Imaclim-R: a risky venture modeling transition towards Sustainable Development pathways in a 2nd best world context

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Stanford
8 September 2010

Outline

- **Motivations and key methodological choices**

- **The Imaclim-R modeling architecture**

- **Policy insights from some results**

Motivation and key methodological choices

Cheap 2K? Too good to be true?
(at the root of the US/EU game of distorting mirrors)

« *The most ambitious pathways [350-450 ppm CO2] are possible* » with a macroeconomic impact comprised between +0.5 and -3% of the GDP in 2030 with technologies currently known and a uniform carbon price between 5 and 80 $/tCO2 in 2030

... a good news subject to a **'never read' caveat** :

'Most models use a global **least cost approach** to mitigation portfolios and with universal emissions trading, assuming **transparent markets, no transaction cost**, and thus **perfect implementation** of mitigation measures throughout the 21st century.' (AR4 WGIII SPM Box 3)

... to which one should add 'and

And **widespread benevolence** to compensate the loosers

What droping these conditions imply?
Mind the transition!
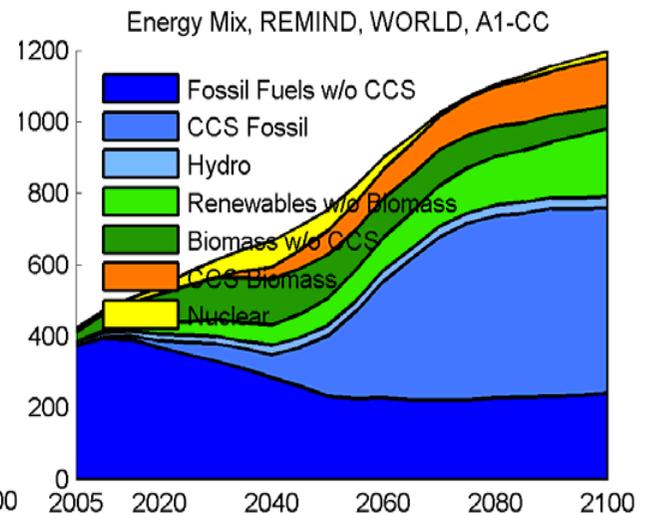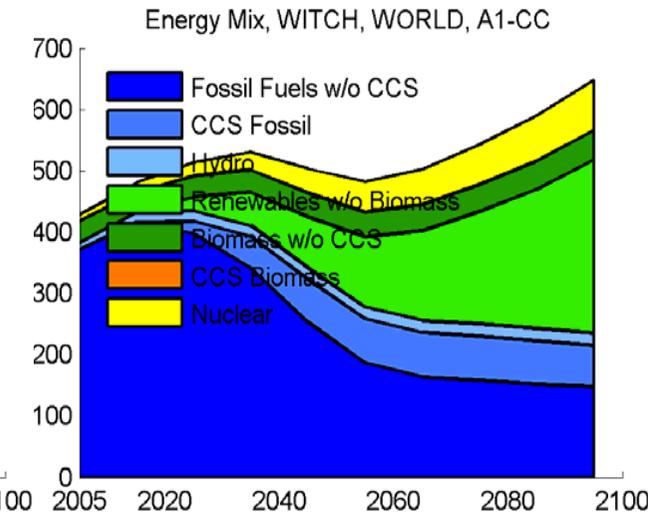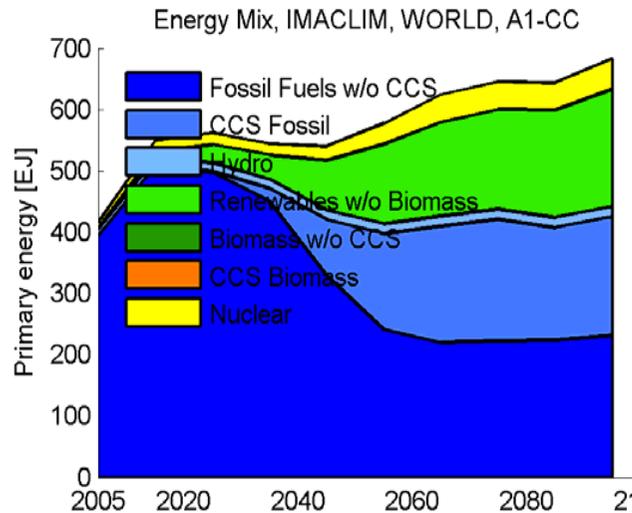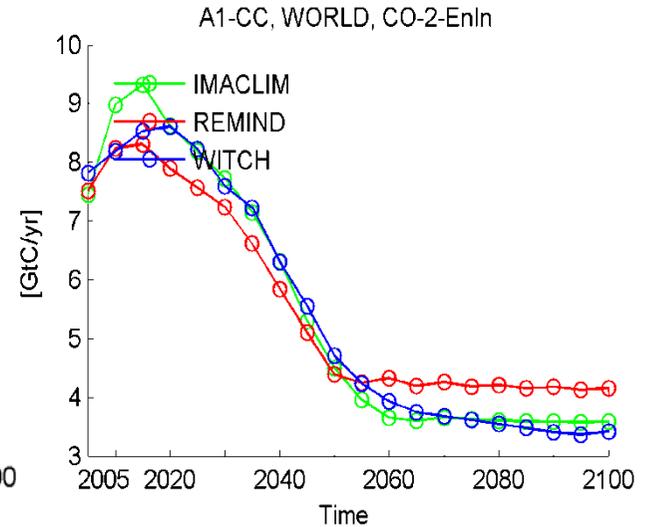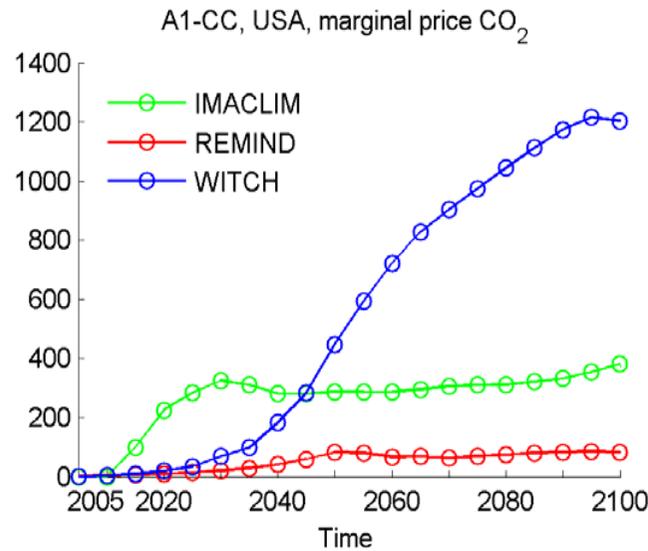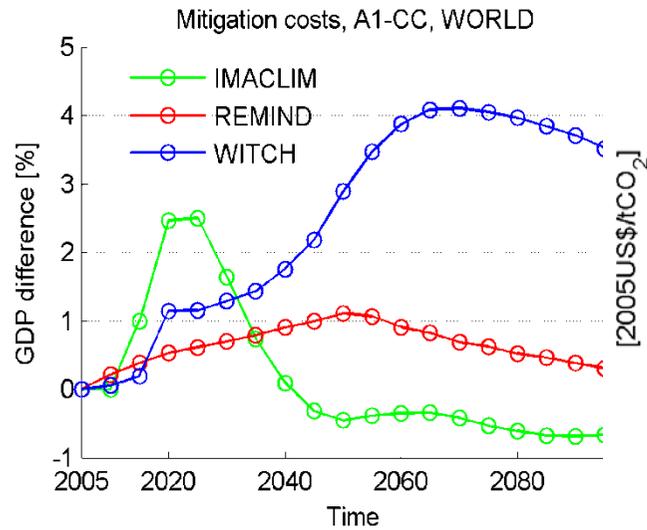
Main requirements to represent transitions

- Information needed about "what to do" in a 2nd best world

  1. Certain markets cannot be organized (forward markets, risk markets...), whereas others cannot be cleared (keynesian underemployment...).
  2. Lump sum transfers postulated by the traditional welfare theory cannot be implemented in the real world .
  3. Even if all markets do exist and if lump sum transfer is feasible, certain agents may have a noncompetitive behavior.
  (Guesnerie, Journal of Economic Theory, 1975)

- Representing both a short term context of **"crisis"** and (alternative trends of **changing balances of economic power**)

- Bridging the gap between empirical models (almost entirely in a 1st best world) and theoretical advances about mechanisms in a 2nd best world (Stern 2010, Foley 2010)

This is not a new story

- *"**If** there is some constraints within the GE system that prevents attainment of at least one of the conditions of Pareto optimality, **then the attainment of the other Pareto optimal conditions is no longer necessarily welfare improving**"*   Lipsey and Lancaster (Review of Economic Studies 1956)

- A theoretical statement which should be qualified through quantifying the real orders of magnitude of the 'distortions' from the 1st best context

- **But** which suggests that together with political vagaries, harsh lobbying and weak economic reasoning, there may be **an economic rationale behind the difficulties in making a deal around policy architectures build around a "pure" pricing of carbon**

- In 2nd second best setting, the necessity of correcting jointly several market failure is the **economic justification for "issue linkages"** … and multiple dividends

IMACLIM, result from a Huron's view in the early 90[ies]

