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CENTRE
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SUR L'ENVIRONNEMENT
ET LE DÉVELOPPEMENT

Transitions towards a F4 society

A three year modelling program supported by IDDRI

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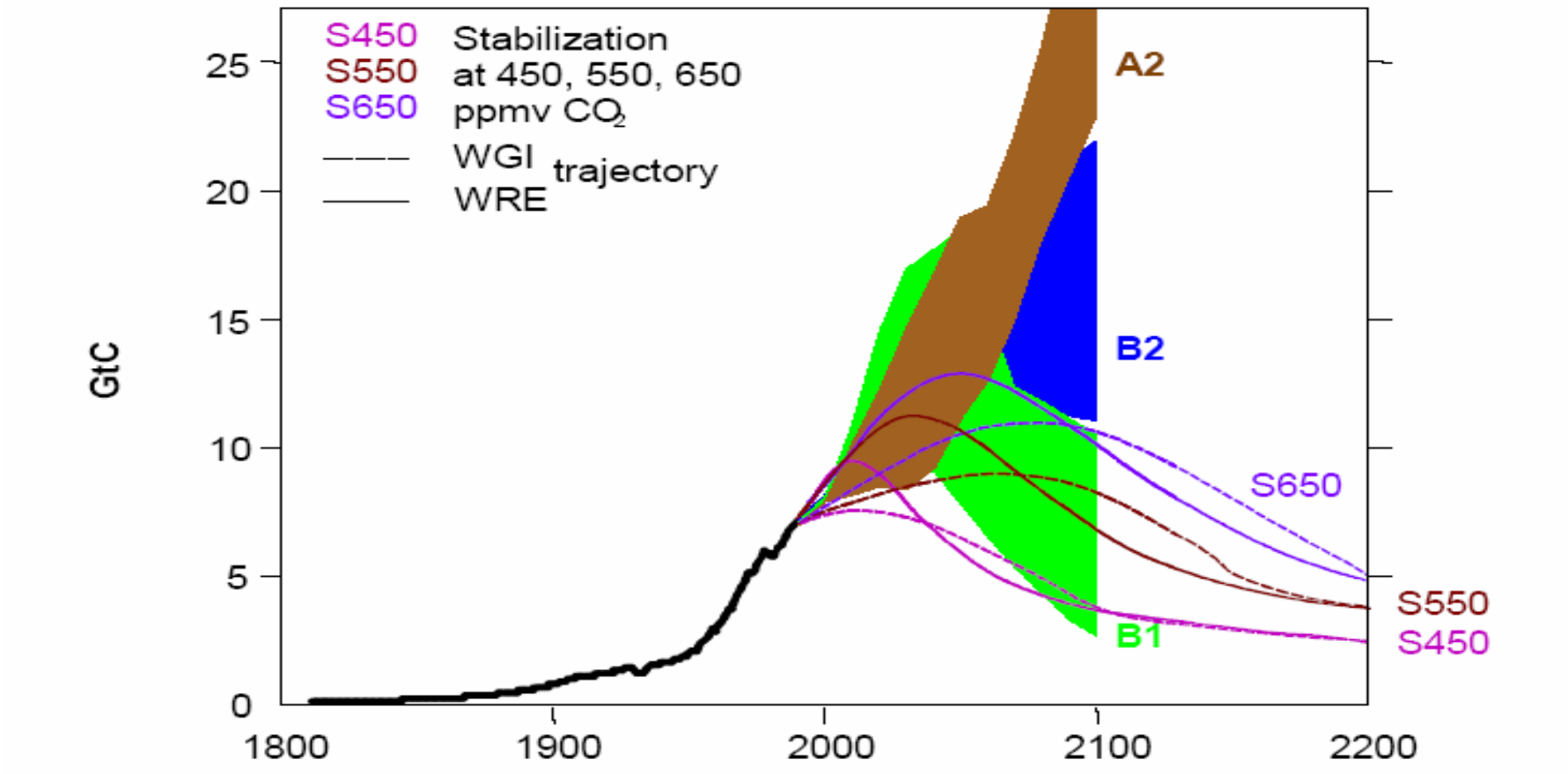
A specific institutional setting

- **IDDRI:** a Research Foundation funded by French Ministries (foreign affairs, finance, environment, research, equipment) and 15 enterprises
- **EPE**: Enterprises for the Environment; a consortium of 22 energy intensive entreprises including the cement,steel and non ferrous industry
- Energy enterprises including **EDF** (Electricité de France) and **Total** (oil company)
- The **CIRED** (Cnrs, Ehess, Enpc, Engref, Meteo – France, Cirad)
- The **LEPII** (Cnrs and University of Grenoble)

A program based on a shared dissatisfaction between modellers and industry

- A F4 objective cannot be reached without **technological breakthrough and deep changes in final demand**
- This breakthrough will not been achieved unless industry sees the F4 objective as a **mobilizing utopia** instead of a pure constraint
- To help policy discussions the current state of the art in long term modelling has to be improved in the following directions:
  - The consistency of the dialogue between ***macro-economists and sector-based expertize***
  - To scrutinize the transformation of the ***final demand***
  - ***Transition mechanisms*** 'instead of steady state economies'
  - Macroeconomic parameters in a world economy under structural ***disequilibrium***
  - Sensitivity to ***controversial judgments***

SRESS : the trap of the combinatory explosion?



