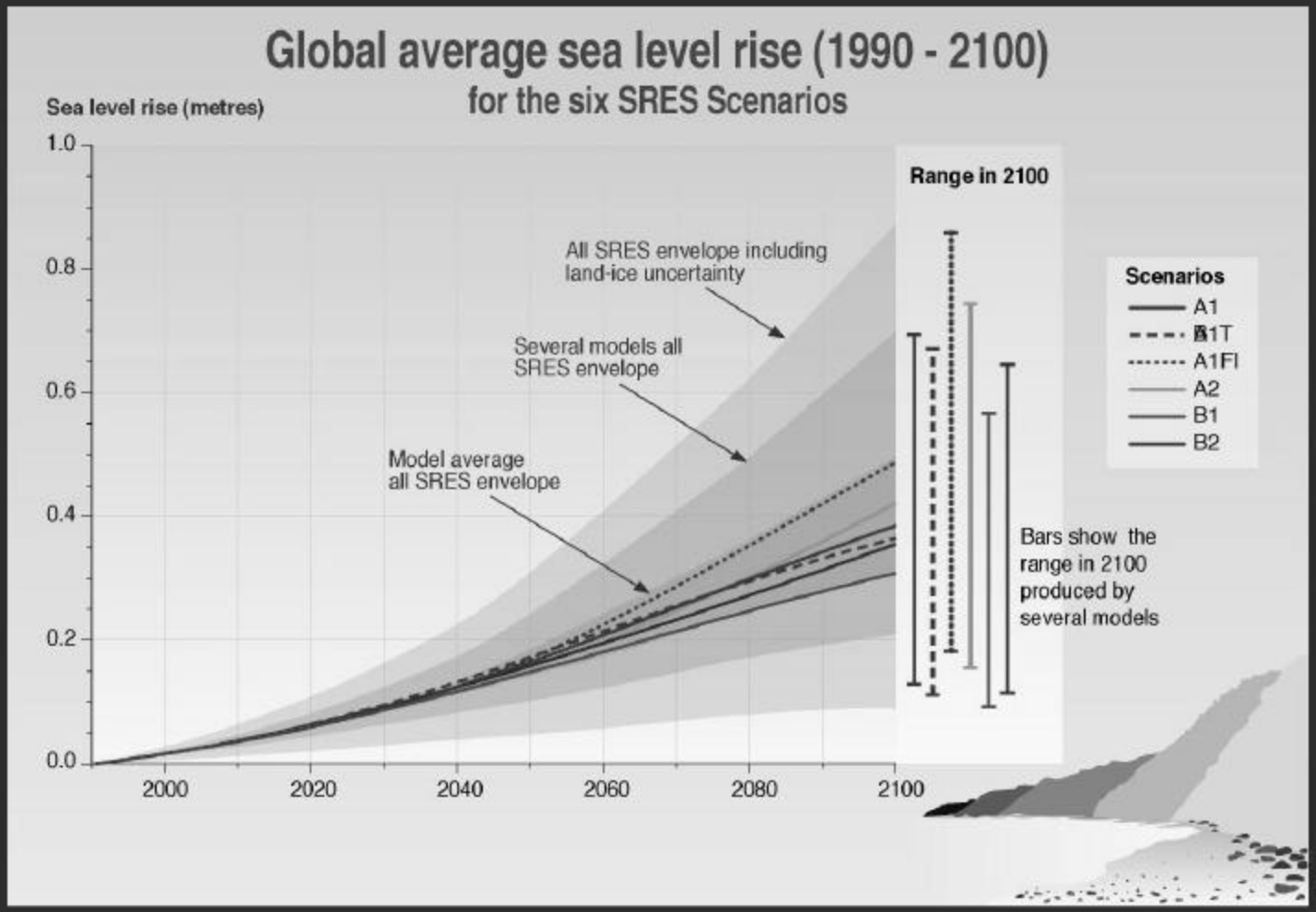
Human influence on climate implies that future changes of climatic variables are likely to be much larger and faster than those observed in the past...

FUTURE CLIMATE



WG1 TS FIGURE 22

FUTURE CLIMATE



WG1 TS FIGURE 24

THEREFORE:

- Climate change is inevitable.
- Future changes may be larger, but not much larger than what they would be without human influences.
- A risk-averse strategy requires the adoption of mitigation measures.
- Whatever the conclusion on the human influence issue, adaptation investments are/will be necessary (as in past centuries)
  - Romans' *termae* (spa) ….

HOW SHOULD CLIMATE POLICY BE DESIGNED?

MITIGATION

- Why is it difficult to reach an agreement on GHG emission reductions?
- Climate change control is a global public good. “Tragedy of the commons”?
- Economic asymmetries, equity concerns?

POLICY ISSUE 1: NO COOPERATION OR GLOBAL COOPERATION ?

- **Theory**: No cooperation or full cooperation at the equilibrium. International environmental agreements as a Prisoners' dilemma.

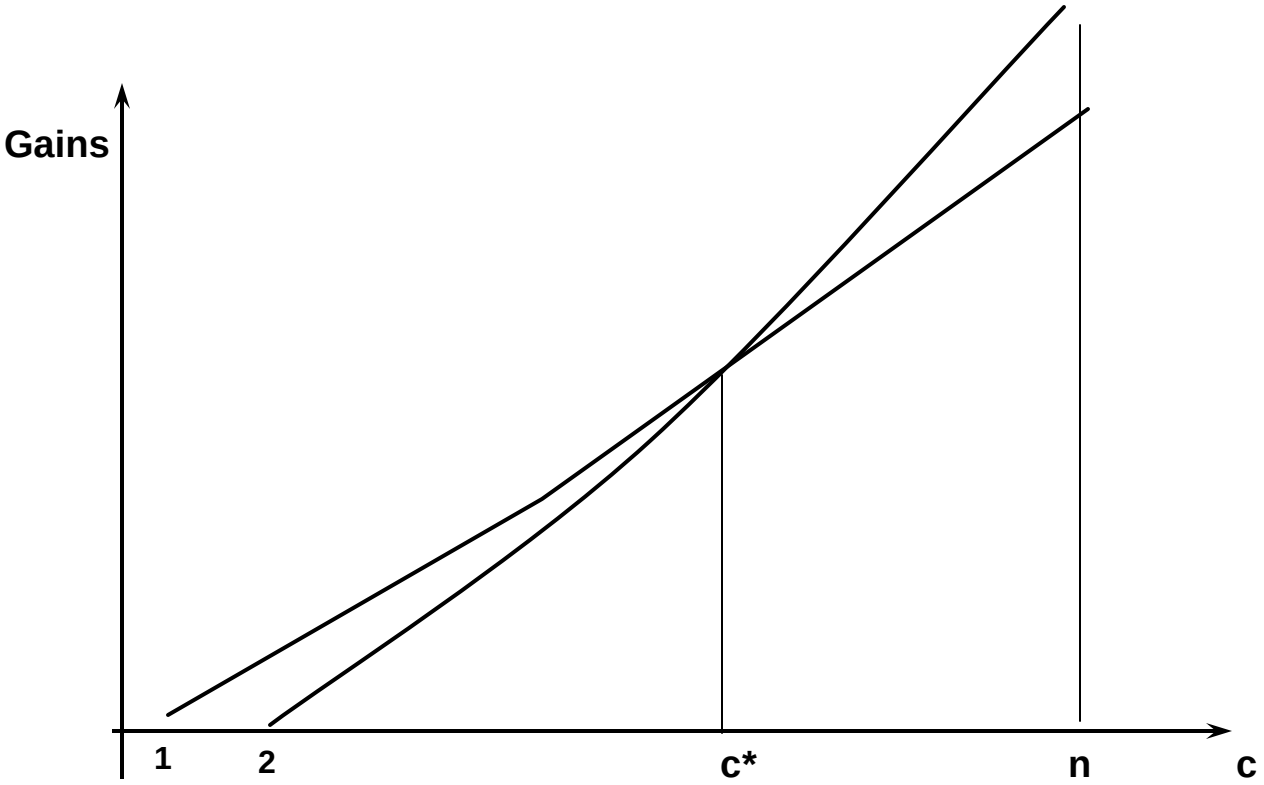
- **Facts**: Many international agreements are partial and in particular the present climate agreement (Kyoto Protocol) is a partial agreement.