- Coupling energy models with long run growth models **was (and is still)** the task to be done, but should not attract all the attention:

  "At short term scales, I think, something sort of 'Keynesian' is a good approximation , and surely better than anything straight 'neoclassical'. At very long time scales, the interesting questions are best studied in a neoclassical framework and attention to the Keynesian side of things would be a minor distraction" *(Solow 2000)*

- The BU/TD debate about the ***energy efficiency gap*** tends to mask ***other sources of pre-existing sub-optimalities*** (labor markets, real estate, infrastructures, informal economy) that may:
  - Be a potential for double-dividends of environmental policies
  - Exacerbate policy costs

- The **'elephant and rabbit stew metaphor'** (Hogan & Manne 1977) holds only under conditions
  - Low departure from pre-existing baselines
  - No deep structural effects

- Others do the job about with long run CGE models and equilibrated pathways .... let us try something else ... this is risky but may be useful

Huron's intuition: hybridizing models in two senses

- **Back to the Arrow-Debreu axiomatic:** hybrid Social Accounting Matrixes in values and explicit quantities to secure the consistency of the engineering based and economically based analyses

- **Hybridizing** long run (**neo-classical colored**) models with short run (**Keynesian colored**) model :

    "At a five to ten year time scale, we have to piece things together as best as we can, and look for a hybrid model that will do the job" Solow 2000

- These **two dimensions are deeply intertwined** and impose to come back to unsettled issues in growth and development theory and models

Three risky but necessary methodological attempts

- Representing **adaptive behaviors** instead of perfect (or myopic) foresight

- **No** ex-ante prescription of tractable (neo-classical) production functions

- Endogenous disequilibrium due to **the interplay between imperfect foresight, technical inertia and social routines** -> a touch of keynesianism under the general equilibrium constraints

A reminder: Solow's message about the production functions

« [...] total-factor-productivity calculations require not only that market prices can serve as a rough-and-ready approximation of marginal products, but that aggregation does not hopelessly distort these relationships [...] over-interpretation is the endemic econometric vice »

« This 'Wrinkle' is acceptable only at an aggregate level (for specific purposes) and implies to be cautious about the interpretation of the macroeconomic production functions as referring to a specific technical content »

in Solow RM. (1988) « Growth Theory and After », American Economic Review 78(3), 307-317

Why to drop this « wrinkle »?

- Allowing for a **distinction between installed productive capacities and the economic capital** to capture investment dynamics

- The derivation of the demand for capital, hence for investment, can no longer by made through the Shepard's lemma when one departs too strongly from equilibrated growth pathways

- Organizing controllable exchanges with engineering based expertise and information about the **physical background of growth pathways** (Hourcade & Jaccard, Energy Journal 2006)

The Imaclim modelling structure

A recursive dynamic approach to disentangle short run constraints/adjustments and long run dynamics
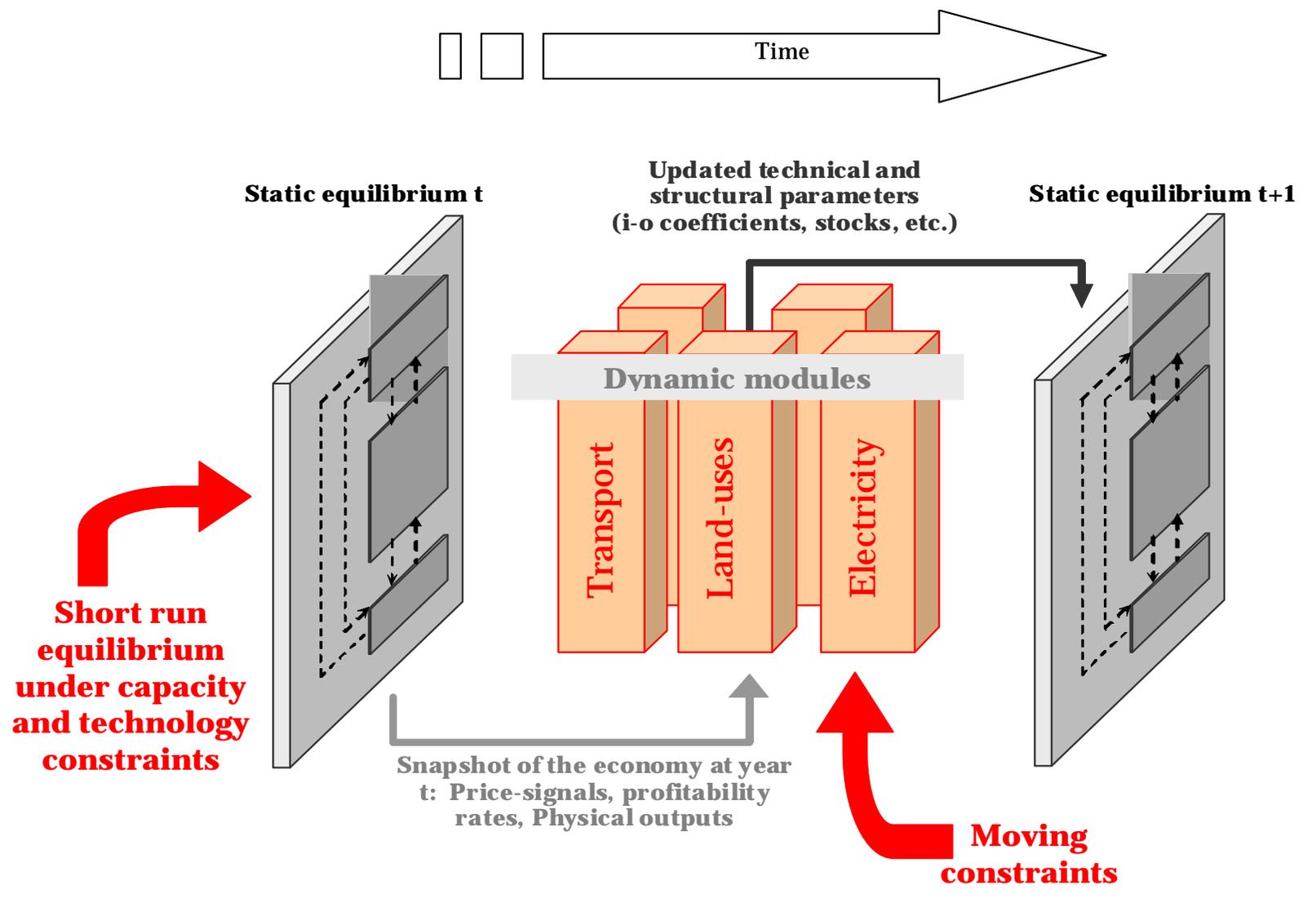
The short run equilibrium

1. **values & physical quantities balances solved jointly**

   ➤ Physical indexes for energy (Mtoe), transportation (vkm and tkm, housing space (m2), land-use, (km2), high intensive industry (tons) and composite goods ... depending upon the disaggregation level

   ➤ Tracking of production capacities

2. An equilibrium under **short-term rigidities**

   ➤ Fixed I/O coefficients

   ➤ Imperfect flexibility of labour markets

   ➤ **Flexibility through the utilization rate of capacities**

   ➤ **Changes in the relative prices**

The short run equilibrium

Mobility : time budget, households equipments and infrastructures

Energy consuming services : stock of m², electric appliances

Ownership of durables

Households
Utility function

prices
wages
income

Final
demand
+
Investment

taxes

Transfers

Production sectors
Under technology and capacity constraints

Exports

Imports

World goods, services and capital markets

Fiscal systems

Public Administration
Redistribution & Infrastructures

12 regions

12 sectors (5 energy, 3 transports, construction, industry, agriculture, composite)

