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Waisman, et al. 2012. 'The Imaclim-R Model : Infrastructures, Technical Inertia and the Costs of Low Carbon Futures under Imperfect Foresight.' Climatic Change, Volume 114, Number 1, 101-120.

Évaluer les coûts des politiques climatiques avec le modèle hybride Imaclim-R.

Le rôle des infrastructures, de l'inertie du capital technique et des anticipations imparfaites.

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Séminaire de Recherches en Economie de l'Energie de Paris-Sciences-Lettres

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École Mines Paris Tech

1. Main features of Imaclim-R model

2. Scenarios to assess global climate policy costs

3. Results

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Hybrid models: what is at stake?

Consistent long-run scenarios…

- Plausible and tangible technological change pathways
- Binding physical constraints (asymptotes, resources, availability of land…)
- Binding economic constraints (investment levels and allocation, terms of trade, final demand patterns, budget constraint)

…to guarantee that the economies depicted are based on realistic technical worlds and vice-versa.

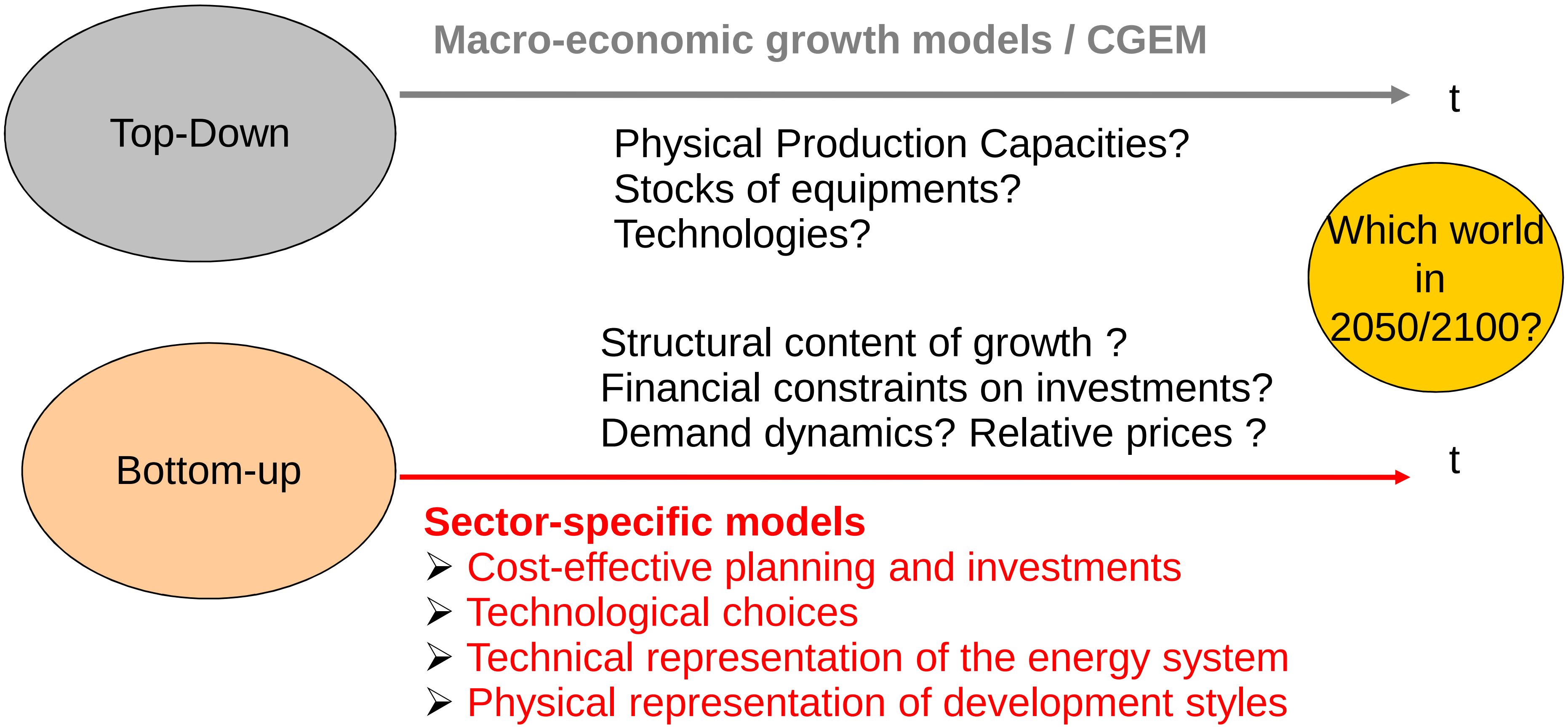
…to capture the **interactions** between energy systems evolutions and economic dynamics, for instance:

- Induced technical change
- Rebound effects between energy efficiency and activity level
- Crowding out effects between households energy bill and other consumptions

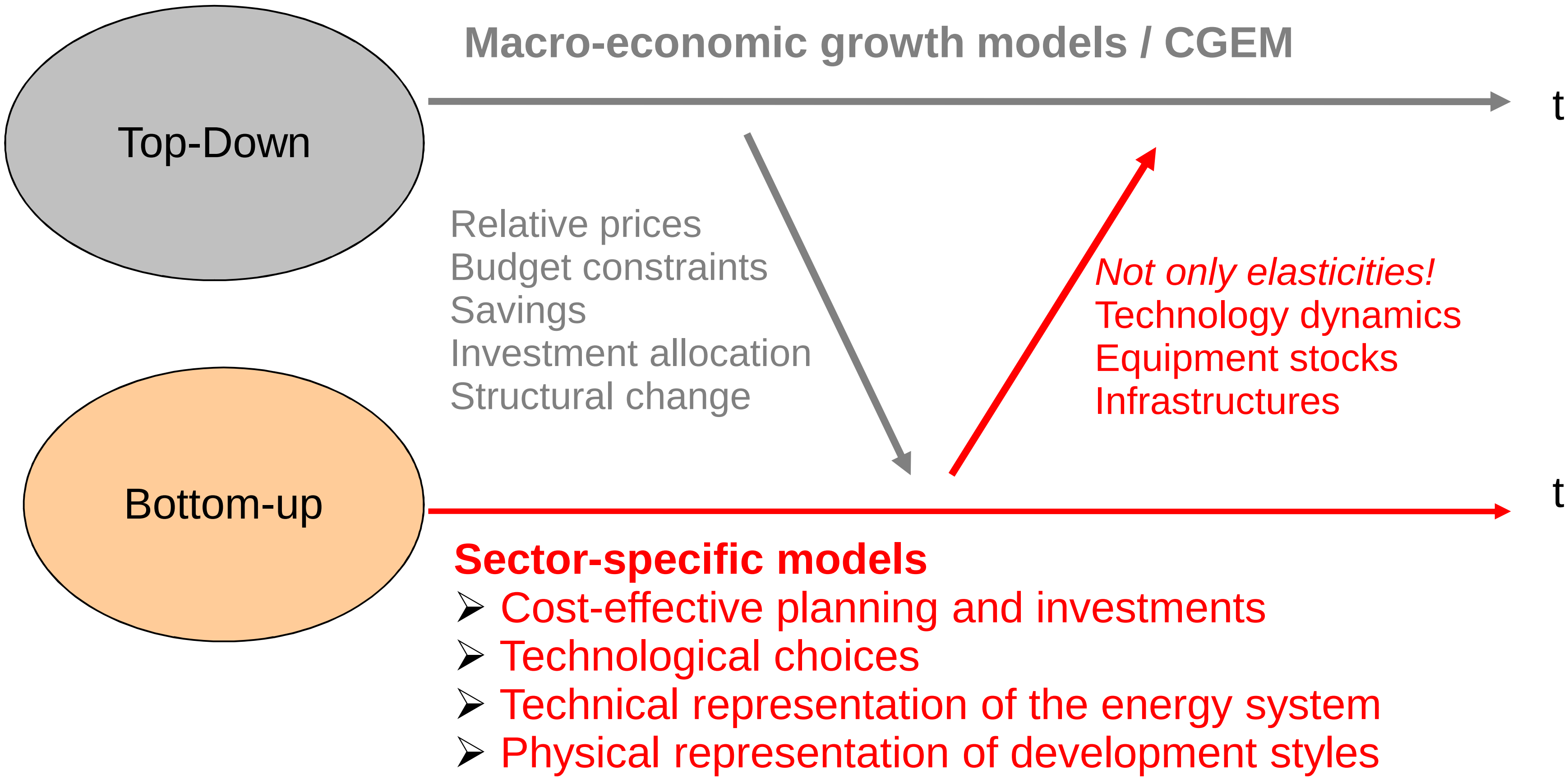
…to explore system-wide issues:

- Climate-Development issue
- Mimetic development styles against sustainability
- Food-Energy-Sequestration issue
- Etc.

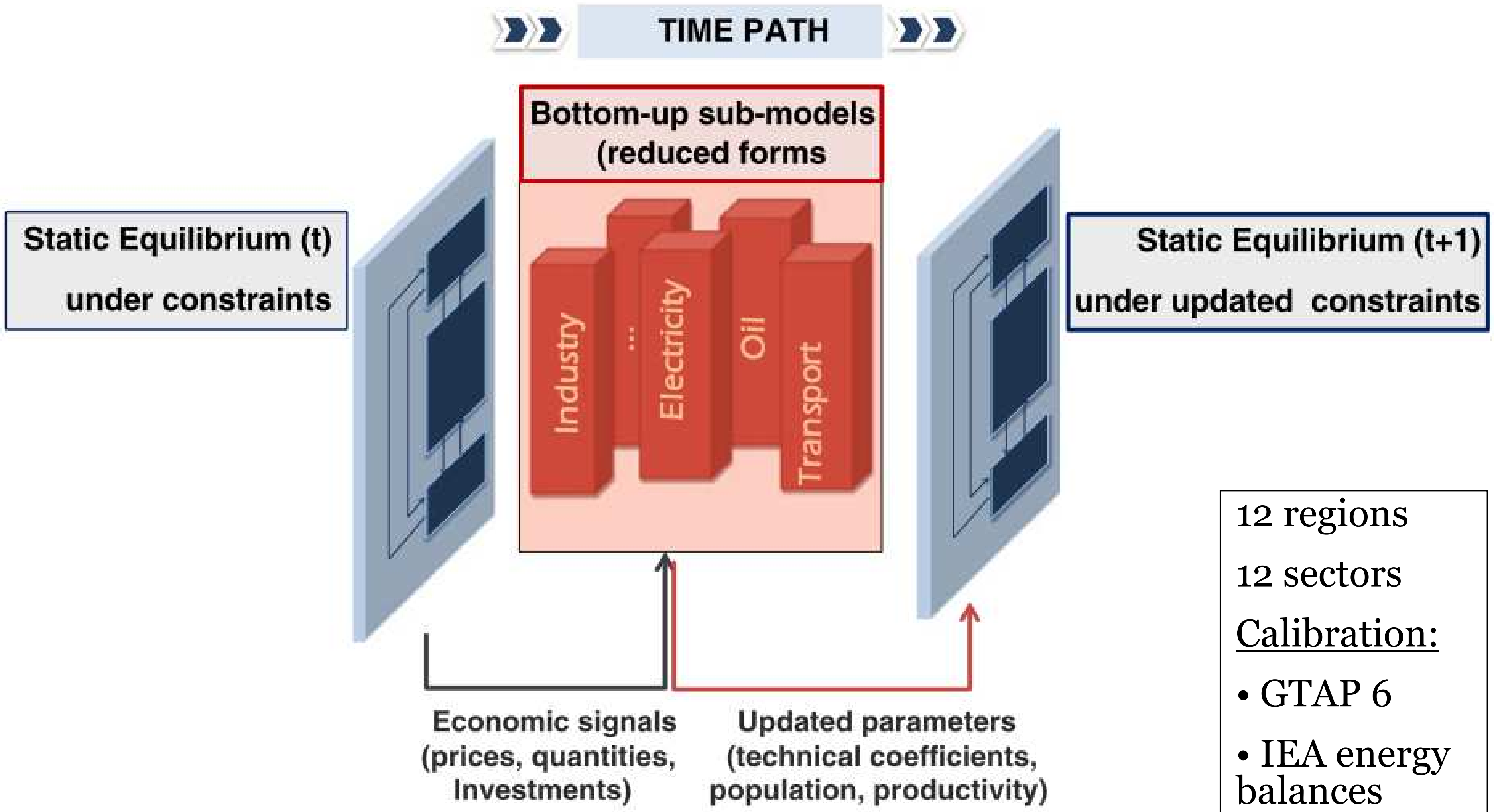
Hybrid modeling and interdisciplinary dialogue