- **New Theory**: Coordination game and not Prisoners' dilemma. Partial agreements at the equilibrium

- **Prediction**: Either a few number of signatories or empty agreement

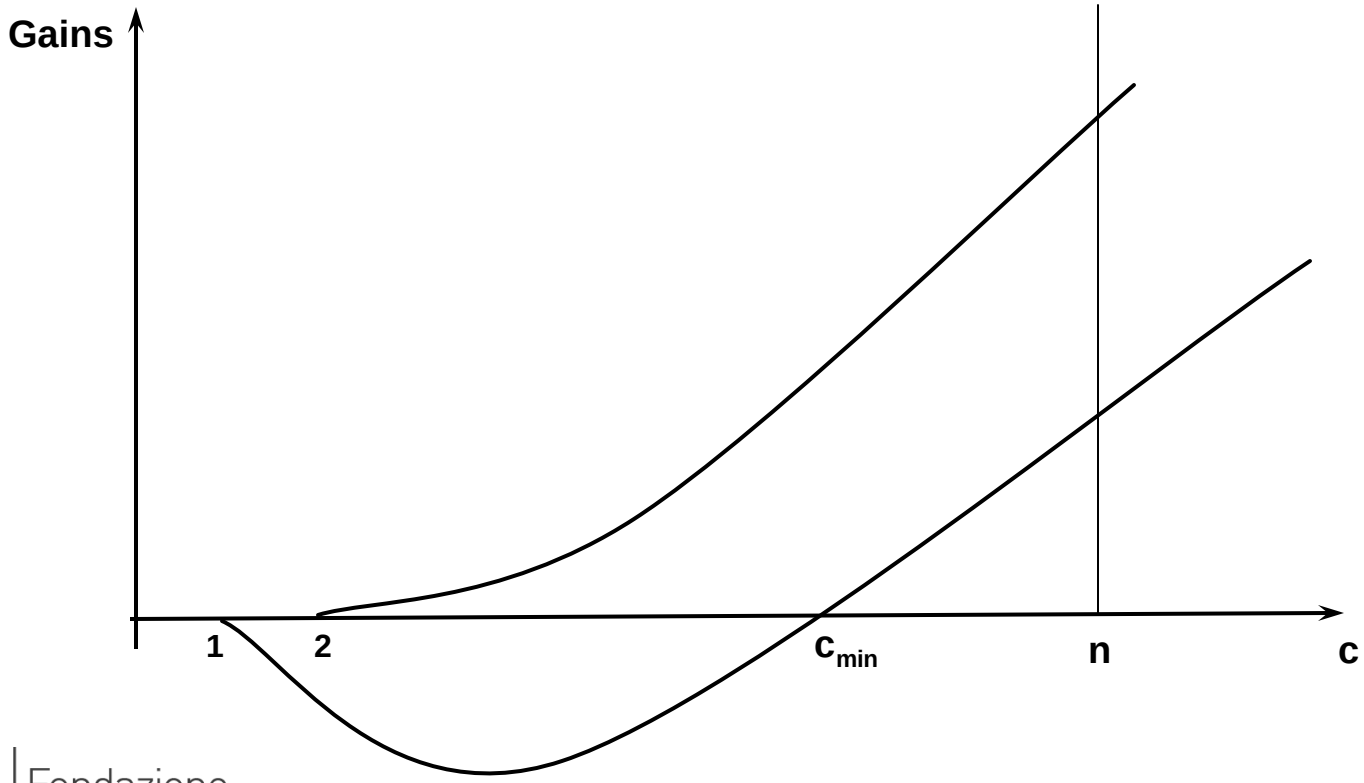
Coalition Theory (1)

Gains from cooperation and from free-riding when a stable coalition exists => Coordination game



Coalition Theory (2)

Gains from cooperation and from free-riding when no stable coalition exists => Prisoners' dilemma



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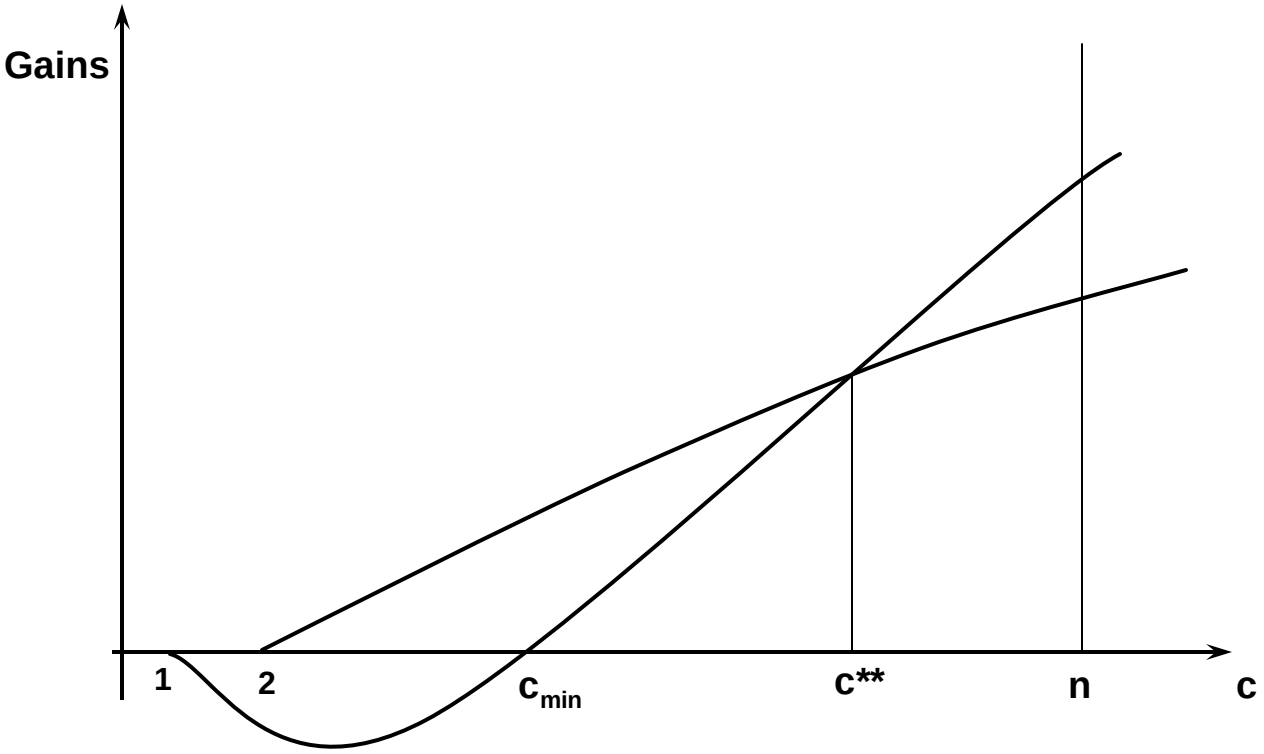
Coalition Theory (3)

Gains from cooperation and from free-riding in the presence of leakage => Possible band-wagon effects