The short run equilibrium

Households
Utility function

prices
wages
income

Final
demand
+
Investment

taxes

Under or over
use of capacities

Rate of utilisation of
the labor force

Production sectors
Under technology and capacity
constraints

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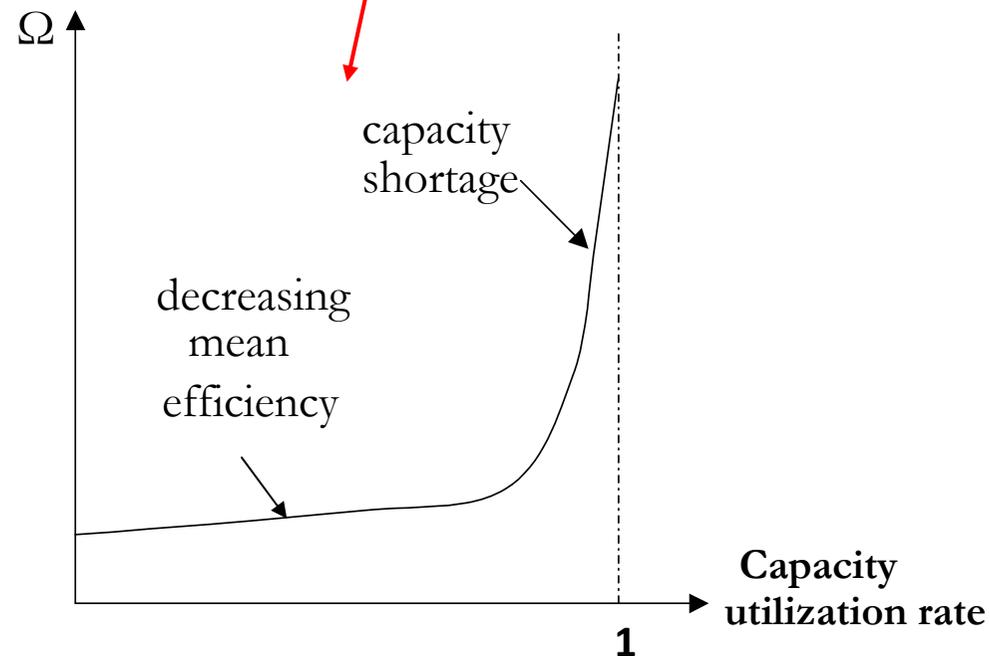
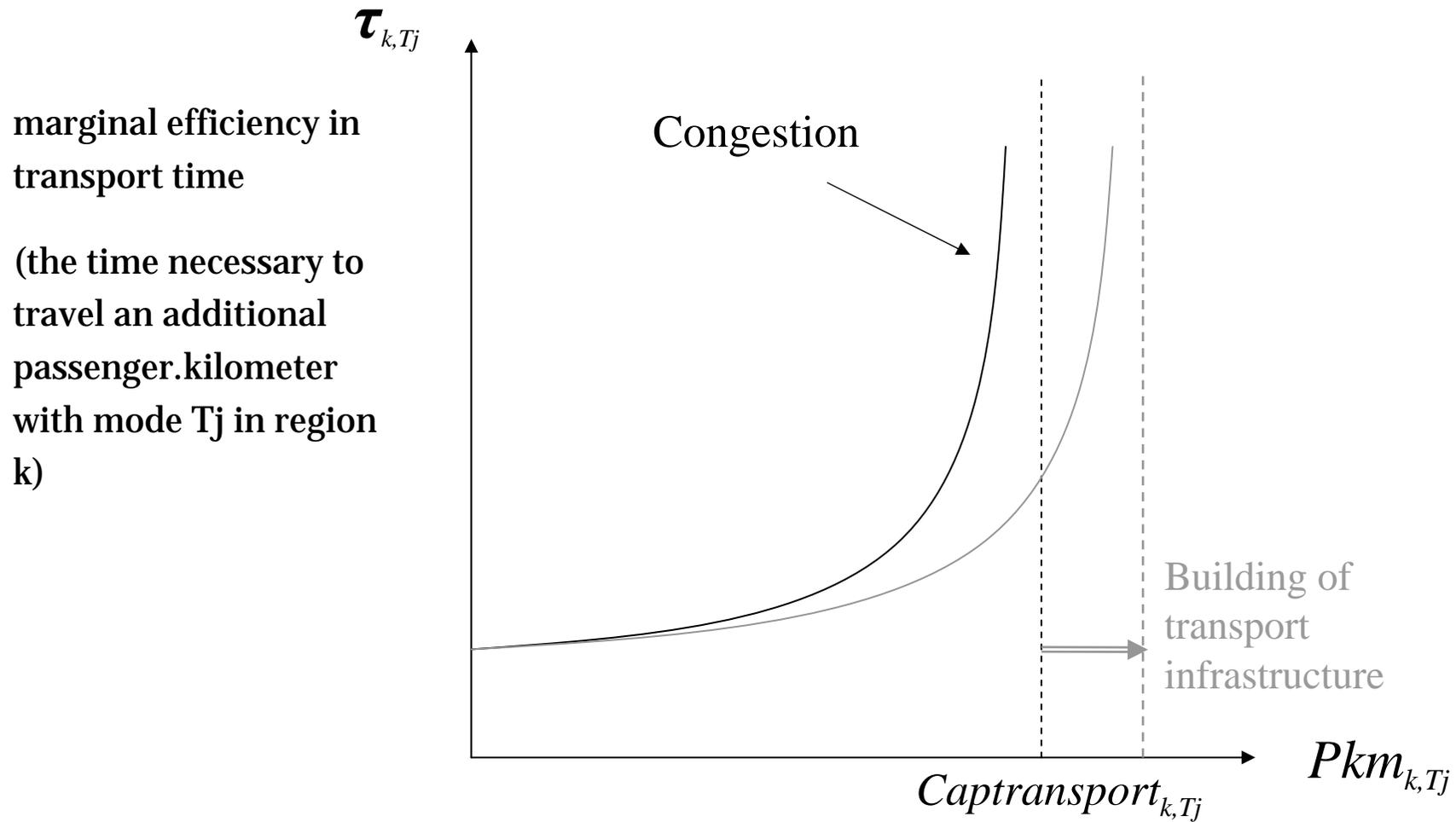# The short run (underoptimal) equilibrium
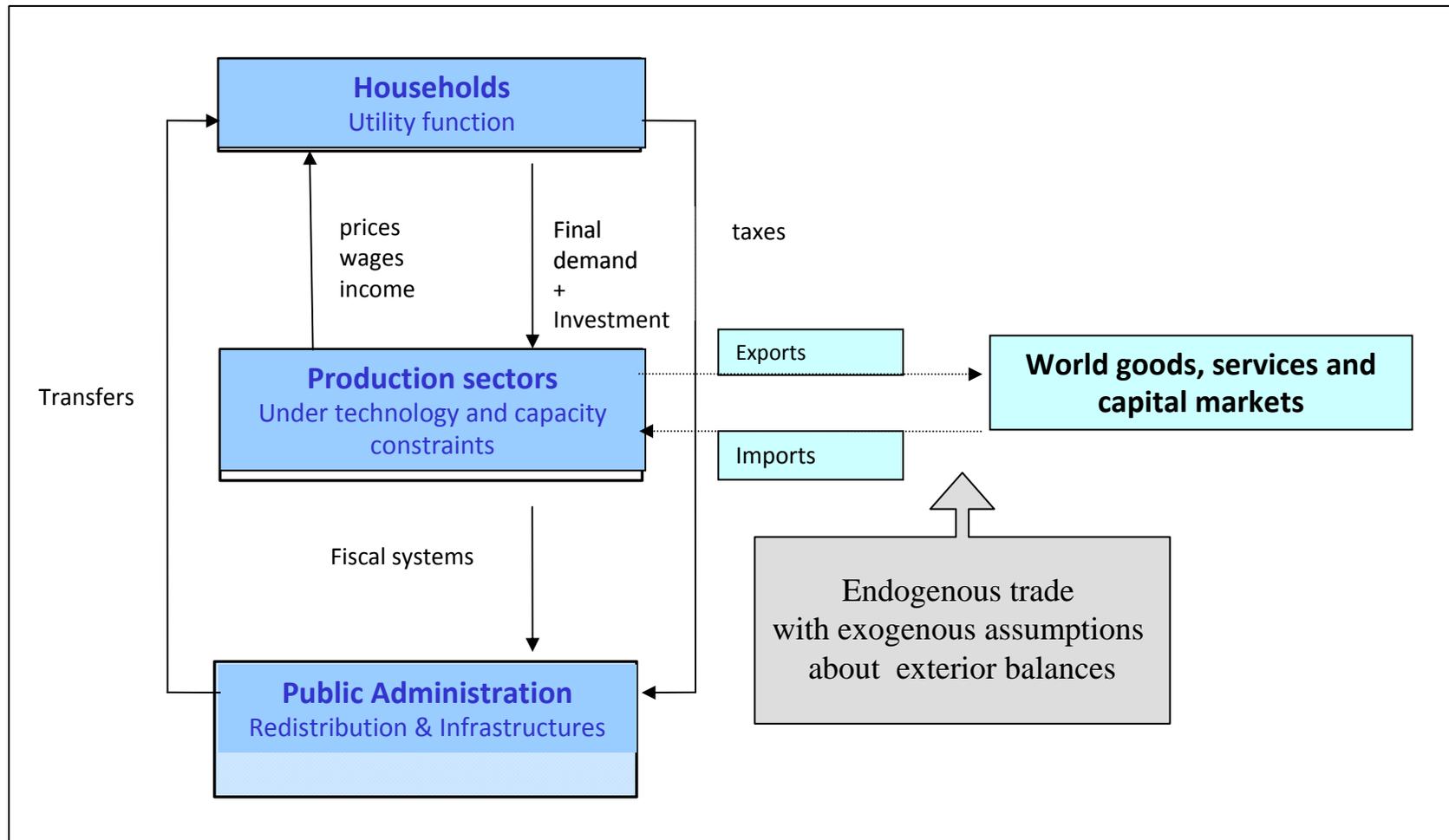
Generation of profits (incentives to invest) and rents

- **Short-term lock-in on technology (putty-clay) and capacity**
- **A flexible rate of capacity utilization**

$$p_{k,i} = \left(\sum_j \boldsymbol{pArmIC_{j,i,k}} \cdot IC_{j,i,k} + \left(\boldsymbol{\Omega_{k,i}} \cdot \boldsymbol{w_{k,i}} \right) \cdot l_{k,i} \cdot (1 + tax^w_{k,i}) + \pi_{k,i} \cdot p_{k,i} \right) \cdot \left(1 + qtax_{k,i} \right)$$

Ω

capacity
shortage

decreasing
mean
efficiency

**Capacity
utilization rate**

1

Transport infrastructures and congestion

$\boldsymbol{\tau}_{k,Tj}$

marginal efficiency in transport time

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

Congestion

Building of transport infrastructure

$Captransport_{k,Tj}$

$Pkm_{k,Tj}$

The Engine of Growth (1)