Hybrid modeling and interdisciplinary dialogue



Imaclim-R: a hybrid recursive model to study the economy-energy-climate dynamics



12 regions

12 sectors

Calibration:

- GTAP 6
- IEA energy balances

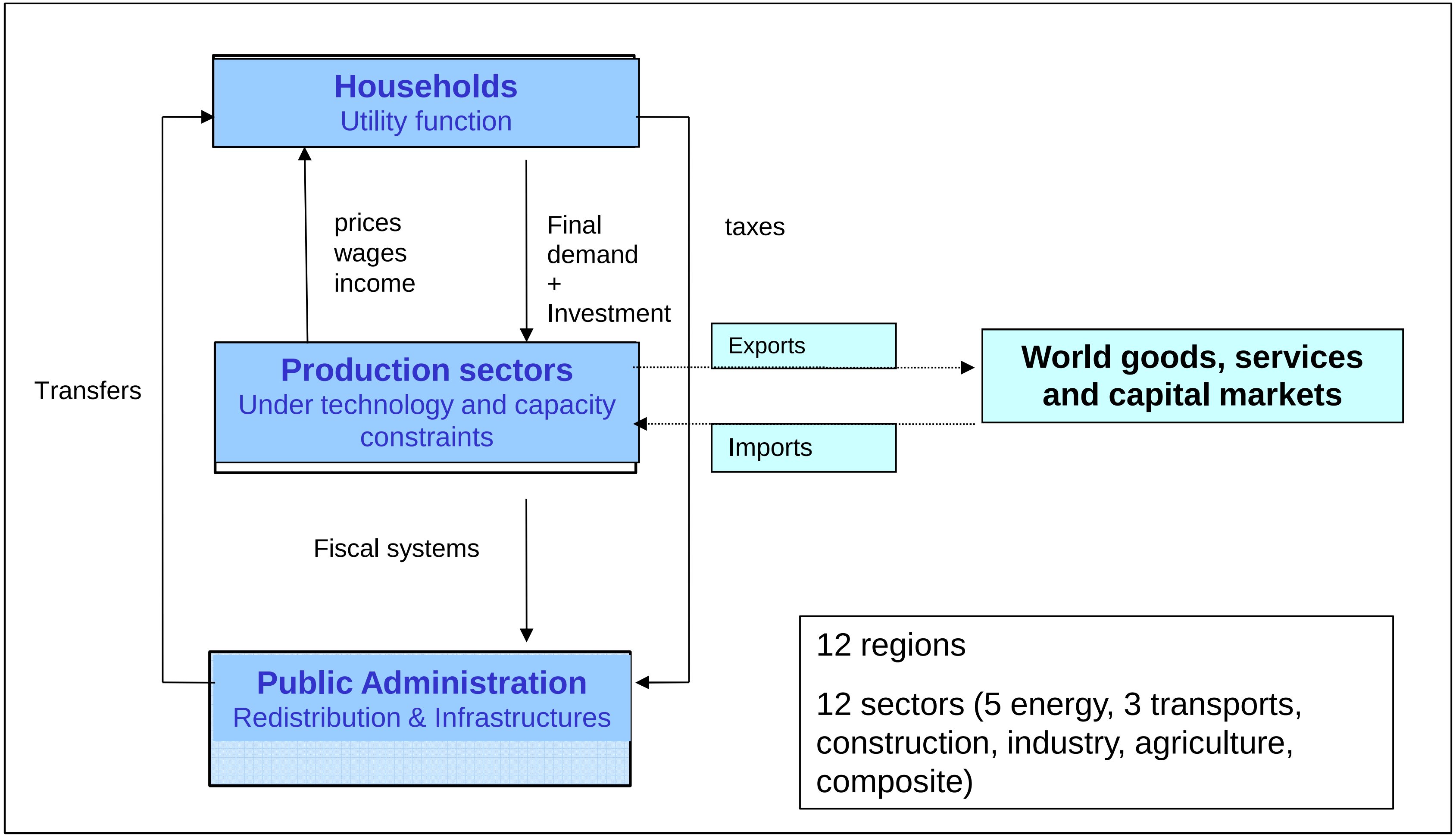
General features of the Imaclim-R model

A comprehensive **price & physical quantities** account :

- energy (Mtoe), transportation (Passenger-kilometre travelled)
- Hybrid matrices, physical production capacities, physical i/o coefficients

- Secure the dialogue with sector - based expertise (sources of technical inertia, technical asymptotes in efficiency gains…)
- Assure consistency between economic projections and technical projections

A yearly static equilibrium to capture general equilibrium effects



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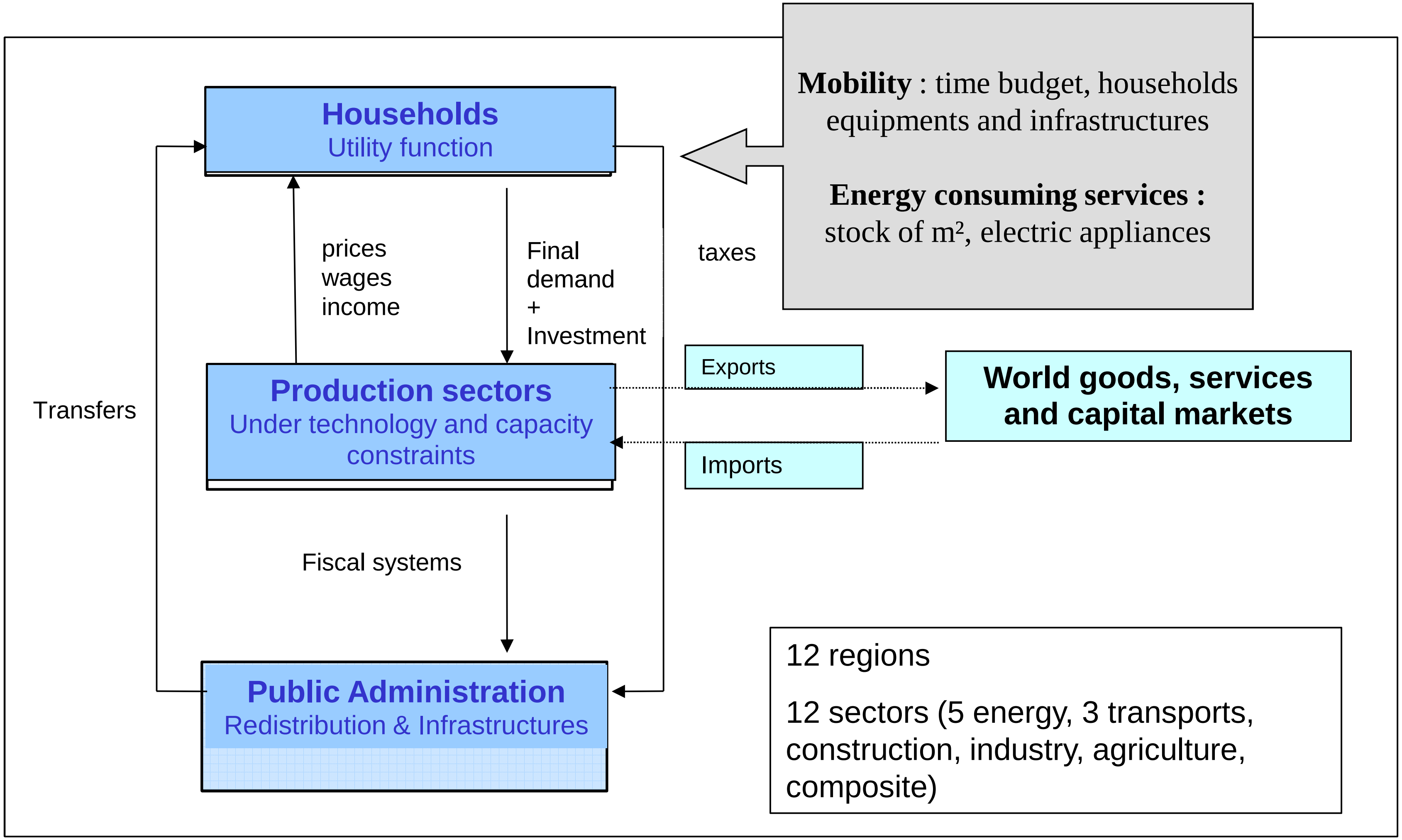