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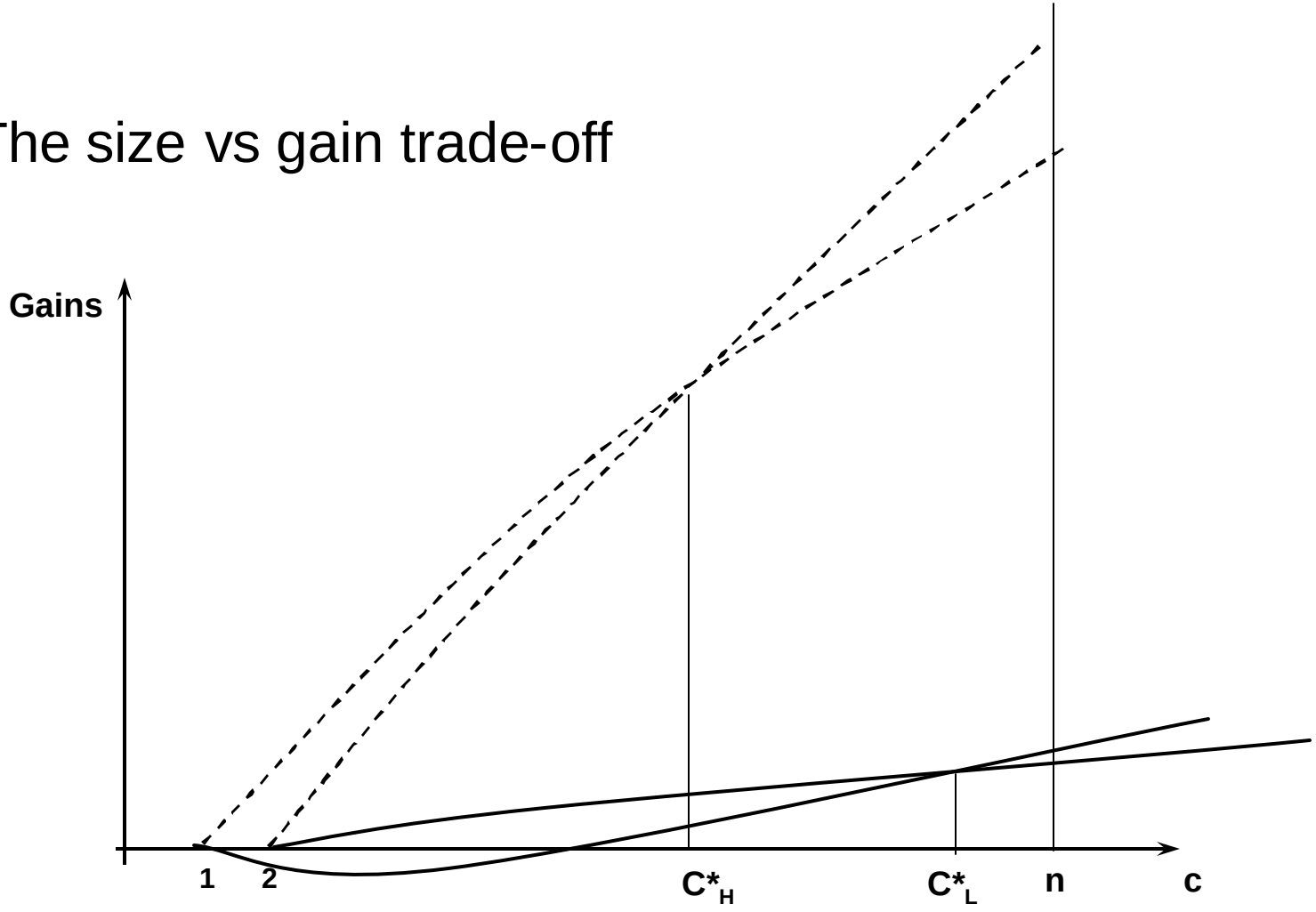
Coalition Theory (4)

The size vs gain trade-off



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IMPLICATIONS FOR MODELLING

- Compute incentives to join a climate coalition (or to defect from it) as a function of policies, future targets, economic and demographic scenarios, etc.
- Costs of complying with the Kyoto agreement are a function of the number of signatories …

  …. but signatories are a function of the costs of complying with the agreement => simultaneity

POLICY ISSUE 2: GLOBAL OR REGIONAL AGREEMENTS ?

- **Theory**: many coalitions (many groups of cooperating countries) form at the equilibrium

- **Facts**: Single agreement (Kyoto Protocol) has been proposed and is presently the goal of climate negotiations

- **Still unresolved paradox**. Unless facts are interpreted differently

IS KYOTO A SINGLE AGREEMENT ?

"In substance, even though not in form, the Kyoto Protocol reflects agreements among several different coalitions"
Eric Haites, former head of the IPCC Technical Support Unit

"It is increasingly becoming clear, [that] the Kyoto Protocol is less a global agreement than a set of differing regional approaches"
Christian Egenhofer, Center for European Policy Studies

GLOBAL OR REGIONAL AGREEMENTS ?

Theoretical results:

- The equilibrium coalition structure is not formed by a single coalition. In general, many coalitions form at the equilibrium;

- Coalitions of different sizes may emerge at the equilibrium (even when countries are symmetric).

- The multiplicity of coalitions may allow for region-specific agreements in which the characteristics of countries in a given region are better reflected by the structure of the agreement that they decide to sign.

GLOBAL OR REGIONAL AGREEMENTS ?

Empirical results:

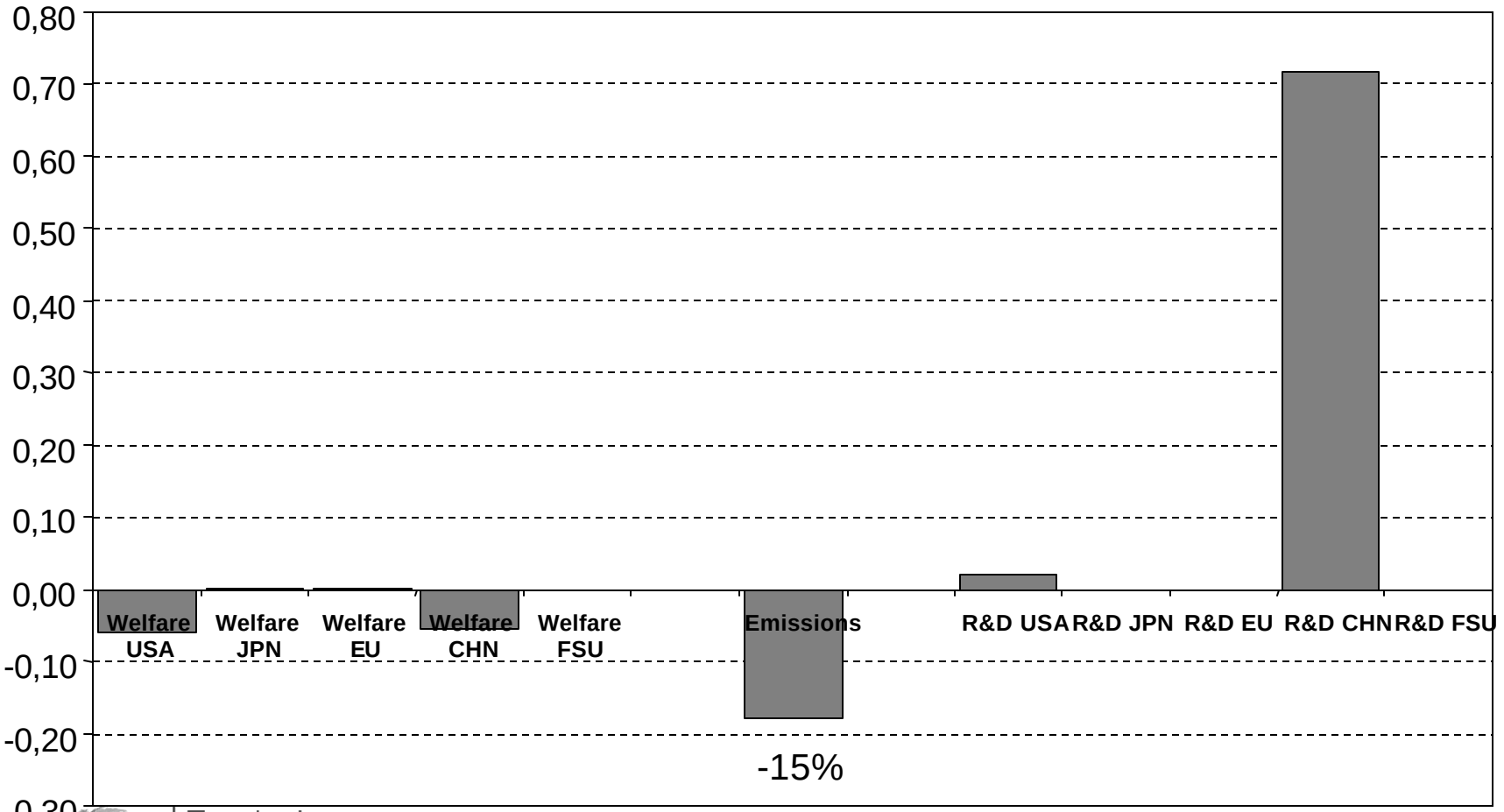
Buchner and Carraro (2002) computed economic and environmental gains when different sub-coalitions and fragmented climate regimes form.

Changes in welfare and emissions with respect to the present situation have been analysed.

Regional or fragmented agreements seem very likely, at least in terms of economic incentives.

A climate regime with two blocs: 1) US and CHN; 2) EU, FSU and Japan

(per cent changes with respect to the Annex B_{-US} coalition)



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RANKING OF COALITION STRUCTURES:

USA	JPN	EU
(JPN, EU, FSU)	(EU, US, FSU)	(JPN, US, FSU)
(JPN, CHN) & (EU, FSU)	(JPN, CHN) & (EU, FSU)	(USA, JPN, EU, CHN, FSU)
(JPN, EU, FSU) & (USA, CHN)	(JPN, EU, FSU) & (USA, CHN)	(JPN,CHN) & (EU, FSU)
(JPN, EU, CHN) & (USA, FSU)	(USA, JPN, EU, CHN, FSU)	(JPN, EU, FSU) & (USA, CHN)

MODELLING IMPLICATIONS

- Regionalism is an increasing phenomenon in trade. More than 200 regional trade agreements already exist.
- What about linking regional trade agreements with regional climate policy?
- What impact of regional trade rules on regional GHG emissions?
- What implications of regional emission trading schemes and of their possible subsequent linking?