- A **potential growth = natural growth,** product of:

  - ➤ **Demography** (pyramid of age) → increase/decrease of the labor force, savings capacity
  - ➤ **Overall productivity rate of growth** (either exogenous catching up assumptions or stylized representation from endogenous growth)

- **Structural Change endogenized by** the product of:

  - ➤ Moving technical constraints within the **'innovation possibility frontier'** resulting from expert-based expertise encapsulated in the "Nexus" modules

  - ➤ Evolution of **consumption patterns** (translated through the coefficients of the utility function)

The Engine of Growth (2)

- **Real growth endogenously determined** by the interactions between the drivers of potential growth, structural change:

    - short-term rigidities
    - Imperfect foresight and routine behaviors (Maladaptation of installed equipment after a price shock)
    - Conditions of international competitiveness
    - International capital flows

- **Endogenous transitional disequilibrium**
    - phases of over and under utilization of production factors
    - related unemployment or tensions on wages

- **Long term pathways as a result from short-term adjustments given long-term limits** (nothing like ex-ante long run elasticities)

The 'Nexus modules' and the evolution of technical constraints

A modular structure which affords the coexistence of:

- ➤ **Very detailed sector-specific submodels**: electricity, fossil fuels, personal vehicles, energy intensive industry

- ➤ **Reduced forms of BU models** : transportation technologies and infrastructures, services, agriculture, industry

- ➤ **Simple exogenous prescription**: transportation input in sectors, material content of investment, material content of infrastructures

To sum up: between the Scylla of blind orthodoxy and the Charybdis of uncontrolled heterodoxy

- A representation of the **'Hicksian' traverse** (1965)

- Substitution vs Fixed production coefficients : **increments à la Johansen** (1959)

- Distinction between production capacity and economic capital .... *in memory of* the 'two cambridges' dispute

- **Kaldorian/Kaleckian dynamics** with investment functions under non fully competitive markets

- **Endogenous Technical Change**: move of the 'rate' and 'direction' of technical change through 'embodied learning by doing'

Concerns about the control of the dynamics?

- *Typically such models* (systems dynamics) *have tendency towards overshoot and collapse. We have found that many of these inconsistensies can be overcome through an intertemporal approach:* **Clairvoyance is an implausible assumption, but myopia seems even worse** (Manne-Rutherford 1994)

- *The rational expectation .... has the considerable advantage of definiteness and convenience ... The disadvantage that it is thought implausible by the very people whose mental processes is meant to be described.* The alternative option has the **disadvantage of indefiniteness; it leaves a lot of options with no good fact-based way of choosing how to represent expectations** (Solow 2000)

- Responses
  - Reality-check of behavioural assumptions through **sector-based expertise**
  - The model secures a **consistent dialogue** between alternative behavioural 'theories' **... imposing them the GE constraints**
  - Harrodian disequilibrium without knife-edge; 'after re-aggregation' the model recovers **Solowian steady states**

Four dimensional accounting as a "garde-fou" (safeguard)

- Consistent accounting matrixes

  - Economic balances
  - Energy balances
  - Material balances
  - Land-use balances

-    Putting these four accounting systems consistent **narrows the set of plausible coefficients**

- Allows for **incorporating 'non statistically standardized' information** (a common practice for climate modelers to recuperate 'missing information'): *"To believe that empirical economics begins and ends with time-series analysis is to ignore a lot of valuable information that cannot be put into so convenient a form. I include the sort of information that is encapsulated in the qualitative inferences made by expert observers …."* Solow 1988
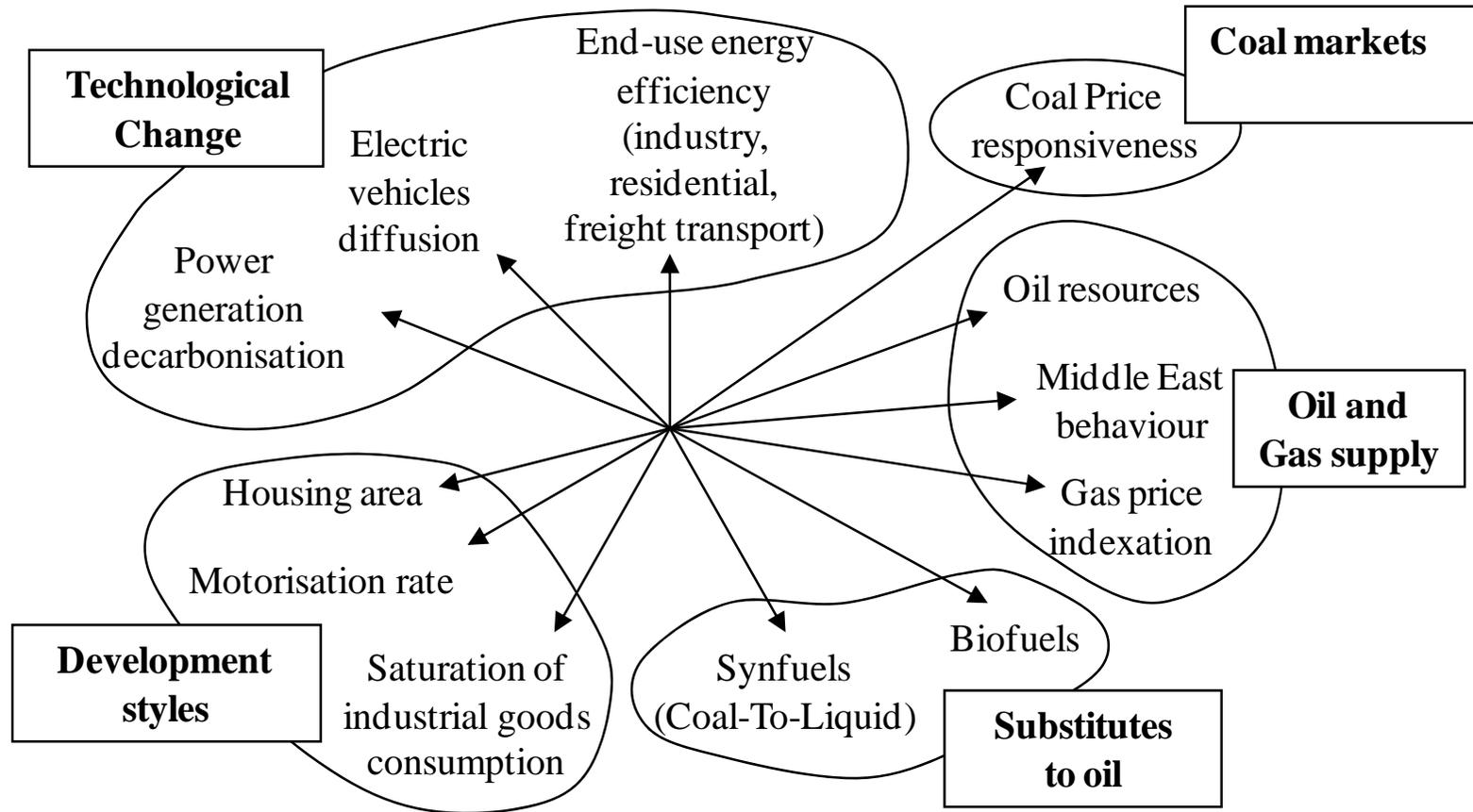
Policy insights from some results

from the economic rationale of the Copenhagen failure to the detection of the missing devices in climate architectures

The basic economic wisdom behind the climate negotiations

- An interpretation of the second theorem of welfare:
  - **Efficiency**: uniform carbon price to equalize marginal abatement costs
  - **Equity**: organize compensations

- Two candidates:
  - Coordinated **carbon tax**, with transfers...
  - **Global Cap-and-Trade**, with quota allocation rules...
    ...Kyoto, and the "fairness of the burden sharing" issue