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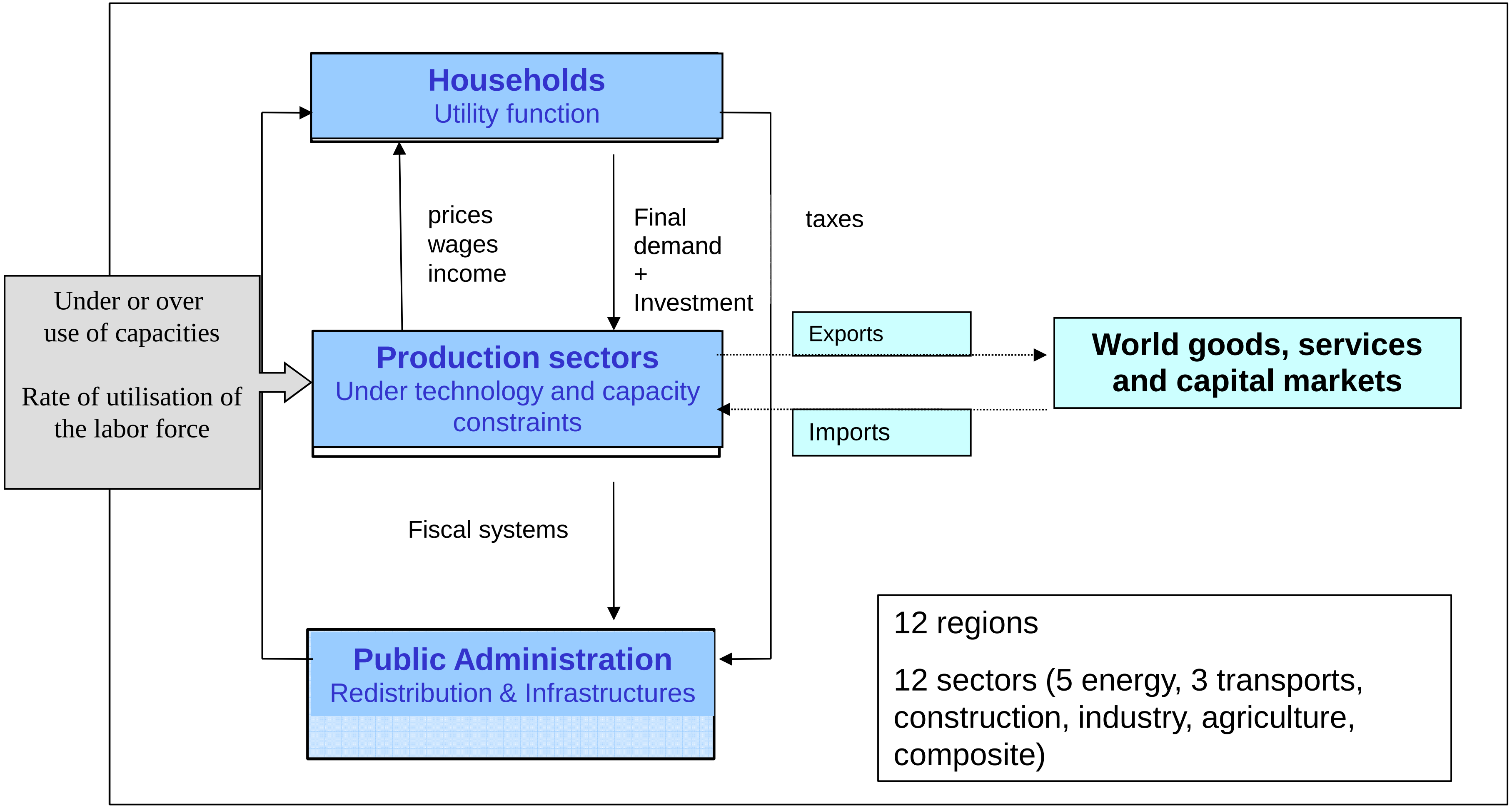
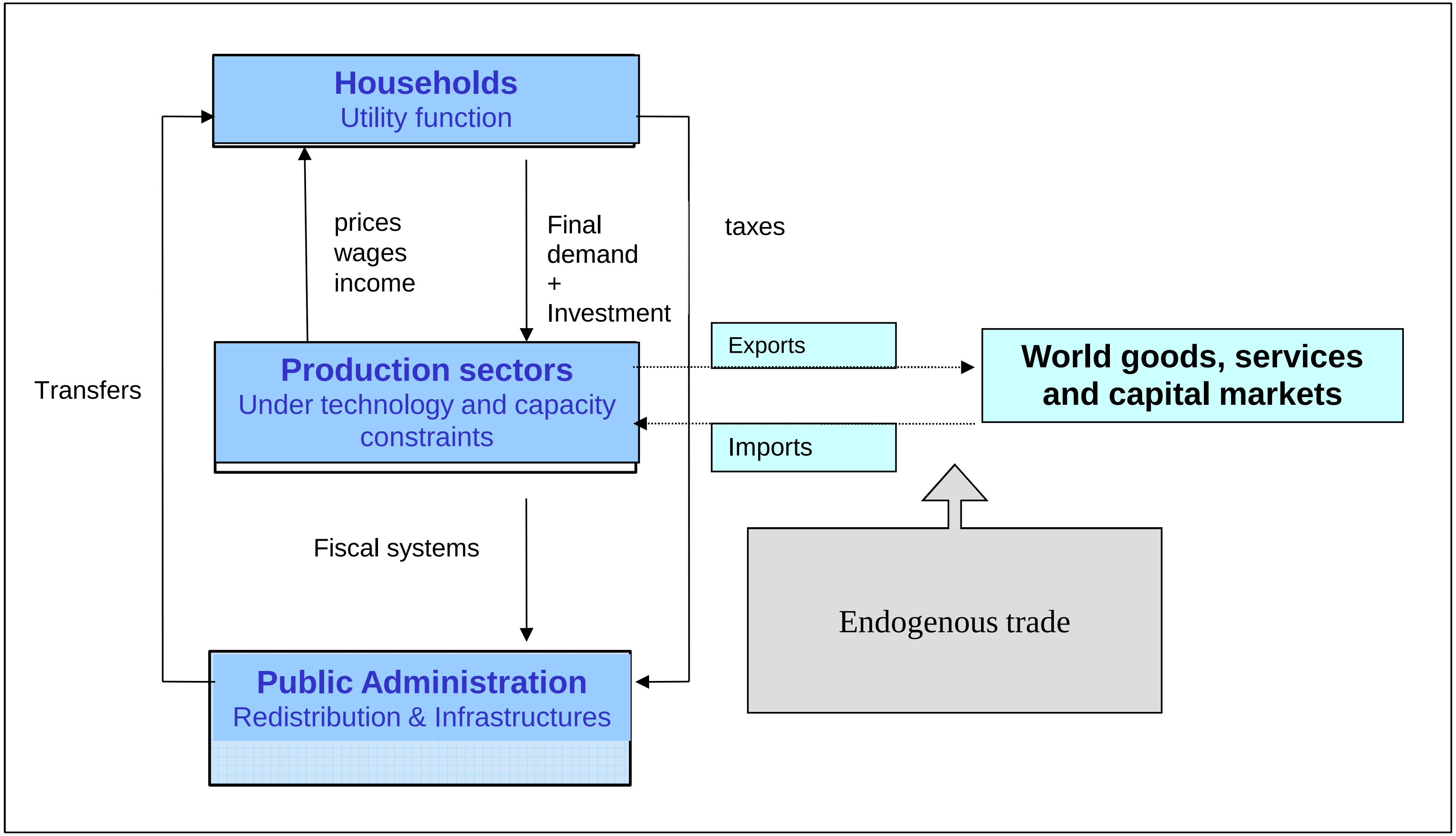


A yearly static equilibrium to capture general equilibrium effects



Focus on the dynamic modules

1. Growth engine
2. Evolution of constraints

Salient features of the IMACLIM-R framework

What Growth Engine? natural growth and effective growth…

- A **natural growth,** the drivers of which are**:**
  - Demography (pyramid of age) → labor force increase/decrease
  - Labor productivity increase (either exogenous catching up assumptions or stylized representation from endogenous growth theories)

  →Exogenous "natural growth" (Phelps, 1961), i.e. the growth rate that an aggregated one-sector economy would follow under full employment of production factors.

- **Effective growth** is endogenous:
  - Allocation of labor force across sections (with different absolute productivities)
  - Shortage or excess of productive capacities, resulting from past investment decisions

Focus on the dynamic modules

1. Growth engine
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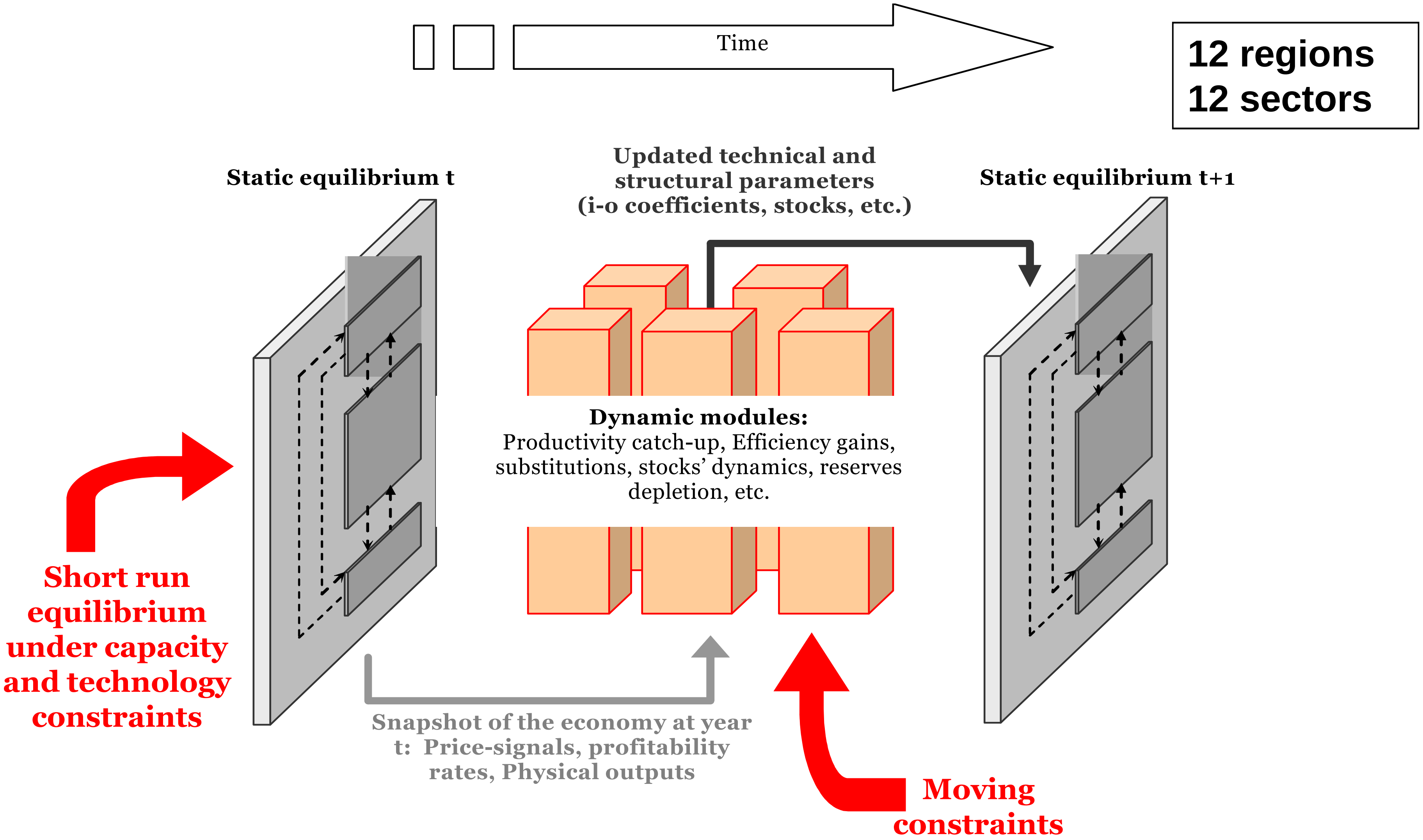
A recursive dynamic approach to disentangle short run constraints/adjustments and long run dynamics