SUMMING UP

- Theory suggests that partial/regional agreements are most likely to emerge at the equilibrium
- Numerical simulations suggest that a two-bloc coalition structure could form (with EU, Japan and Russia in one bloc and US and China in the second bloc).
- What about reality ?

WHERE ARE WE?

- **Kyoto Protocol:**

  low environmental effectiveness, even though ratified by 122 countries (as of May 29th, 2004)

- EU and Japan have ratified the Protocol and are leading the climate coalition (that covers only 44% of total emissions)

- EU is negotiating with Russia to provide incentives for ratification (WTO deal)

AND...

- Japan focuses on domestic policies (carbon taxes) and regional cooperation (mostly with China)
- US adopted a low emission intensity target (-18%) and focuses on technology policy
- China announced ratification, but no target
- A number of **bilateral / regional cooperations**, particularly on research and technological developments, have been signed.

THE FUTURE OF KYOTO

- ✓ The US withdrawal from Kyoto has largely penalised Russia, that therefore delays ratification.
- ✓ Russia's bargaining power has increased. Therefore, ratification can be expected only after some important economic concessions by the EU.
- ✓ Kyoto may not come into force, but main countries will reduce their emissions anyway.

KYOTO'S WEAKNESSES

The Kyoto Protocol's architecture has been criticised on a variety of grounds, including:

- → it imposes high costs and unfair burdens on some industrialised countries;
- → it effectively forbids developing countries from taking on emissions commitments;
- → it provides ineffective incentives for participation;
- → and it generates modest short-term climate benefits while failing to provide a long-term solution.

PATH 2: ALTERNATIVE APPROACHES

1) A Hybrid International Trading Program with Safety Valve (Kopp, Morgnestern and Pizer, 1997; Aldy, Orszag, and Stiglitz, 2001)
2) A Research and Development Protocol (Barrett, 2001, 2003)
3) Harmonized Domestic Carbon Taxes (Cooper, 1998, 2001)
4) Domestic Hybrid Trading Schemes (McKibbin and Wilcoxen, 1997, 2000)

ALTERNATIVE APPROACHES (2)

5) An Efficient Set of Harmonized Carbon Taxes (Nordhaus, 1998)
6) A Global Climate Marshall Plan (Schelling, 1997, 1998, 2000)
7) A Broad but Shallow Beginning (Schmalensee, 1996, 1998)
8) A Three-Part Policy Architecture (Stavins, 2001b)
9) Emission intensity regime (Pizer, 1998)

ALTERNATIVE APPROACHES (3)

10) Using Quotas to Attract Developing Countries (Stewart and Wiener, 2001)
11) Increasing Compliance through Buyer Liability (Victor, 2001)
12) The Global Public Good Purchase System (Bradford, 2002)
13) Regional Climate Agreements (Carraro, 1998, 2002)
14) Trade and Banking (Viguier, 2003)

TOO MANY PROPOSALS ?

"I have not failed. I’ve just found 10,000 ways that don’t work.”

Thomas Alva Edison

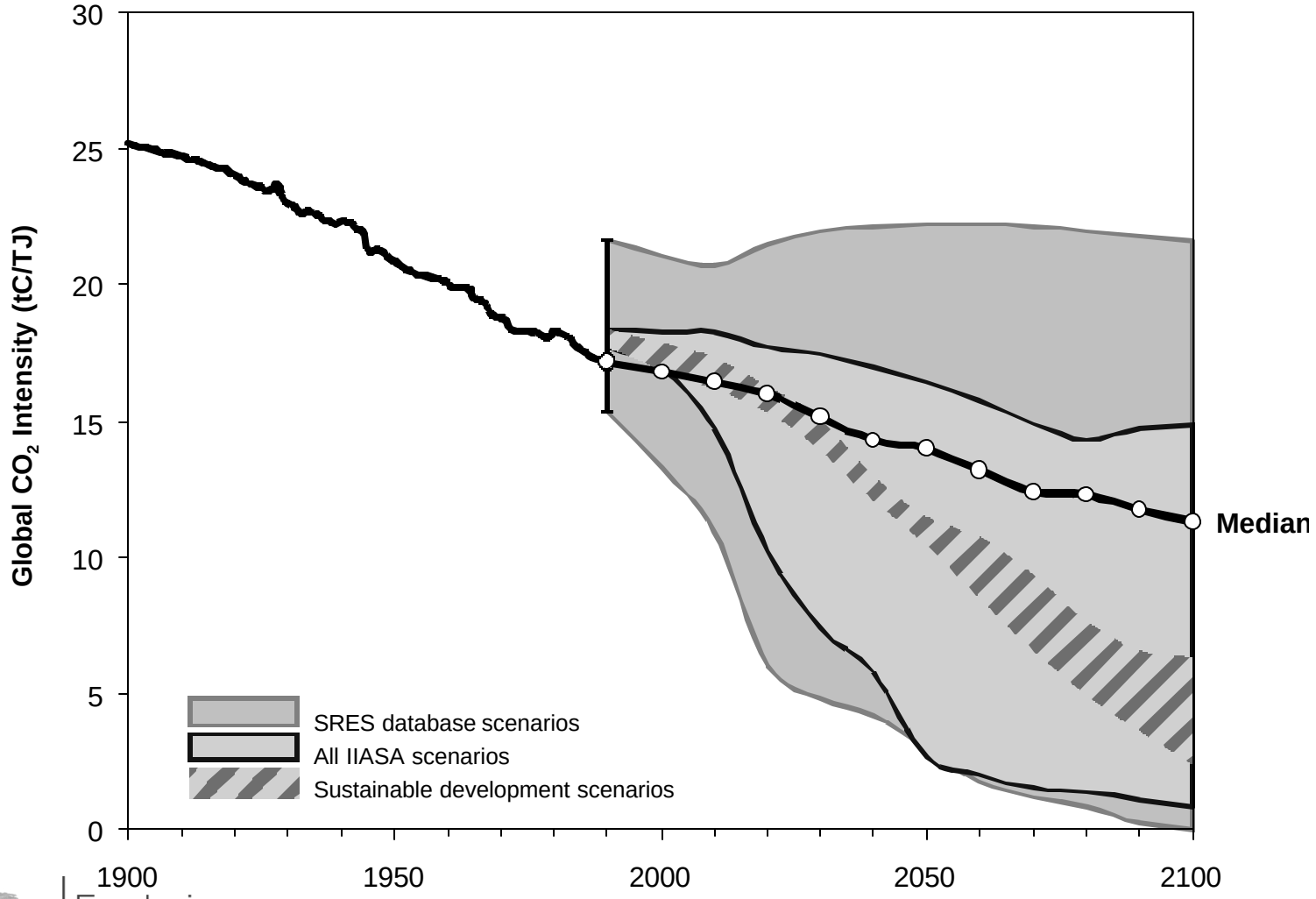
COMMON FEATURES:

- → use of relatively moderate short-term goals;
- → use of market-based mechanisms;
- → cost constraints through hybrid instruments;
- → provision of incentives for participation and compliance.

HOWEVER:

- Kyoto target (-5.2%) is largely insufficient.
- Present post-Marrakech agreement is even weaker (-2.1%).
- More ambitious targets are too costly unless a technological breakthrough is introduced.
- Investments in research and development of new energy sources are necessary.

Carbon Intensity of Primary Energy



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MODELLING IMPLICATIONS

- Large literature on how to model technical change in climate models:
- R&D, learning curves,knowledge spillovers, irreversibilities, path dependency …
- Bottom-up vs. top down, endogenous vs. exogenous …
- Etc.

MITIGATION IS NOT ENOUGH...

- Whatever action to reduce GHG emissions is taken today, climate is going to change anyway. This is true for both those who believe that human influence is small and those who believe that human influence is very important.
- Therefore, we need ADAPTATION policies.

ADAPTATION

- Adaptation implies investments to protect:
  - coastal zones and small islands (from sea level rise, ...)
  - agriculture production (from water stress, droughts ...)
  - poor countries (from loss of natural resources, ...)
  - ageing population (from heat waves and other extreme events, ...)
  - infrastructures (from floods, …)
  - national security (migrations, political instability ..)
  - etc.