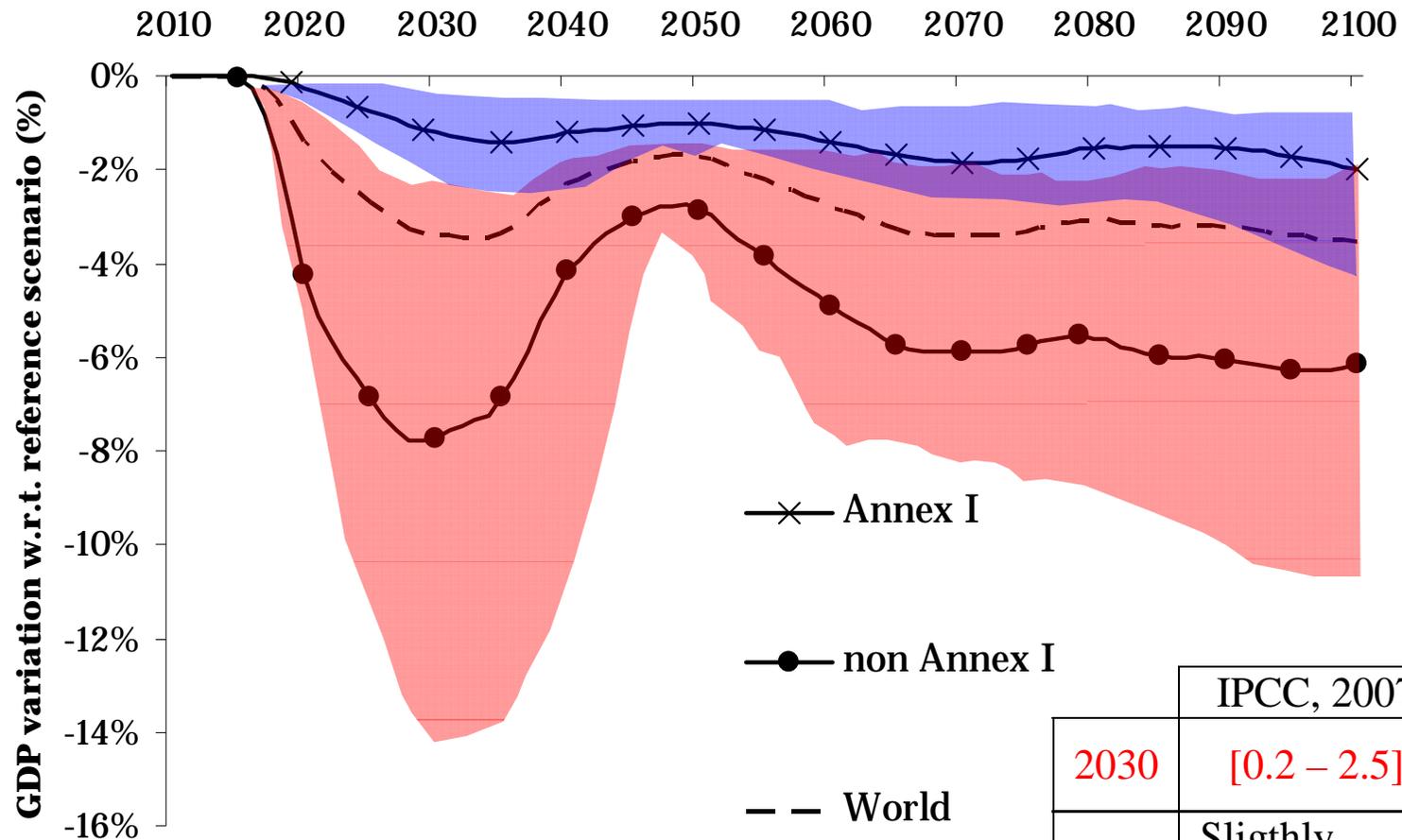# Exploring uncertainty in the energy/economy interface

Technological Change

Coal markets

Electric vehicles diffusion

End-use energy efficiency (industry, residential, freight transport)

Coal Price responsiveness

Power generation decarbonisation

Oil resources

Middle East behaviour

Oil and Gas supply

Housing area

Gas price indexation

Motorisation rate

Biofuels

Development styles

Saturation of industrial goods consumption

Synfuels (Coal-To-Liquid)

Substitutes to oil

→768 consistent scenarios

"Second best" – Bad news?

Or some economic rationale behind
the failure of Copenhagen…

A « carbon price only regime » .... or the economics of the Copenhagen failure in the 'cap & trade' only framework

A time profile robust to uncertainty

GDP variation w.r.t. reference scenario (%)

2010 2020 2030 2040 2050 2060 2070 2080 2090 2100

— ✕ — Annex I

— ● — non Annex I

— — World

	IPCC, 2007	Imaclim-R
2030	[0.2 – 2.5]	3.8 [1 – 9.5]
2050	Sligthly negative - 4	2.5 [0.5 – 4]

(550ppm CO2-eq stabilisation scenarios, +3°K)

# At the roots of the « bad news »

Significant short-term losses:

- **Inertia** in installed capital and **imperfect foresight** limit the pace of decarbonization, and requires high carbon prices

- **Increased production costs** transmitted to consumers

- Inertia in changing households equipment reinforces the **loss of purchasing power**

- **Macroeconomic feedbacks** (unemployment, lower wages, lower consumption...)

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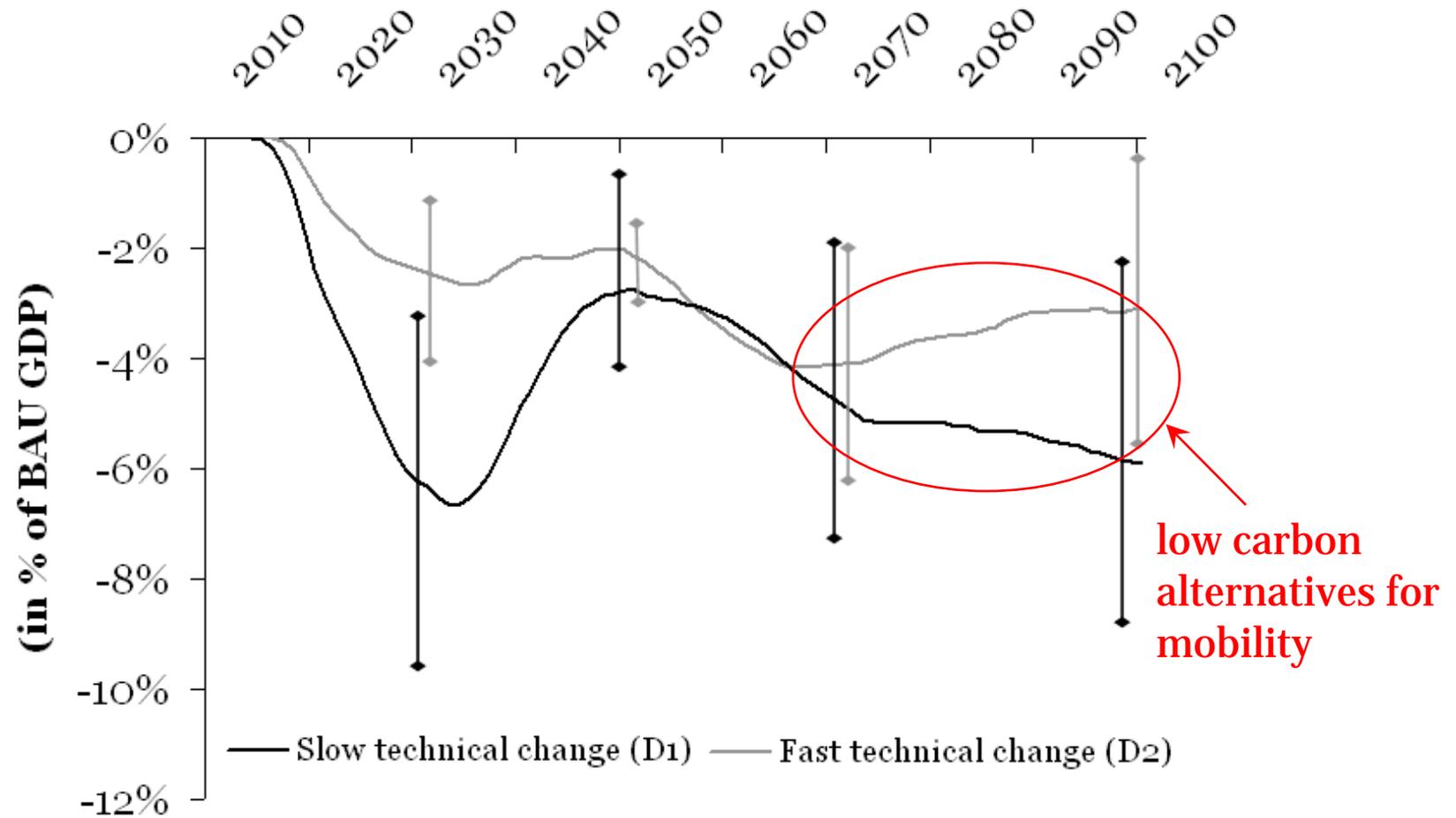
Long-term losses:

- **Inertia of infrastructures, location choices, urban forms**

- **Rebound effect of mobility needs** requires very high carbon prices in the second half of the century