A specific effort to describe technological choices, technical constraints and structural change

- An explicit **technology portfolio** for critical elements of the energy system
  - Power generation (Advanced coal, CCS, nuclear, various renewable…)
  - Light Duty Vehicles (Hybrid, plug-in Hybrid, electric…)
  - Alternative liquid fuels (Biofuels, Coal to liquid…)
- An effort to represent **physical constraints** bearing on energy supply and demand
  - Temporal availability of oil resources
  - Load curve for power generation
  - Technical asymptotes for energy efficiency gains
- Including **Structural Change**
  - R&D and learning-by-doing mechanisms apply to the sets of techniques
  - Endogenous Structural Change results from interactions between demand, supply, and ITC mechanisms

Dynamic module « mimic » investment choices

- Sectors chose how many new producing capacities they wish to build and what technical characteristics they want (type of energy, energy efficiency), given:
  - Depreciation of old capital generations
  - Anticipated demand (with information on current and past demands)
  - Anticipated prices (with information on current and past prices)
  - Technologies characteristics in the portfolio (costs, efficiencies…)

- Households similarly chose their equipments (cars, …)

- The capital stock characteristics evolve « at the margin »
- Putty-clay representation allows to distinguish between short-term rigidities and long-term flexibilities

A « detailed » representation of transports

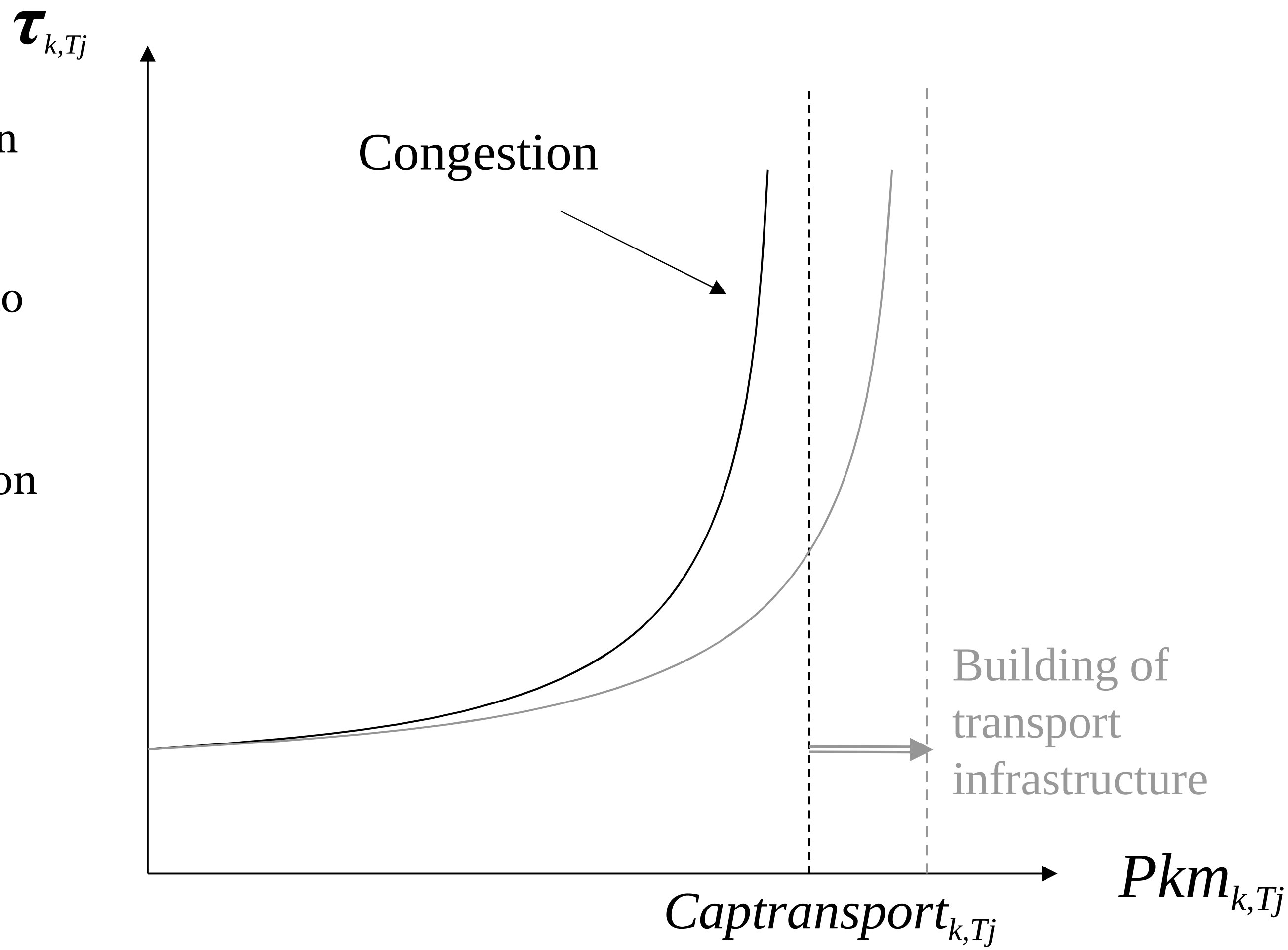
- Passengers mobility:
  - 4 modes: personal vehicles, terrestrial public transport, air, non-motorized
  - Overall mobility volume and modal shares determined by:
    - Households utility maximization under two constraints: budget and time spent in transport (Zahavi's "law")
    - Modes are characterized by a price and a speed
    - "Basic mobility needs" to capture constrained mobility and its induction by location choices and urban forms

- Freight transport content of production processes:
  - 3 modes: terrestrial, water, air
  - Explicit input–output coefficients.
  - Default assumption: constant input–output coefficient (absence of decoupling between production and transport)

Transport infrastructure and congestion

marginal efficiency in transport time

(the time necessary to travel an additional passenger.kilometer with mode Tj in region k)



1. Main features of Imaclim-R model

- A hybrid recursive model
- GE under capacity and technical constraints each year
- Dynamic modules representing investment decisions
  - Imperfect foresight
  - Technical systems inertia

2. Scenarios to assess global climate policy costs

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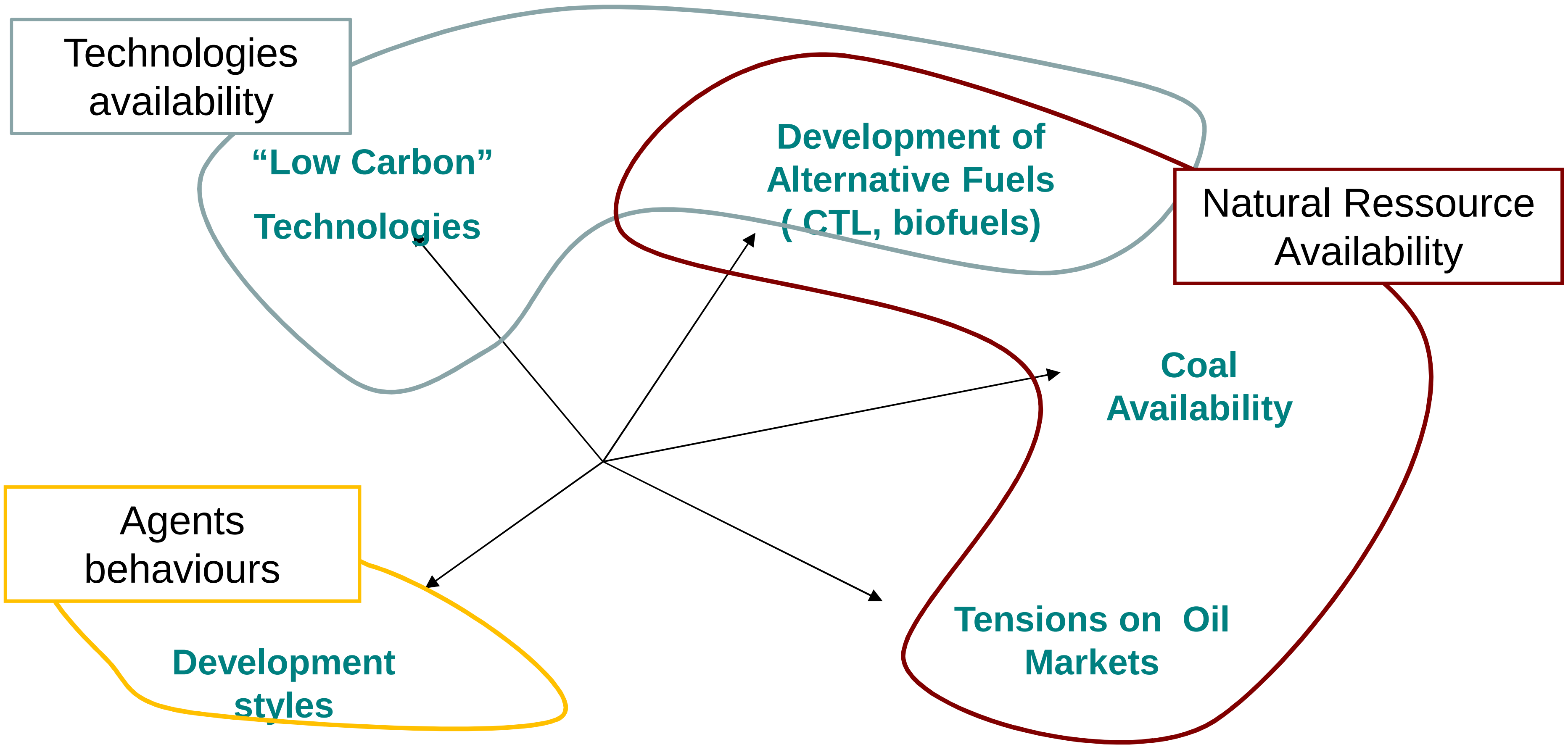
Scenarios to explore the time profile of climate policy costs

- Reference scenarios: no constraint on GHG emissions

- Climate objective: an exogenous emissions trajectory, leading to stabilization of concentration at 450 ppm CO2

- (Very) stylized policy:
  - uniform carbon tax at the global level, endogenously determined each year to respect the emission target
  - No international redistribution of carbon tax revenues, given back to households in each region

Scenarios to explore the time profile of climate policy costs



Scenarios to explore the time profile of climate policy costs

"Low Carbon" Technologies

Electricity Generation:

- Dates of entry into the market of the CCS, the Nuke 4th generation, advanced renewables

- The speed of the technical change: "learnig-rate" of the technologies

- Market share asymptotes

End Uses :

-Hybrid and Electric Vehicles

- Low energy buildings

- ...