Source : IIASA, Nakicenovic

Parameters of the KAYA entity are in fact linked by endogenous interplays

$$E_{CO_2} = POP \cdot \frac{GDP}{POP} \cdot \frac{Energy}{GDP} \cdot \frac{E_{CO_2}}{Energy}$$

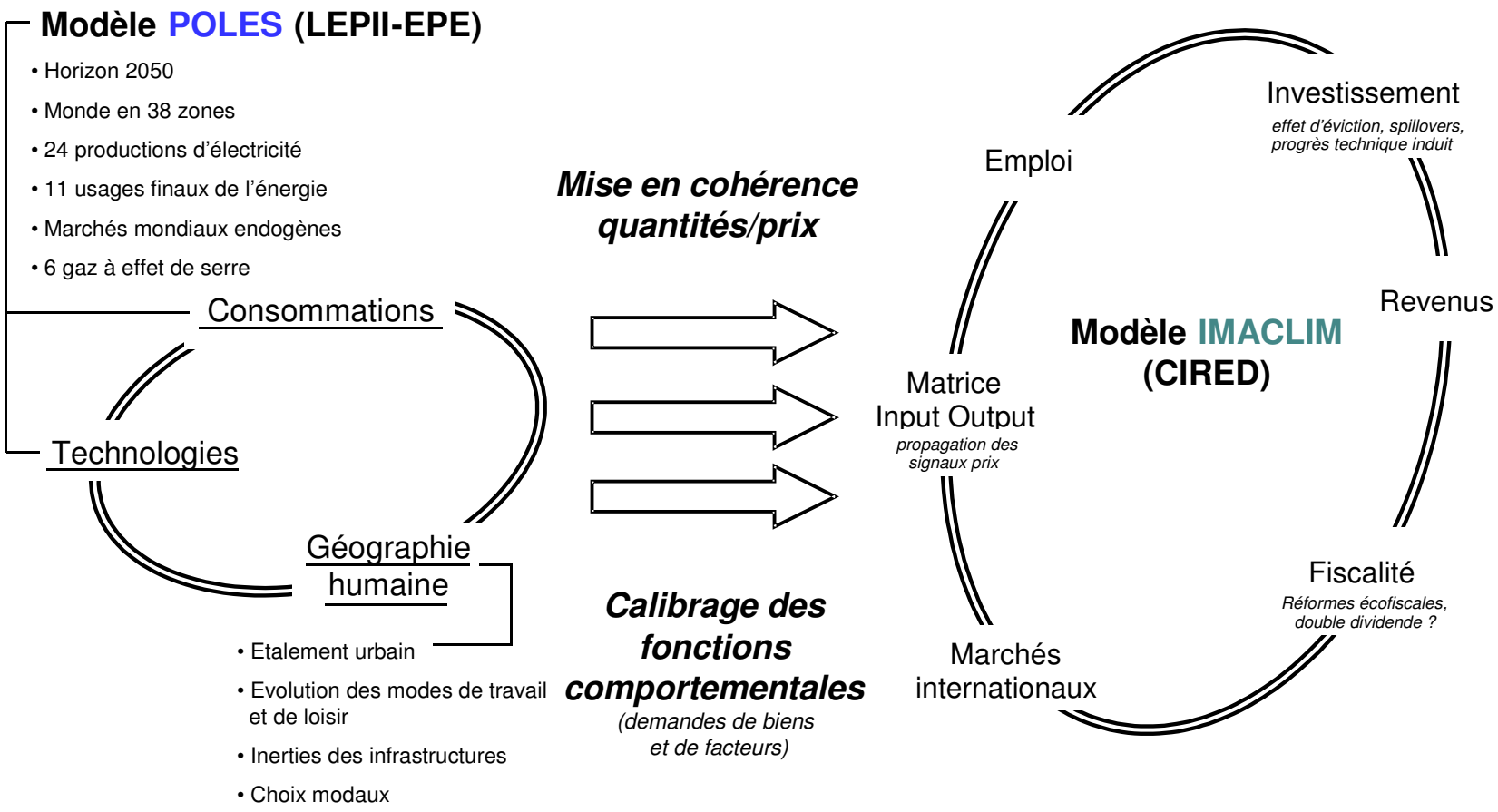
Two Main Policy Questions

- For minimizing the costs a F4 objective what is the relative role of:
  - The decarbonisation of ***energy supply*** (fuel switching and minimisation on the conversion losses
  - The ***end – use energy efficiency***
  - ***Structural changes*** in final demand of goods and services (dematerialisation of growth patterns)
  - ***Macroeconomic*** parameters in opened economies
- **What 'climate regime'** is capable to incite
  - Industry to provide responses to the first three challenges (technologies, products)
  - Goverments to provide the most favorable macroeconomic context and to mobilize **–non carbon price only -** policies

A scientific strategy with four components ….