A long-distance race: technical change versus inertia

low carbon technologies for power generation
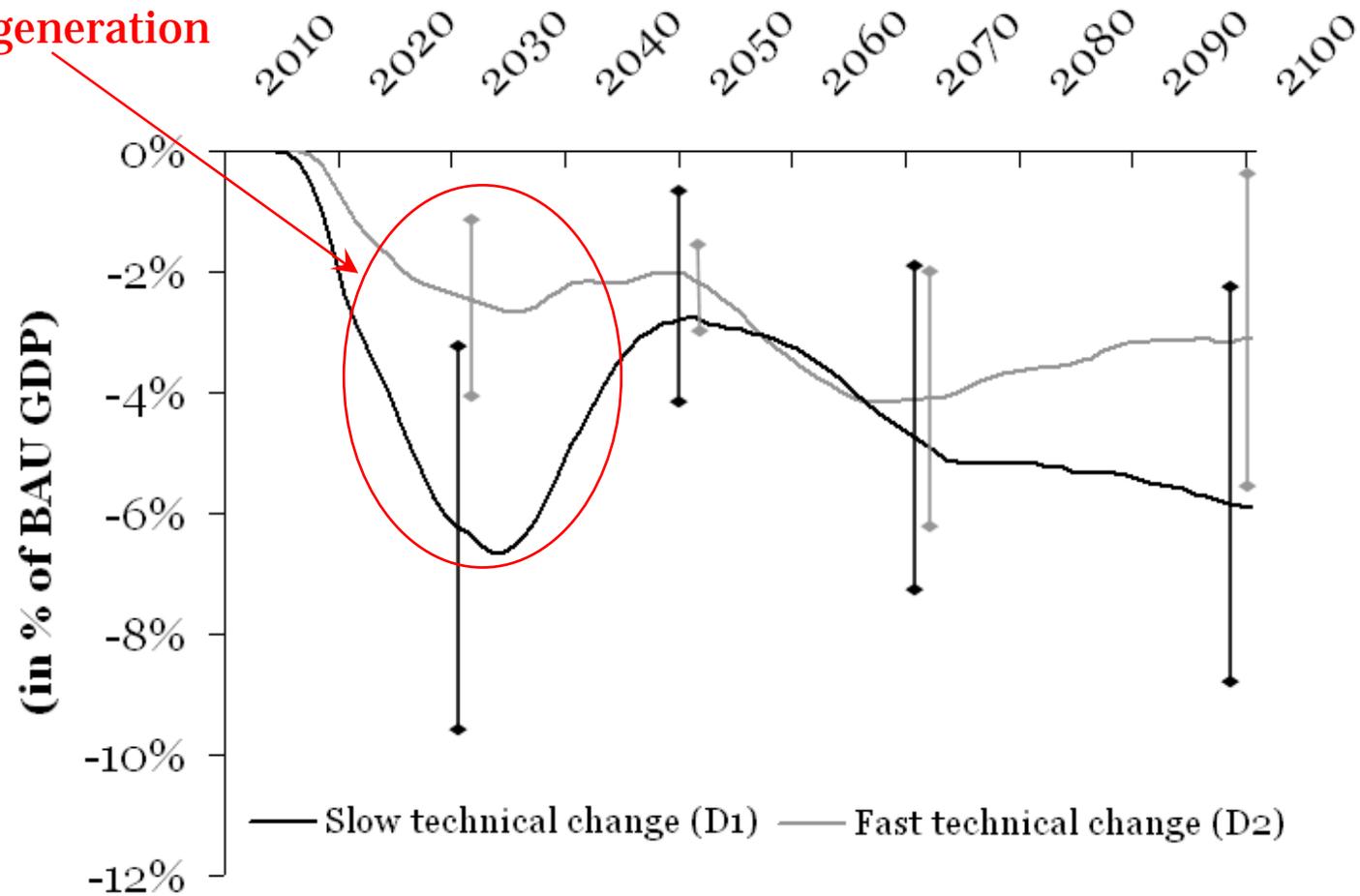
A long-distance race: technical change versus inertia

Compensatory transfers for a 'fair' burden sharing?

- **Unrealistic amounts** (direct or through quotas allocation) to equate welfare losses, e.g. in 2030:

Africa	+8% of GDP
India	+6% of GDP
CIS	-4% of GDP (better-off thanks to gas exports)
Europe	-1.2% of GDP
USA	-1.7% of GDP

- Impossible to afford in an Overseas Development Aid perspective and in an **untimely context**

  ➢ Financial crisis

  ➢ Emerging countries are net capital exporters

  ➢ Emerging economies perceived as threats for jobs, and getting a financial power capable to take control of significant parts of their industry

The basic economic wisdom of climate negotiations in question…

- Uniform carbon prices (only) policies are **squeezed**:

  - They **hurt emerging economies over the short run** (when the carbon prices are low relatively low)

  - Without preventing **risks of lock-in** in carbon intensive development pathways

- **Non negotiable « equity »** of the burden sharing and compensations

  Thanks for the « fairness » but …. We don't want the burden!
  'We do not want your money' Pdt Lula at Copenhagen
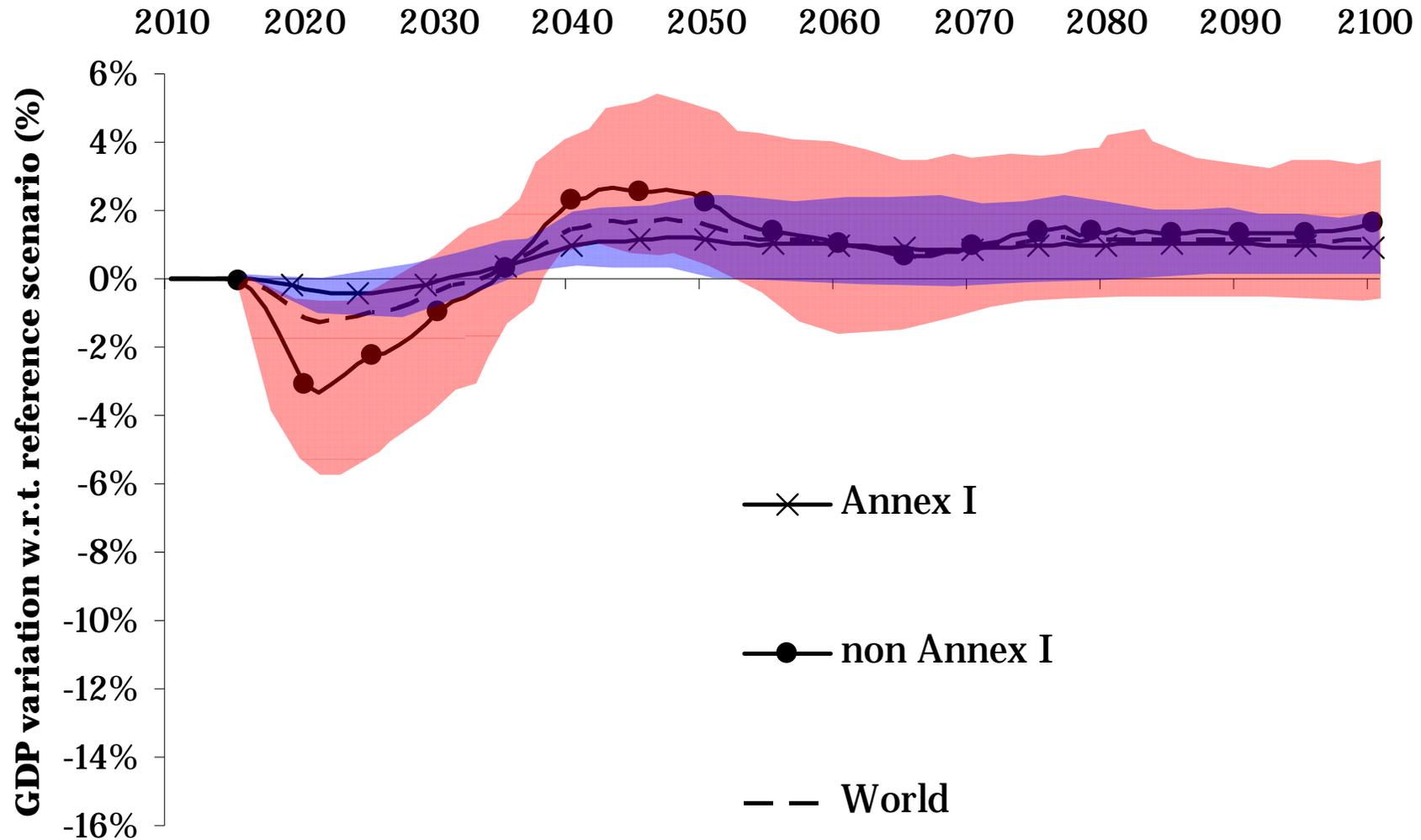
"Second best" – Good news?

Or new room for manoeuvre...