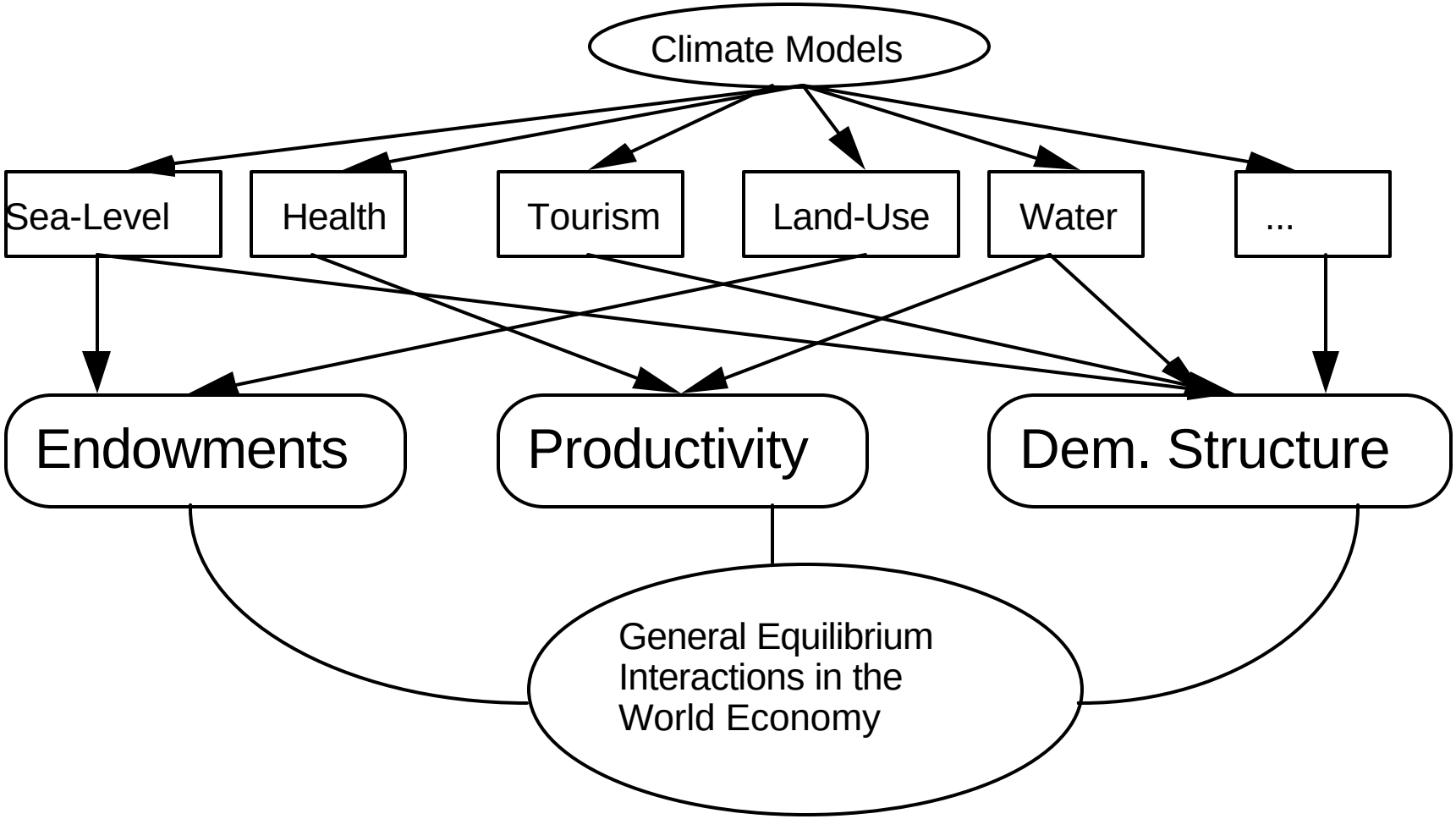
MODELLING IMPLICATIONS

- What is the optimal level of adaptation?
- Do investments in adaptation crowd out resources to be devoted to mitigation?
- Does adaptation reduce incentives to undertake mitigation?
- What is the relationship between technical change and the time profile of optimal adaptation and mitigation ?
- How effective is adaptation in protecting economic systems from impacts of climate change?

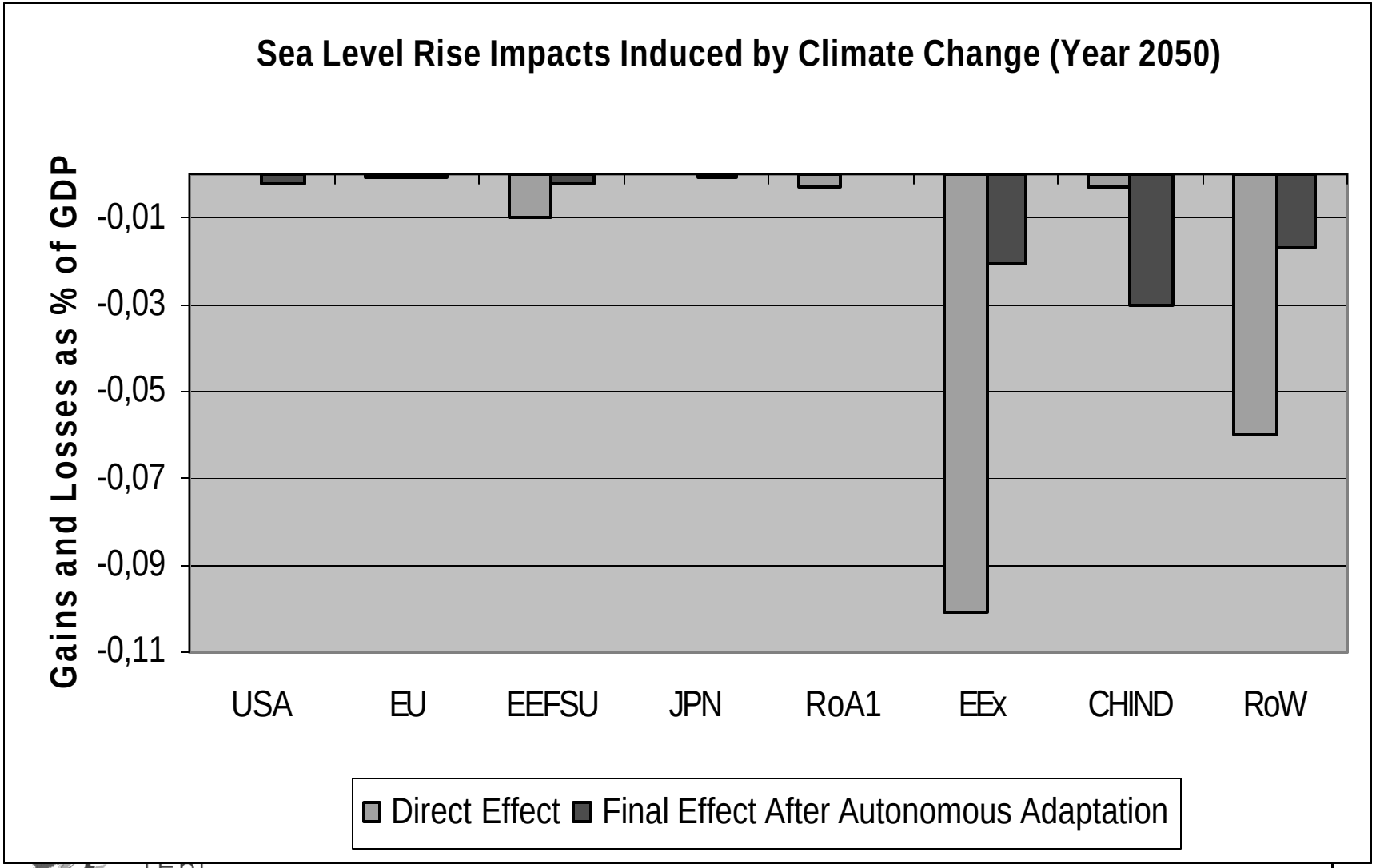
MODELLING ADAPTATION

- “Autonomous” vs “Planned” Adaptation
- Physical impacts of climate change can be translated into economic impacts
- A general equilibrium framework is the appropriate tool to assess how economic systems (sectors in different countries) react/adapt to impacts of climate change
- Final output is a climate induced GDP loss that take into account “autonomous” adaptation