Scenarios to explore the time profile of climate policy costs

“Low Carbon” Technologies

Fast Technical Change:

- **Early** dates of entry into the market
- **Important** “learnig-rate” of the technologies
- **High** asymptotes for the market shares

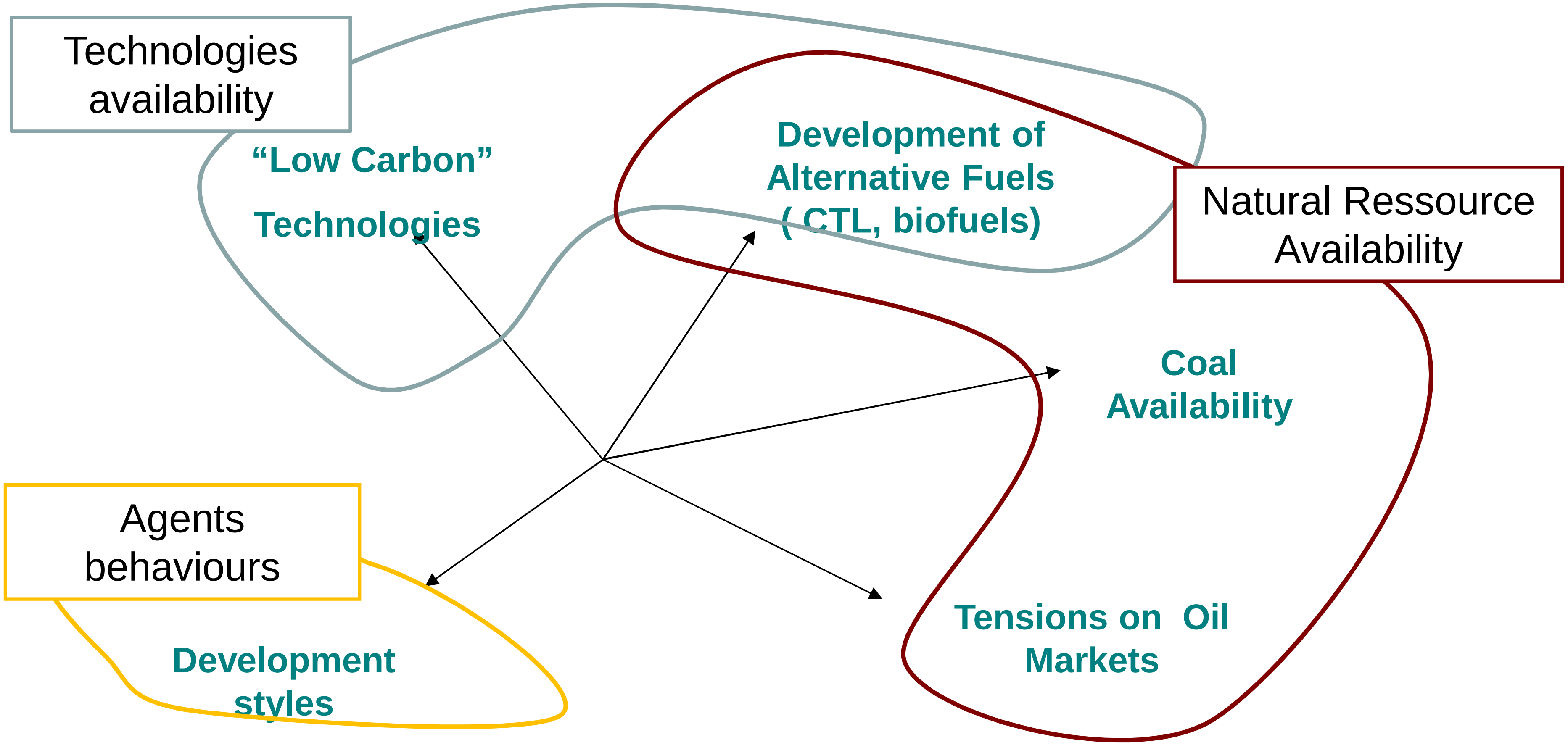
Ex: Learnig-rate for the Electric Vehicles: 20%

Slower Technical Change :

- **Later** dates of entry into the market
- **Smaller** “learnig-rate” of the technologies
- **Low** asymptotes for the market sharesv

Ex: Learnig-rate for the Electric Vehicles: : 10%

Scenarios to explore the time profile of climate policy costs



2 options for all the groups of parameters…
3 alternatives for Oil markets

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- Reference scenarios
- Global climate policy scenarios
- « Database » of scenarios to explore uncertainties

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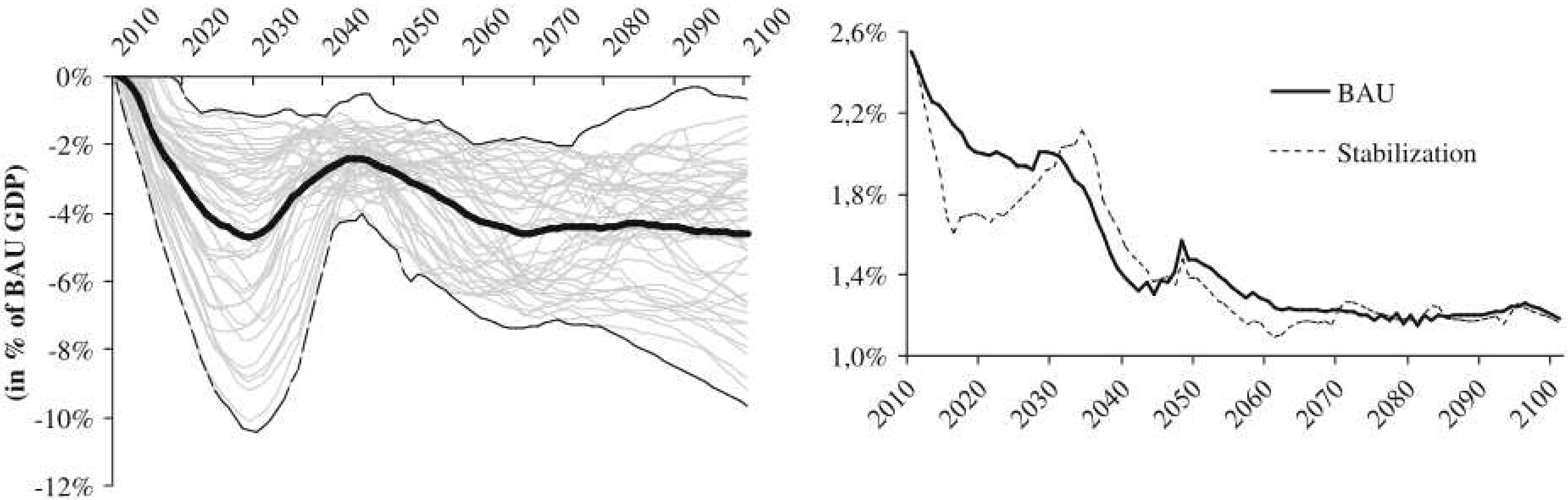
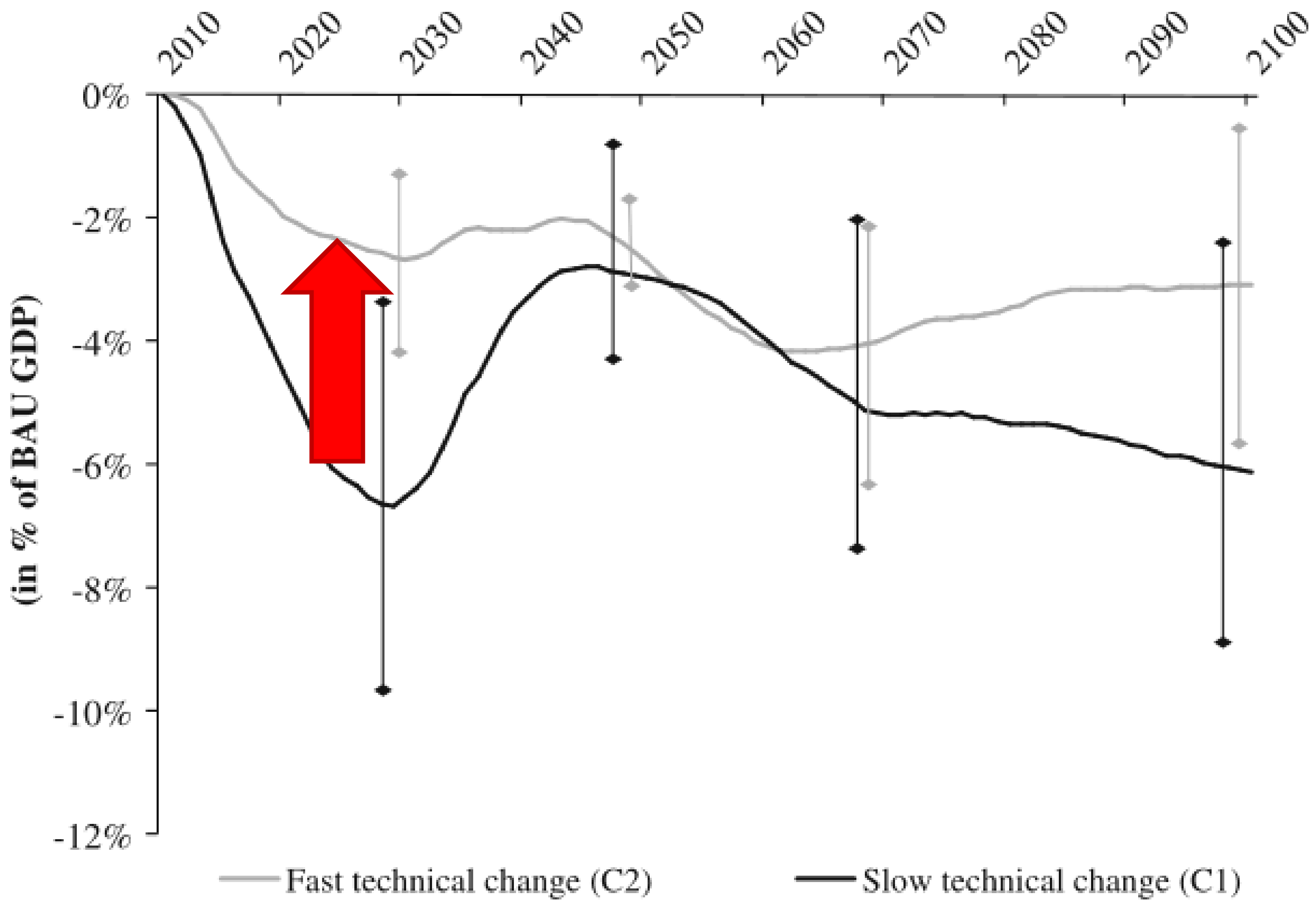
Carbon price-only policy: a time profile robust to uncertainties