Early transport infrastructure policies open room for long-run benefits of climate policies
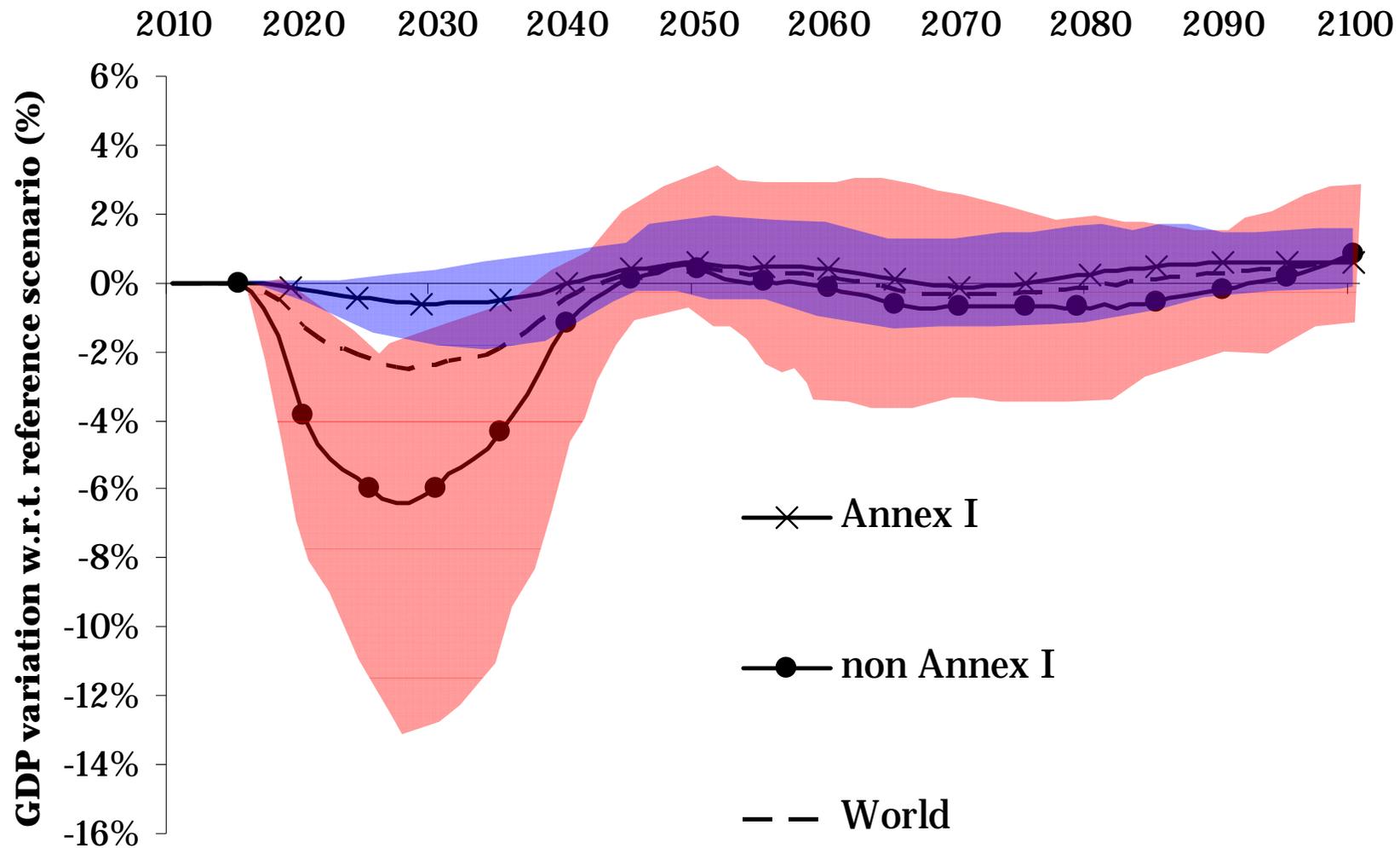
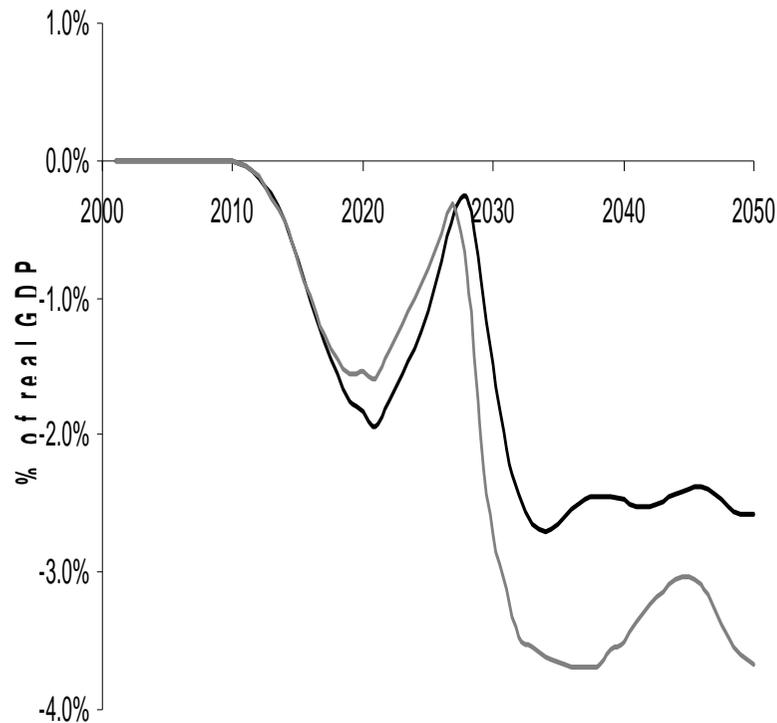*(550ppm CO2-eq stabilisation scenarios, +3°K)*

Fiscal policies to smooth the transition

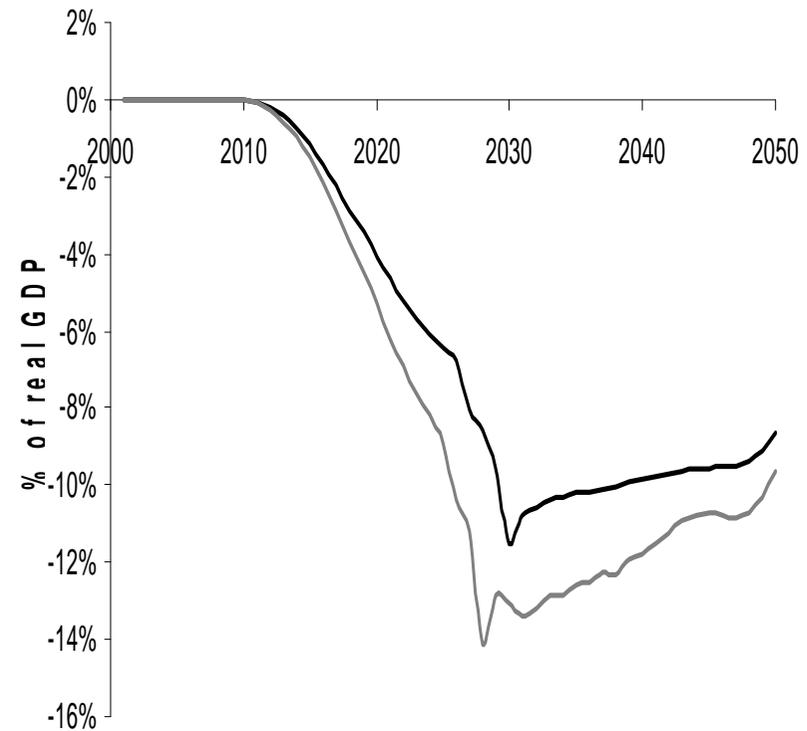*(550ppm CO2-eq stabilisation scenarios, +3°K)*

At the occasion of an IMF-WB meeting … the interest of reasoning with non steady states pathways
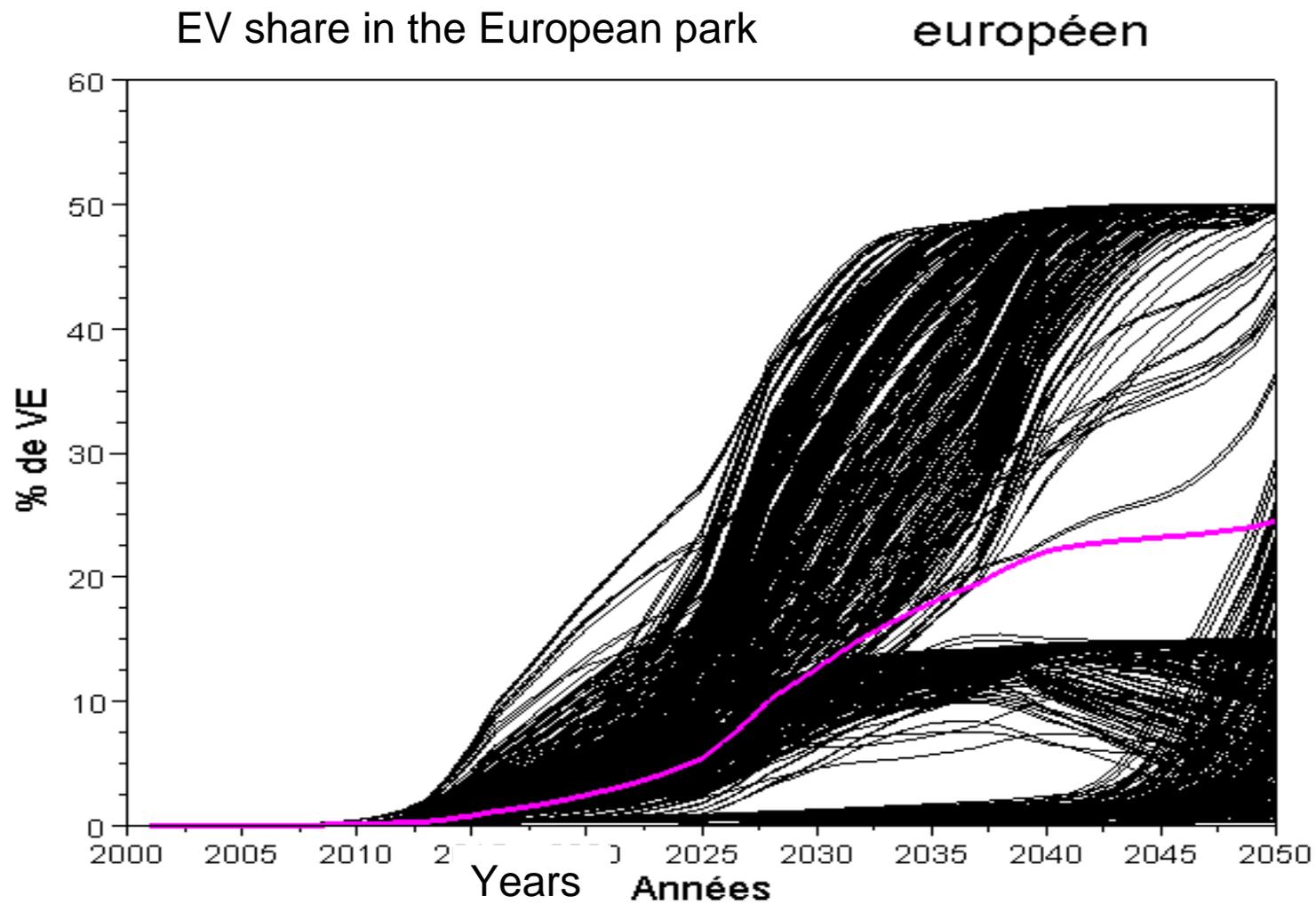
Real GDP losses - China