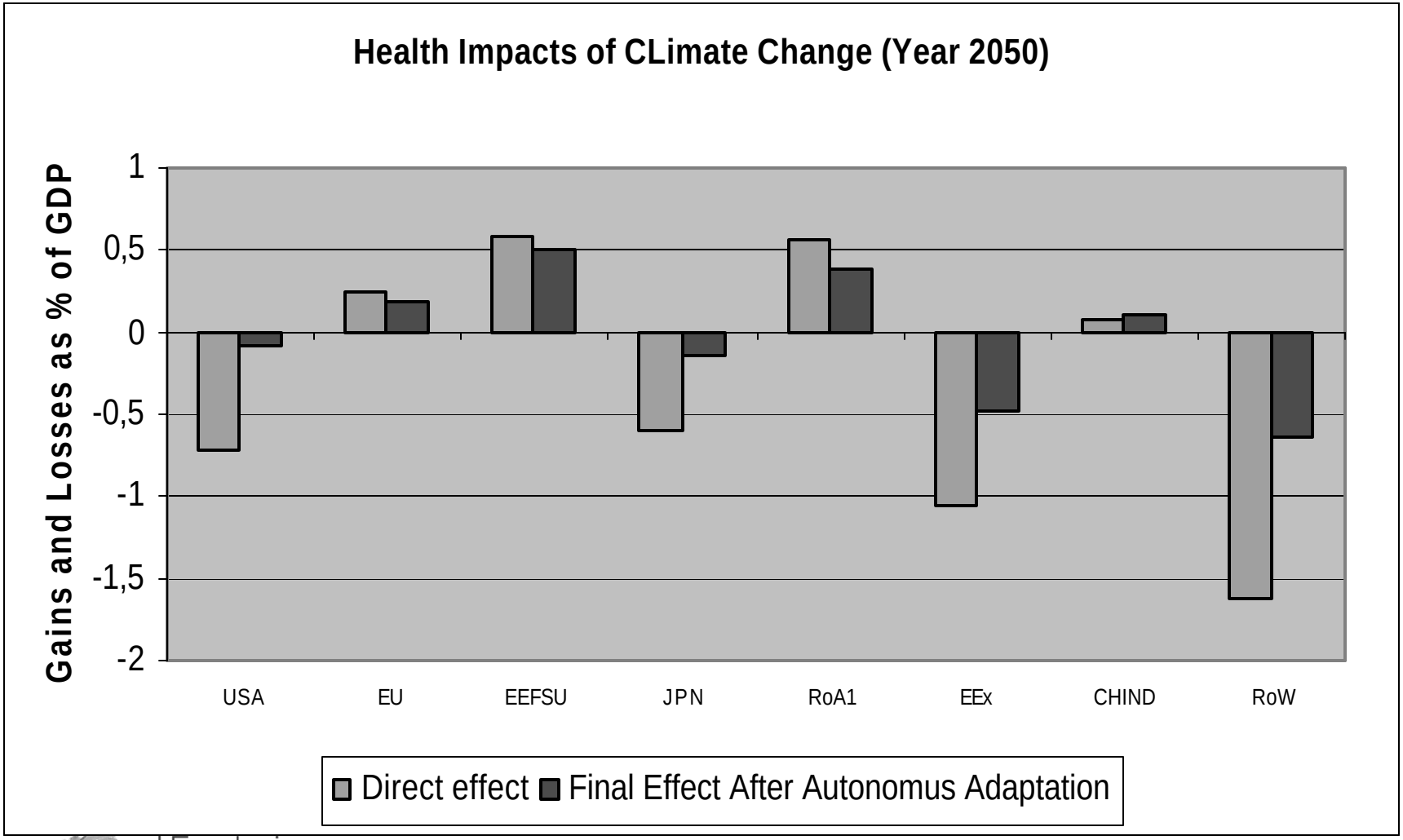
MODEL STRUCTURE



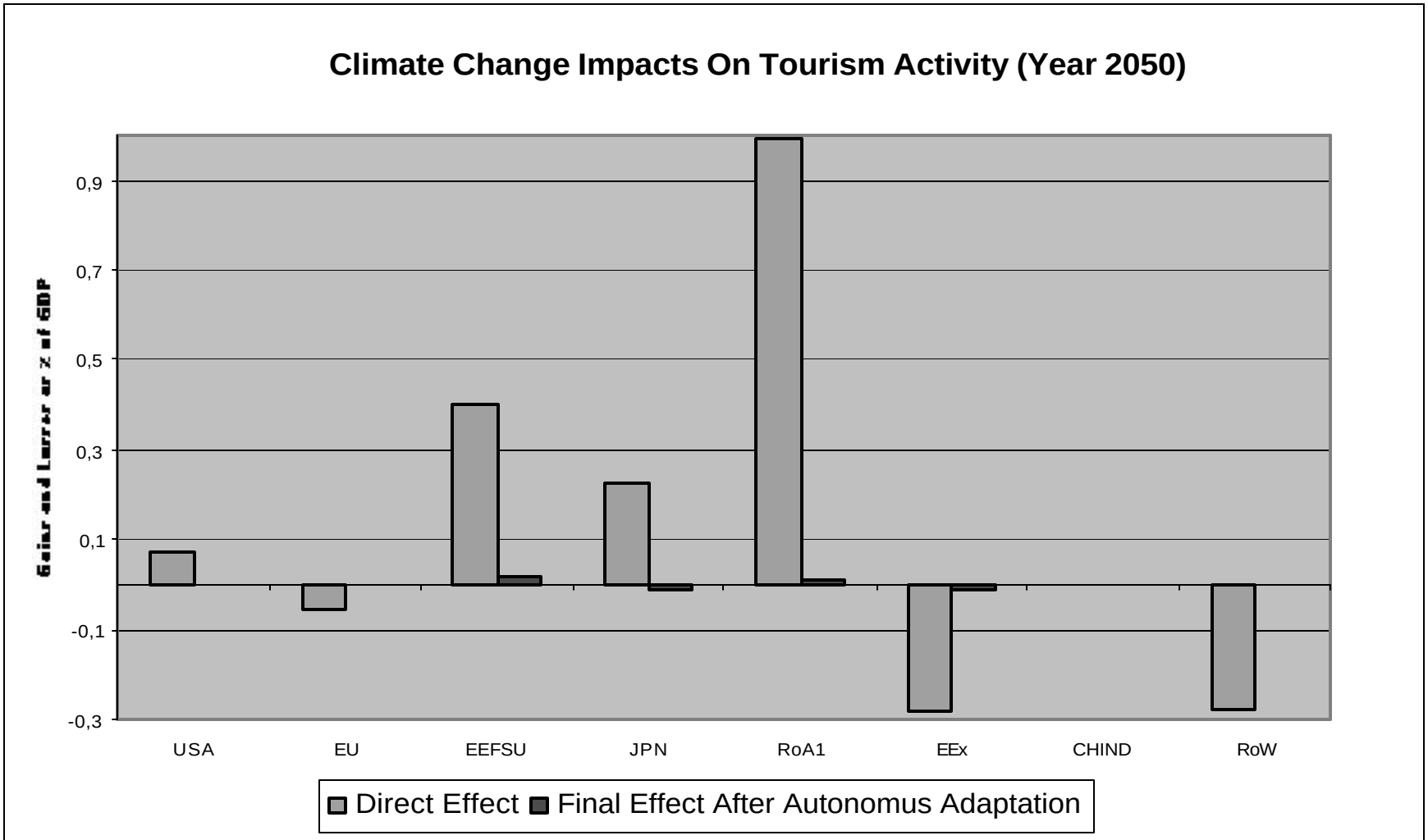
AUTONOMOUS ADAPTATION TO CLIMATE CHANGE. SEA LEVEL RISE



AUTONOMOUS ADAPTATION TO CLIMATE CHANGE. HEALTH



AUTONOMOUS ADAPTATION TO CLIMATE CHANGE. TOURISM



MODELLING THE ADAPTATION/MITIGATION TRADE OFF

Empirical optimal growth model with four stocks:

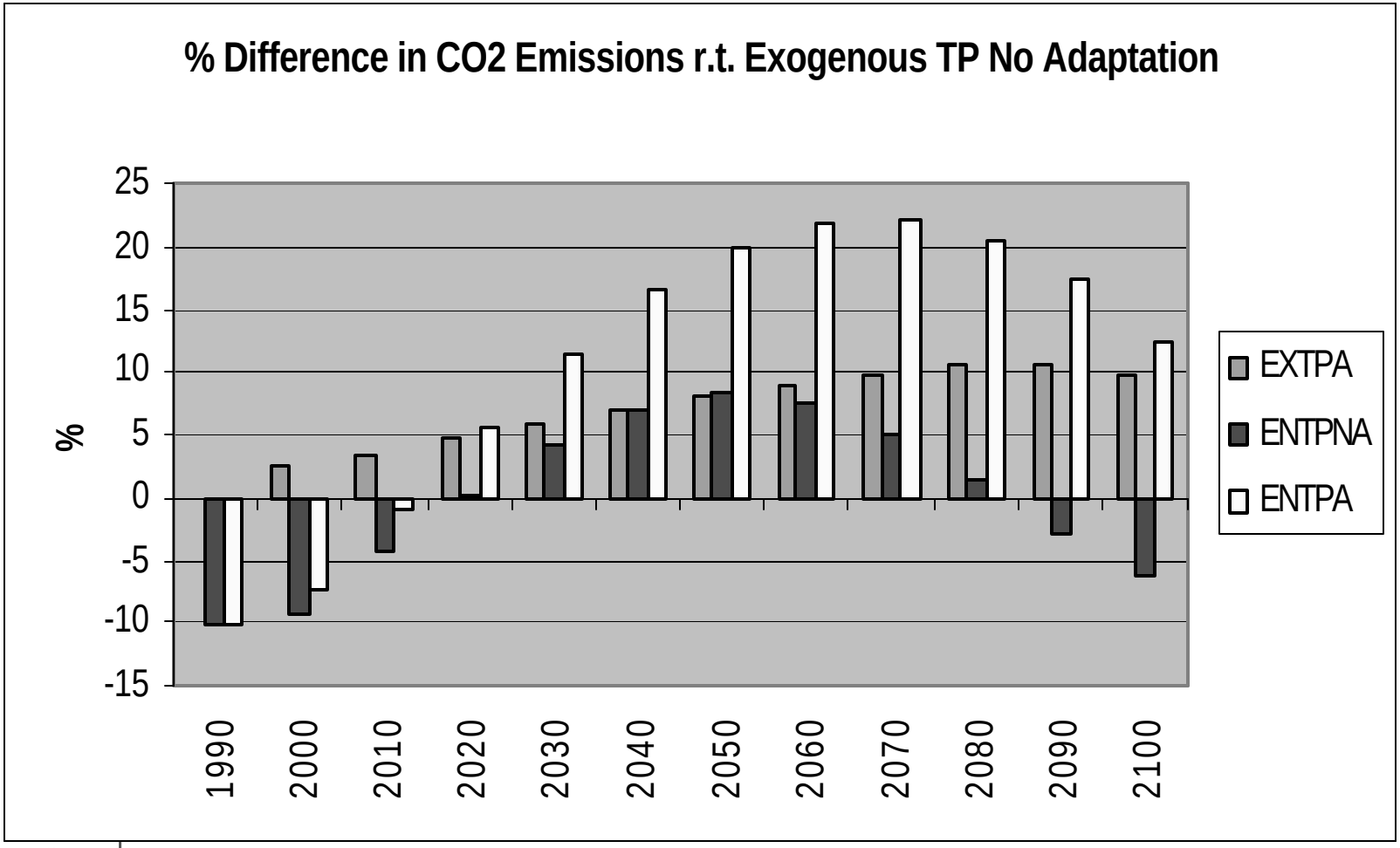
- Capital (cumulated via investments)
- Emissions Concentrations (cumulated via CO2 emissions)
- Defensive capital (cumulated via investment in adaptation)
- Knowledge (cumulated via R&D investments)

MODELLING THE ADAPTATION/MITIGATION TRADE OFF

And four control variables:

- capital investment
- R&D
- adaptation investment
- emission abatement

ADAPTATION/MITIGATION TRADE-OFF



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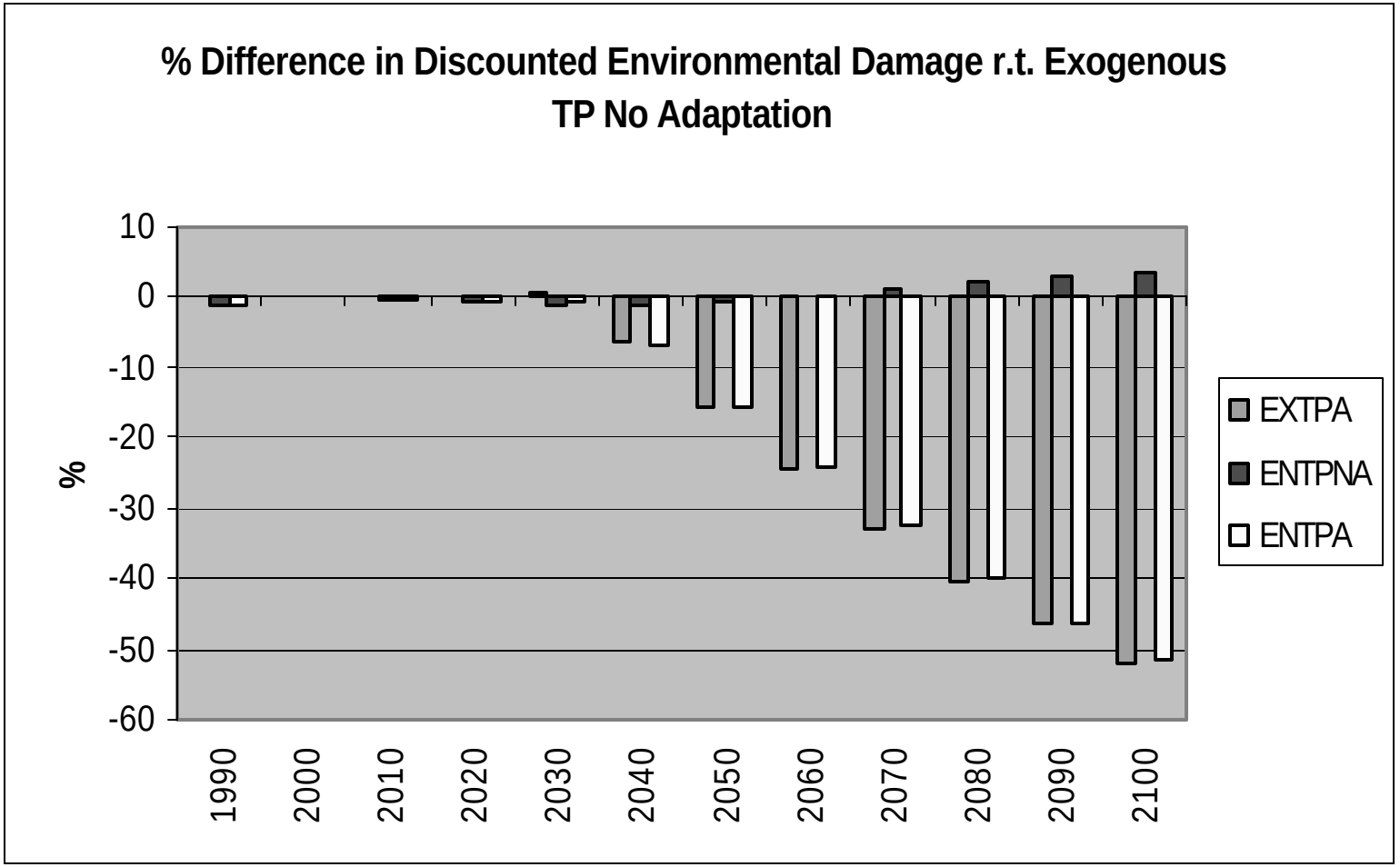
EFFECTIVENESS AND TIME PROFILE OF OPTIMAL ADAPTATION