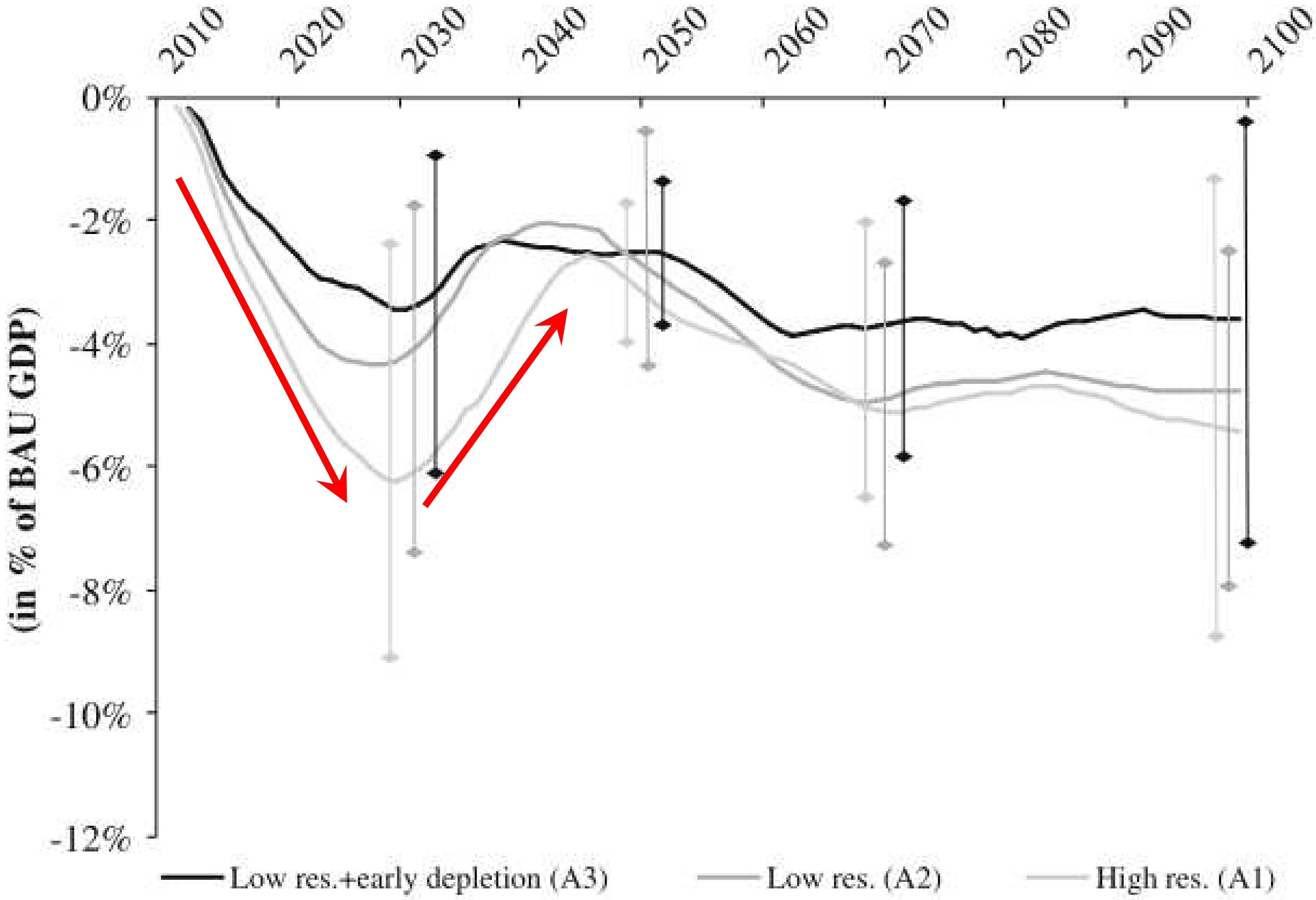


Global GDP variations between stabilization and BAU scenarios, over the 2010–2100 period [left-hand panel]; Average GDP growth rate across all BAU (*solid line*) and stabilization (*dotted line*) scenarios [right-hand panel]

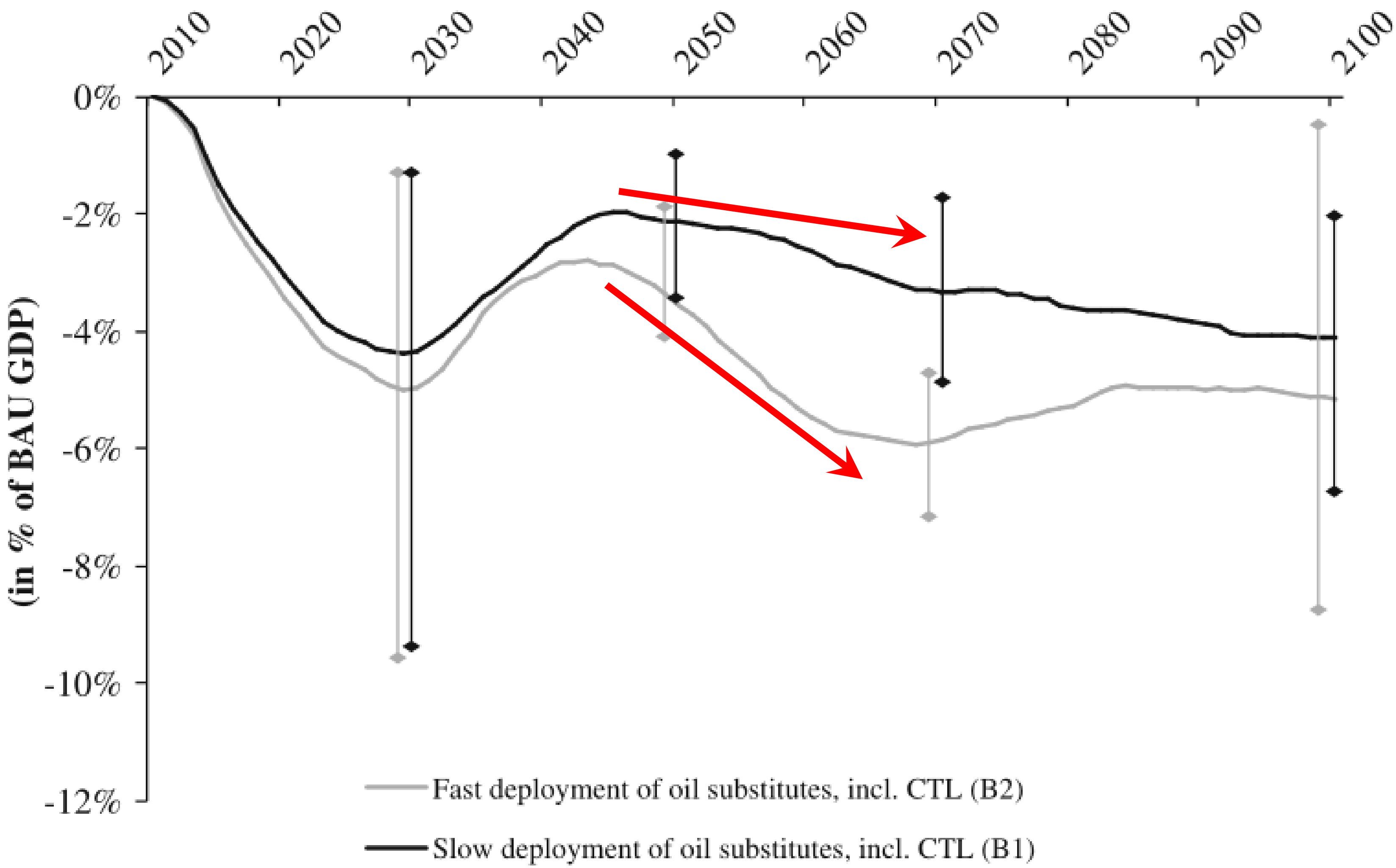
More optimistic assumptions on low carbon technologies limit short-term losses



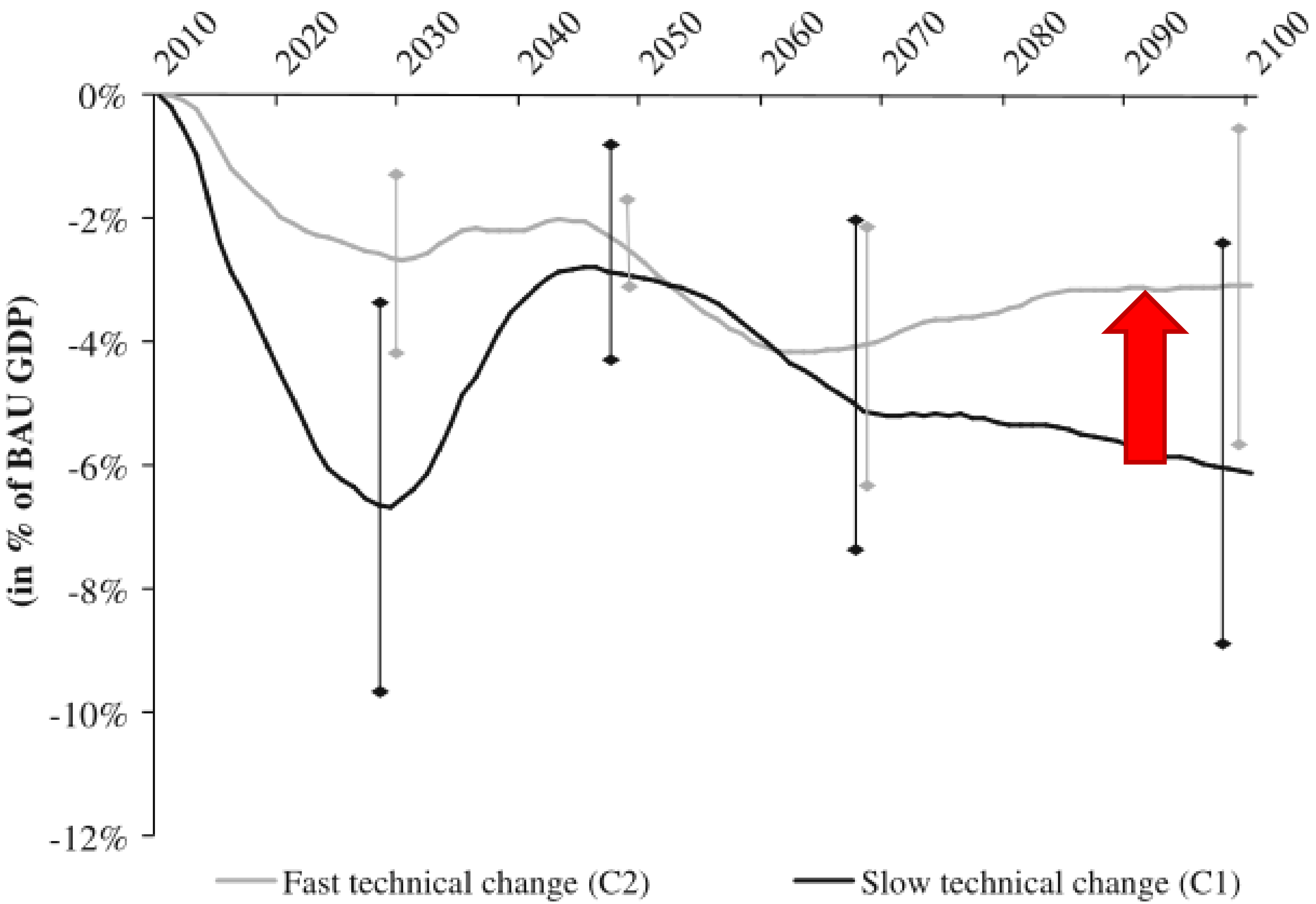
Short-term losses, but also medium-term catch-up, are stronger with high oil reserves assumption