Legend:
— Low Growth + energy frictions
— High Growth + energy frictions

Real GDP losses - India

Legend:
— Low Growth + energy frictions
— High Growth + energy frictions

Endogenizing the link between the economic context and technological bifurcation ... the example of the EV

EV share in the European park — européen

Aligning climate and development policies through a wider palette of signals

- **Upfront public and private investments** on buildings, urban infrastructures and long distance transportation

- Mobilizing **a wider set of price signals** (real estates, land)

- **Carbon prices cannot do the job alone …. Urgent to account for the whole set of relative prices!!**

Index 1 in 1960

— Real price of housing
— Real fuel price
— Real income per capita
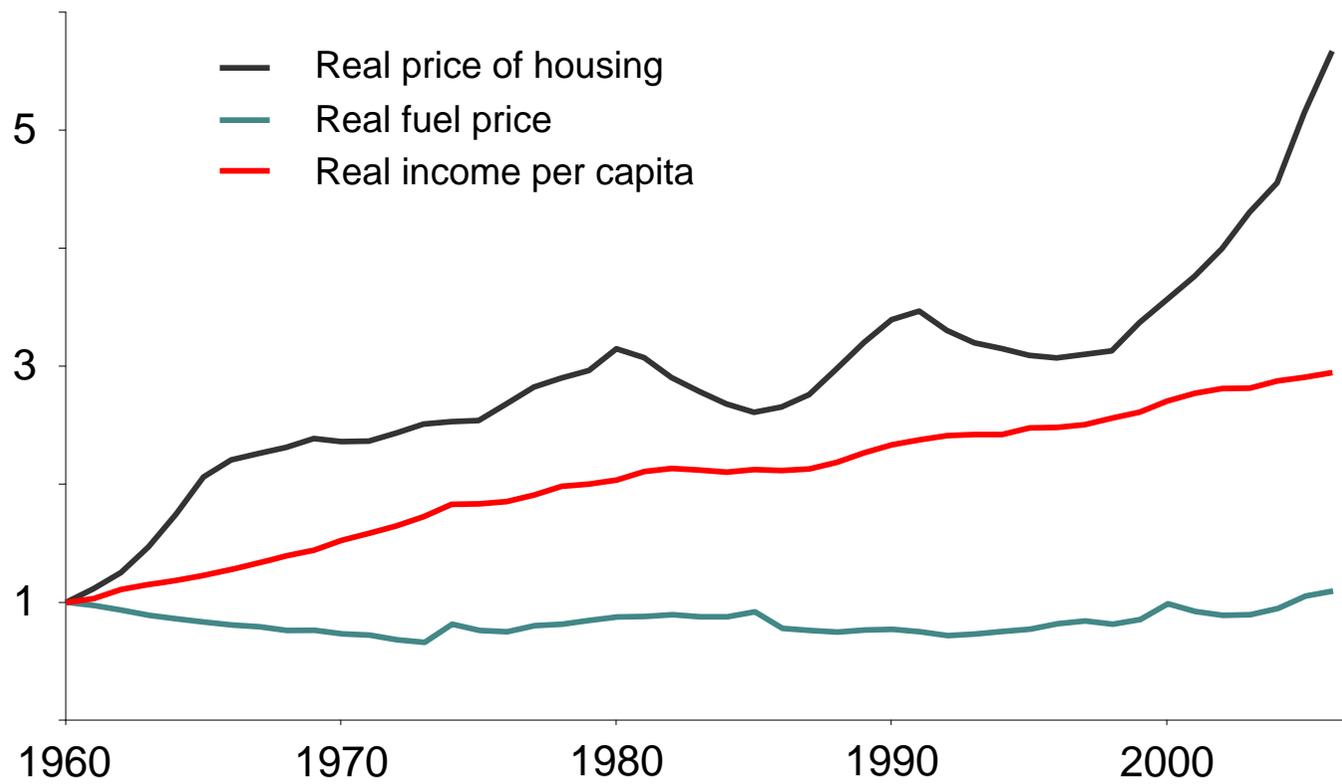
Combet, Ghersi, hourcade, Thubin, 2009 « Economie d'une fiscalité carbone en France »

Source : INSEE

Aligning climate and development policies using a wider palette of signals

- **Upfront public and private investments** on buildings, urban infrastructures and long distance transportation

- Mobilizing **a wider set of price signals** (real estates, land, capital)

- **Timing their use to mitigate the adverse distributional impacts**
  - **aligning** the increase of **domestic carbon prices** to the penetration of energy efficient end-use equipments
  - adopting **"climate friendly" fiscal systems**

- An international architecture **abandoning the** *who picks the remainder* **approach**

  - **Using carbon prices as an inducement** not as the only driver of technical and behavioral changes
  - Aligning development policies and climate objectives
  - Supporting a variety of development measures adapted to the diversity of specific local conditions
  - **Breaking the circle of despair by reducing investment risks** on carbon saving equipments and fostering R&D

'Financial' crisis: a moment of opportunity?

- Towards a climate friendly « Marshall Plan »
  - Less export oriented industrial policies in emerging economies
  - A wider domestic market
  - An global 'spill-over effect'
  - a calming down of industrial competition through wages

- Climate regime and the reform of the international financial system
  - Socialisation of bad debts ....in exchange of what?
  - « social value of carbon » as a way out the risks of the «commerce of promises»
  - and a way of re-directing world savings

Back to the result and modeling agenda

'A few' theoretical and empirical issues to deliver more convincing responses … and not overinterprete our results

- Capital deepening to prevent excess savings over the century?

- Labour markets in a world with migrations and informal economies in perpetual reformation

- The formation of "scarcity rents' and their reallocation: fossil fuels, land, real estatesf "rents"

- Capital flows and debts

- Utility functions and the 'endogenization' on preference

Publications

Methodological principles and model description

- Hourcade, J.-C., Jaccard, M., Bataille, C. et F. Ghersi (2006), « Hybrid Modeling : New Answers to Old Challenges », **The Energy Journal,** introduction to the Special Issue Hybrid Modeling of Energy-Environment Policies : reconciling Bottom-up and Top-down : pp. 1-12.
- Ghersi, F. et J.-C. Hourcade (2006), « Macroeconomic Consistency Issues in E3 Modeling : The Continued Fable of the Elephant and the Rabbit », **TheEnergy Journal,** Special Issue Hybrid Modeling of Energy Environment Policies : reconciling Bottom-up and Top-down : pp. 39-62
- Sassi, O., R. Crassous, J. C. Hourcade, V. Gitz, H. Waisman, and C. Guivarch. 2010. Imaclim-R : a modelling framework to simulate sustainable development pathways. **International Journal of Global Environmental Issues,** Special Issue on Models for Sustainable Development for Resolving Global Environmental Issues: Vol. 10, Nos. 1/2, pp.5–24.

Applied exercises (Imaclim-R only)

- Crassous, R., Hourcade, J.-C., Sassi, O., 2006, 'Endogenous structural change and climate targets : modeling experiments with Imaclim-R', **Energy Journal,**
- Guivarch, C., S. Hallegatte, and R. Crassous. 2009. The resilience of the Indian economy to rising oil prices as a validation test for a global energy–environment–economy CGE model. **Energy Policy,** Volume 37, Issue 11, November 2009, Pages 4259-4266.
- Mathy, S. and Guivarch, C. 2010. Climate policies in a second-best world - A case study on India. **Energy Policy,** Volume 38, Issue 3, March 2010, Pages 1519-1528.
- Rozenberg, J., Hallegatte, S., Vogt-Schilb, A., Sassi, O., Guivarch, C., Waisman, H., Hourcade, J.-C. 2010. 'Climate change and energy security: climate policies as a hedge against the uncertainty on future oil supply'. **Climatic Change** 101: 663-668.
- Hamdi-cherif, M., Guivarch, C. and Quirion, P. 2010. Sectoral targets for developing countries: Combining "Common but differentiated responsibilities" with "Meaningful participation" (accepted in **Climate Policy**).
- Guivarch, C., Crassous, R., Sassi, O. and Hallegatte, S. 2010. The costs of climate policies in a second best world with labour market imperfections. (accepted in Climate Policy)
- Hourcade, J.-C. and Guivarch, C. 2010. Climate Negotiations: What is missing to break the circle of mistrust? (under review for **Climate Policy**)

Participation to policy expertise

- World Bank (Development Report 2010)
- International Energy Agency (WEO2007)
- La mission Rocard, the French carbon tax
- The Recipe project
- Several EU projects ... Transust, Pashmina, Augur, Globis