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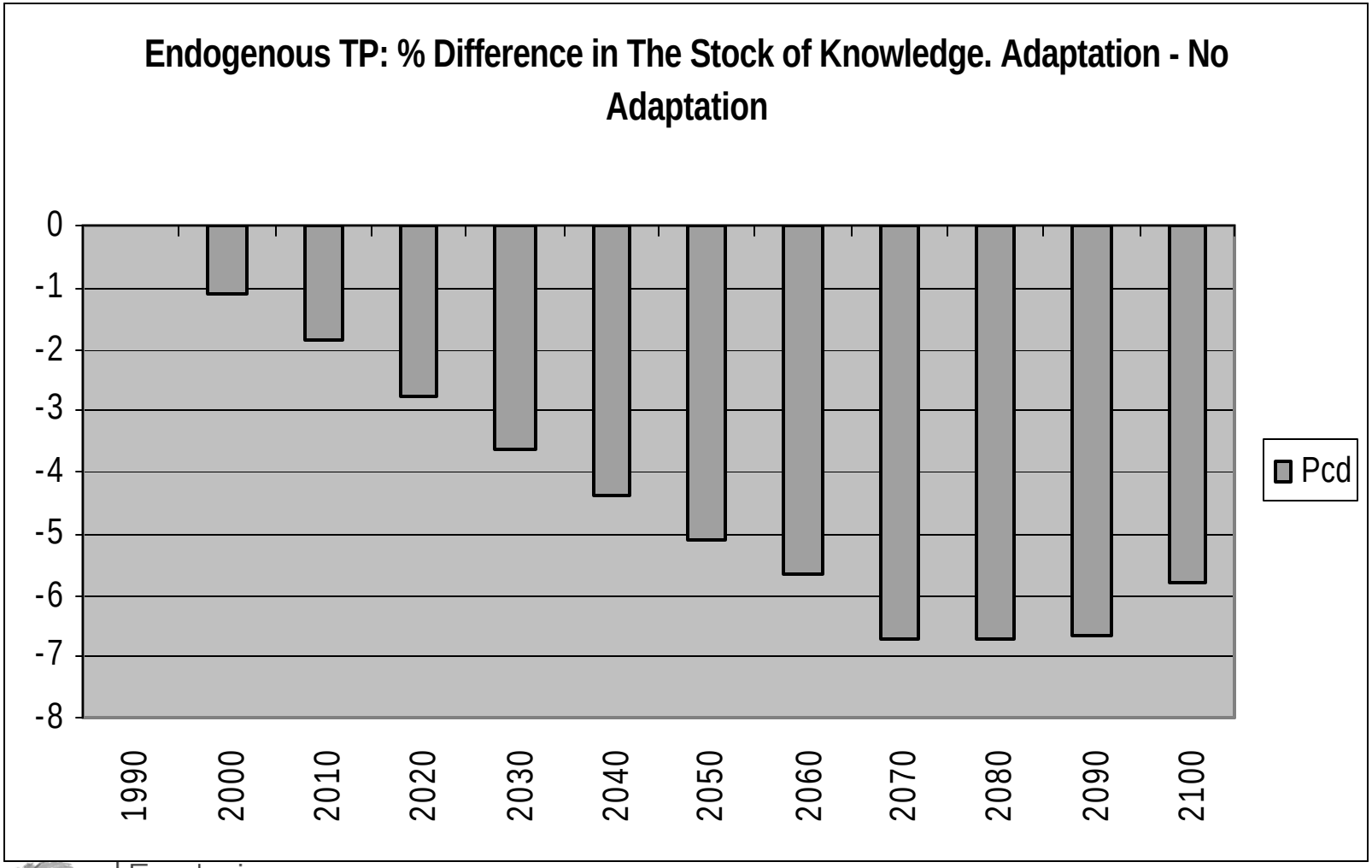
CROWDING-OUT EFFECTS



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OUT OF TIME ?

ENDOGENOUS INDUCED TECHNICAL CHANGE

In modern growth models, where impacts on climate change are also modelled, technical change is not only the engine of growth, but also the only way to effectively address climate change in the long-run.

Technical change has large potential in bottom-up techno-economic models. However, in long-run optimisation economic models evidence is controversial.

New approaches to deal with technological change in climate models. Mixed LbD and R&D models.

Past FEEM experience in modeling ETC (1)

- FEEM-RICE Model
  - An endogenously generated stock of knowledge affects both factor productivity and the emission-output ratio

- FEEM-RICE Model version 1 "*Learning by Researching*"
  - Knowledge is the result of the intertemporal optimal accumulation of R&D, where R&D is an additional choice variable
  - R&D spending claim on resources in addition to consumption and physical investment

Past FEEM experience in modeling ETC (2)

- FEEM-RICE Model version 2 "*Learning by Doing*"
  - Knowledge is approximated by installed capacity. Installed capacity is represented by physical capital, which cumulates through periodic investment.
  - LbD approach entails one less choice variable with respect to the R&D approach, but no further claim on resources.

Limitations

- The absence of a Carbon Energy (CE) variable in the model.
- The impossibility of including both *Learning by Researching* and *Learning by Doing*.
- The impossibility of distinguish between R&D expenditures in the energy sector and R&D expenditures in all the other sectors

The FEEM-RICE Model version 3

- ✓ Start from RICE-99 by Nordhaus and Boyer (2000), a single sector optimal growth model which accounts for the interactions between economic activities and climate.
- ✓ Extend the model to endogenise technical change and allow for both Learning by Researching and Learning by Doing
- ✓ The new model has been developed for the eight macro regions into which the world is divided and includes Carbon Energy as a production factor.

Technical Change in FEEM RICE v.3

- ✓Innovation is brought about by *R&D* spending which contributes to the accumulation of the stock of existing knowledge.
- ✓R&D investments contribute to reduce emissions and induce a "*Learning by Doing*" effect, modeled as cumulated past emission abatement.
- ✓These two factors are combined in an index of Technical Progress - TP - generally defined as,

$$TP = f(Knowledge, Cumulated\_Emissions\_\mathrm{Re}duction)$$

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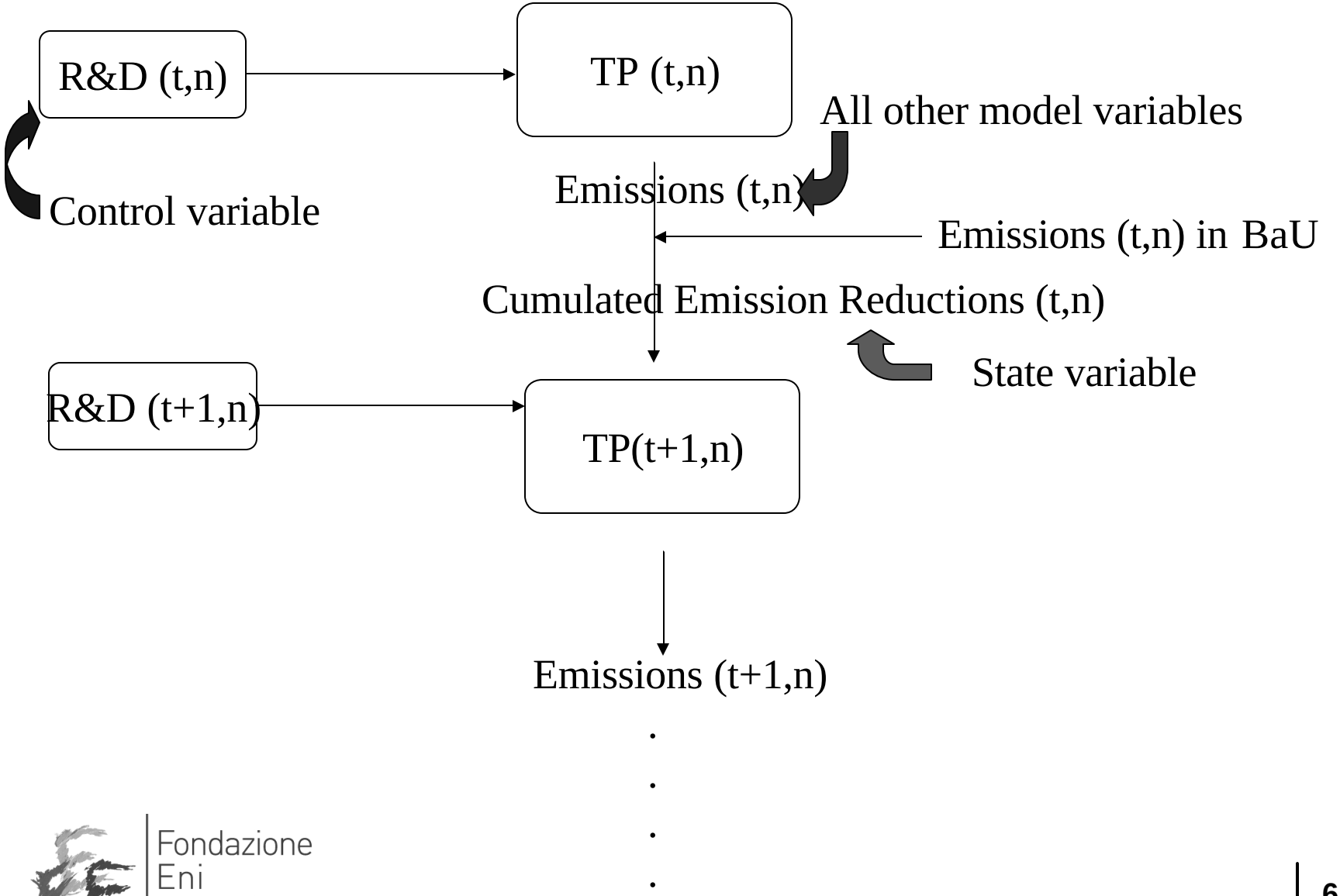
The structure of technical change in FEEM RICE v.3



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Preliminary results

- Technical change more effective on energy switching than on energy saving
- Small incentives from carbon price implicit in Kyoto
- Larger incentives from ambitious future targets and from R&D protocol

THE END ?

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