2040-2070 dynamics are strongly deterrmined by the assumption on substitutes to oil



The costs and potential of transport decarbonization determines long term costs

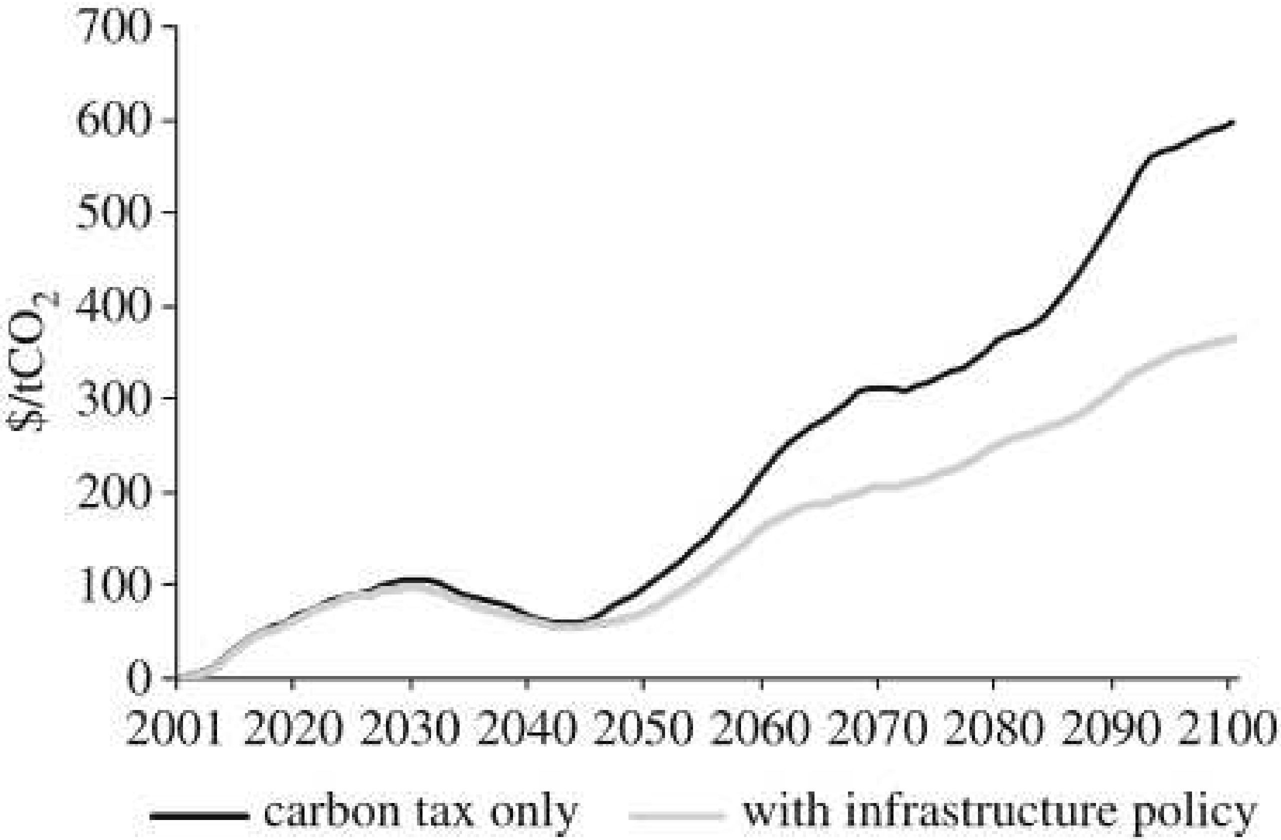


A new set of scenarios to test the role of investments in long-lived transport infrastructure

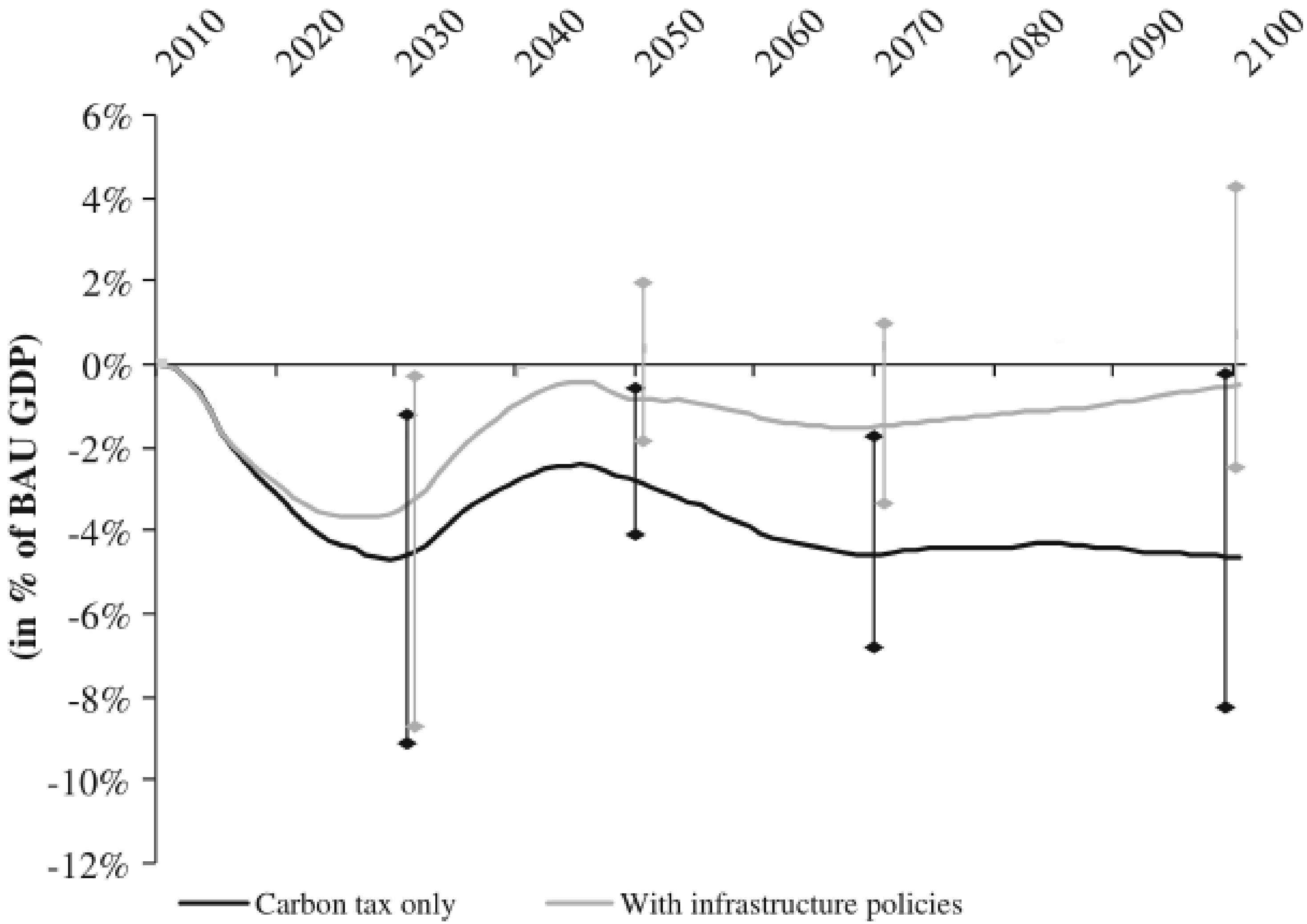
Changing three sets of assumptions as a proxy for "infrastructure and spatial planning policies":

- Investments in transportation infrastructure, modal allocation:
  - From an allocation following modal mobility demand (avoid congestion)
  - To a reallocation favoring low-carbon transportation infrastructure (rail and water for freight transport, rail and non-motorized modes for passenger transport).
- Constrained mobility ("basic needs"):
  - From 50% of past mobility
  - To a progressive reduction to 40% .
- Freight content of production:
  - From constant input-output coefficients
  - To a 1% yearly decrease

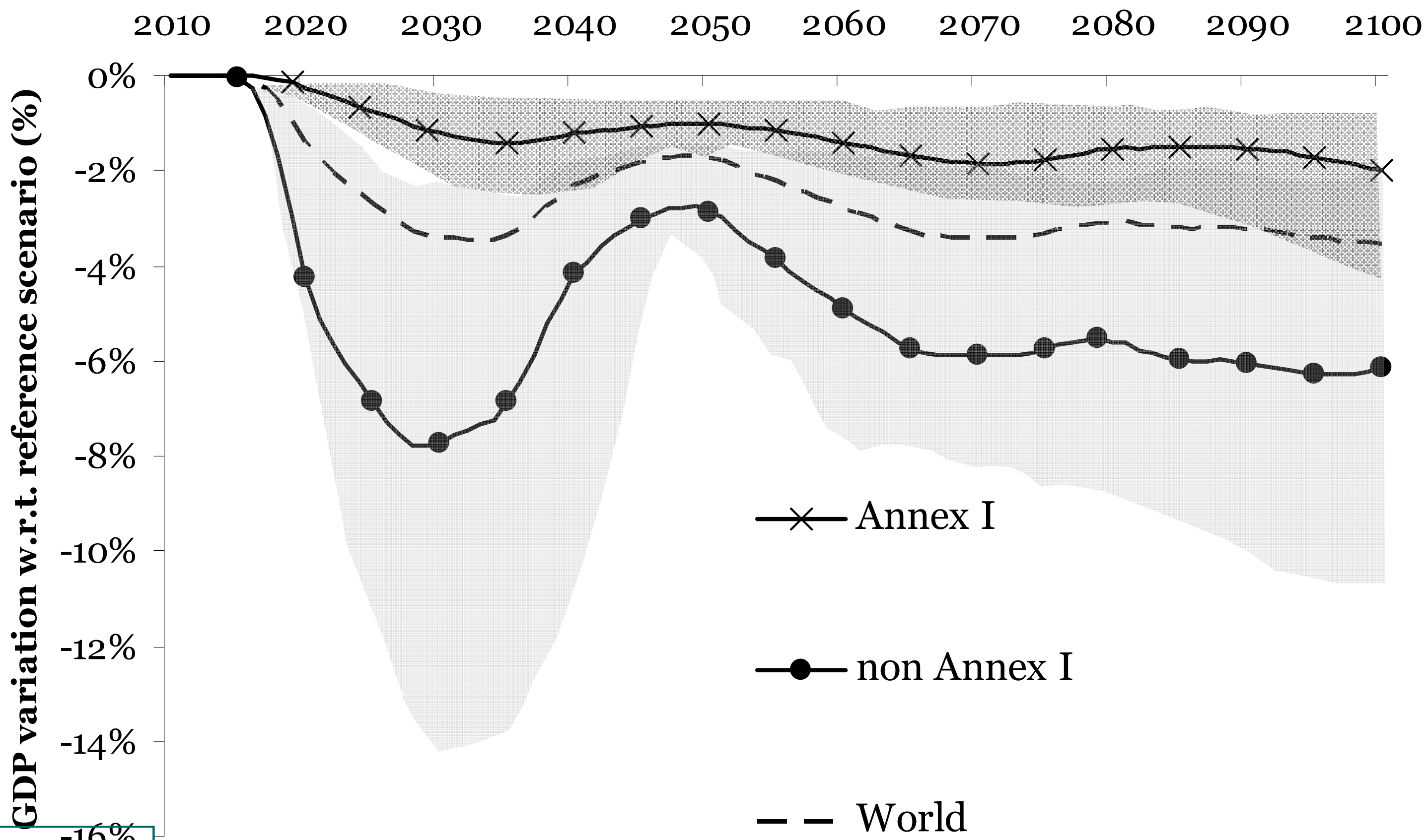
Infrastructure policies reduce the long-term carbon prices



Infrastructure policies reduce the long-term climate policy costs



Costs are higher in emerging and developing countries

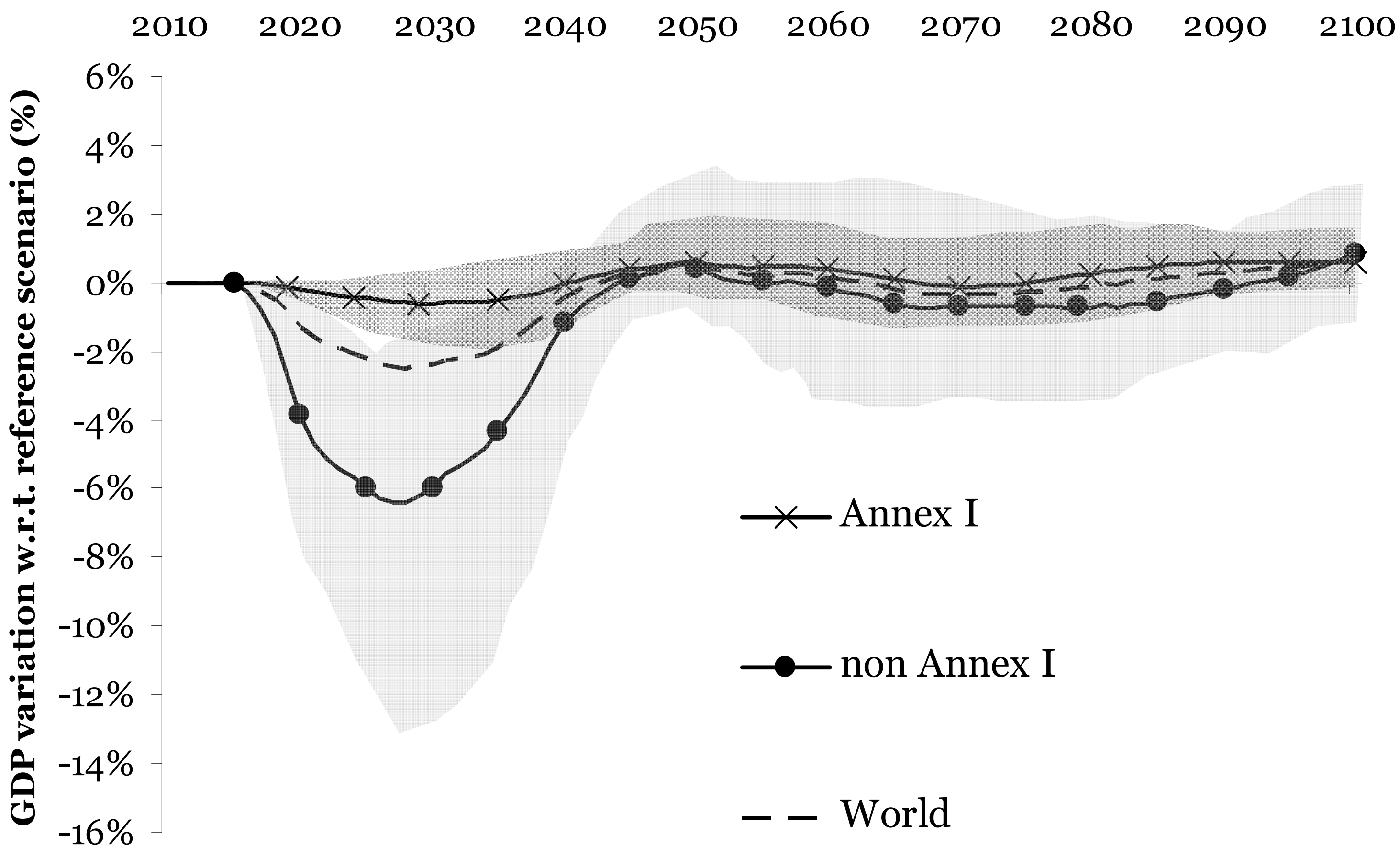


World (dashed)

Annex I (crosses)

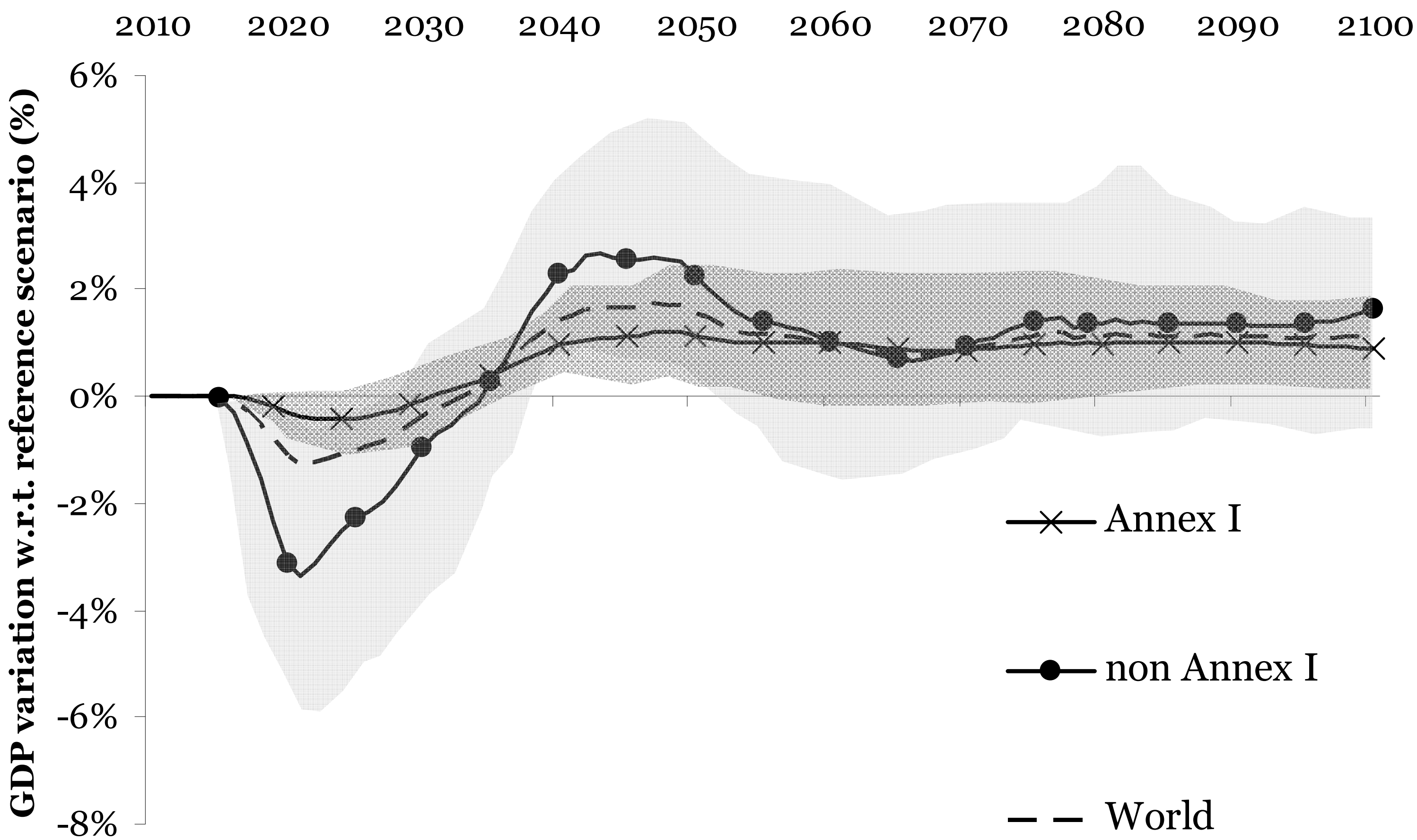
Non-Annex I (dots)

Infrastructure policies reduce policy costs in all regions



With specific early action on transportation infrastructure

A fiscal reform can reduce transition costs



With specific early action on transportation infrastructure + Fiscal Reform

Conclusions

- The conjunction of inertia of technical systems and imperfect foresight can lead to significant costs of climate policies
- A uniform carbon price leads to higher costs in emerging and developing countries
- There are large uncertainties on the quantification of these costs
  - Changing the question from « what is the cost? » to « what determines the costs? » and « how can they be reduced? »
- Transport is the main « stumbling block » over the long-term for deep decarbonization
- Policies on long-lived transport infrastructures and spatial planning policies can reduce long-term climate policy costs

Limits and further work

- A model always implies simplifications and assumptions, that can be discussed, challenged and improved
- Our representation of technical inertia and imperfect foresight can be seen as « extreme »…

  …but we can test alternative representations in the modeling framework
- The representation of climate policies is extremely/too stylized…

  …testing more refined/realistic representations is in progress
- GDP losses is only one (very imperfect but largely used) metric of costs...

  …others are under study

Merci pour votre attention
… et vos questions.

- Waisman, et al. 2012. ‘The Imaclim-R Model : Infrastructures, Technical Inertia and the Costs of Low Carbon Futures under Imperfect Foresight.’ Climatic Change, Volume 114, Number 1, 101-120.
- Waisman, H.D., Guivarch, C., Lecocq, C. 2013. ‘The transportation sector and low-carbon growth pathways’ Climate Policy 13(1) : 106–129.

http://www.imaclim.centre-cired.fr