- An ‘novel’ modelling framework (Imaclim – Poles)
- A representation of alternative development styles
- A specific scenario approach
- A heuristic approach with a permanent dialogue with industry and other stakeholders

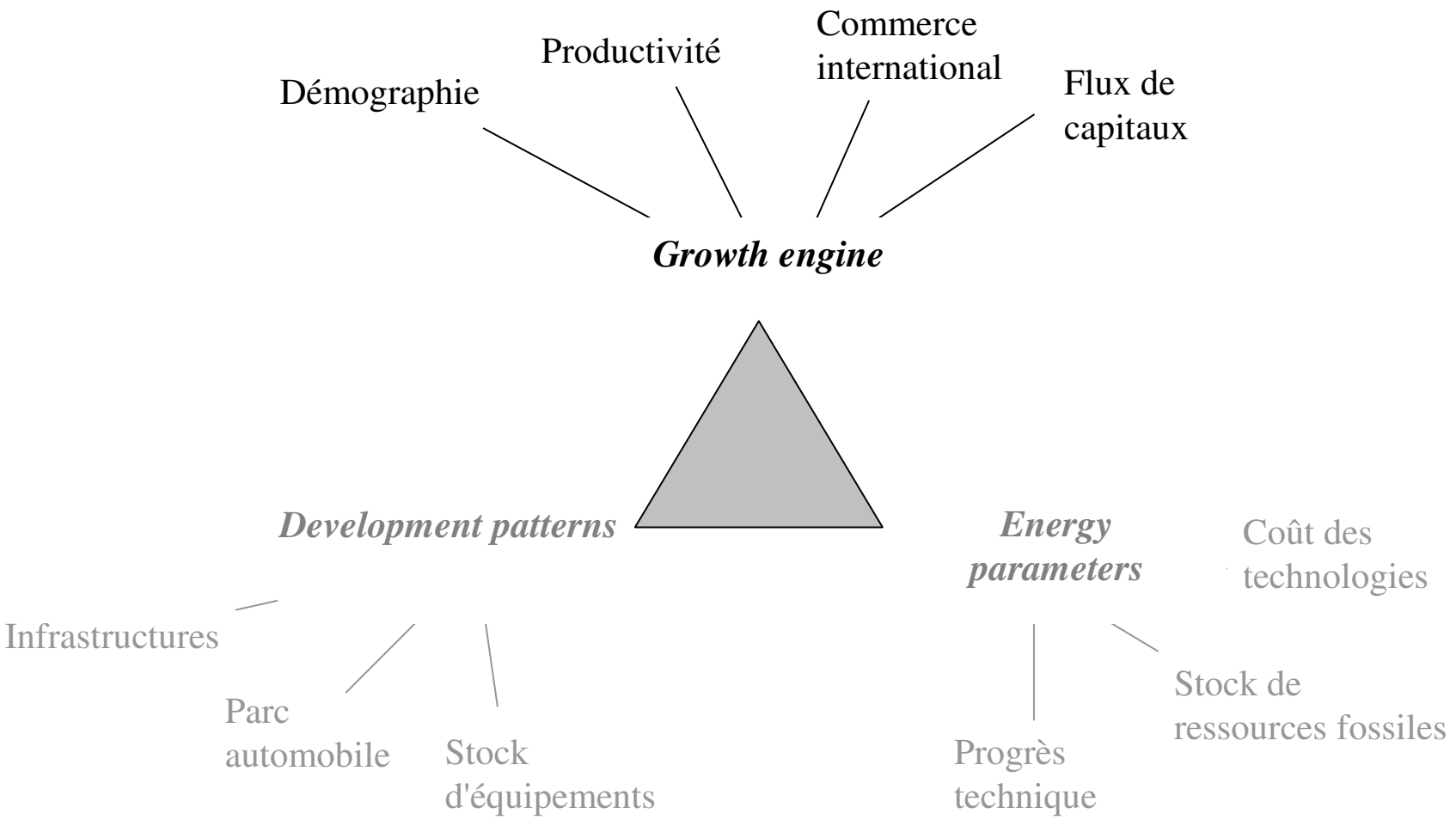
… and relying on two pre-existing models



Prospective énergétique

Prospective macroéconomique

What would we like to represent?



Main modelling principles

- An **hybrid modelling structure** in physical and money flows in order to secure the dialogue with sector - based expertise and make explicit
  - the assumptions governing the dematerialisation of the economy
  - The sources of technical inertia

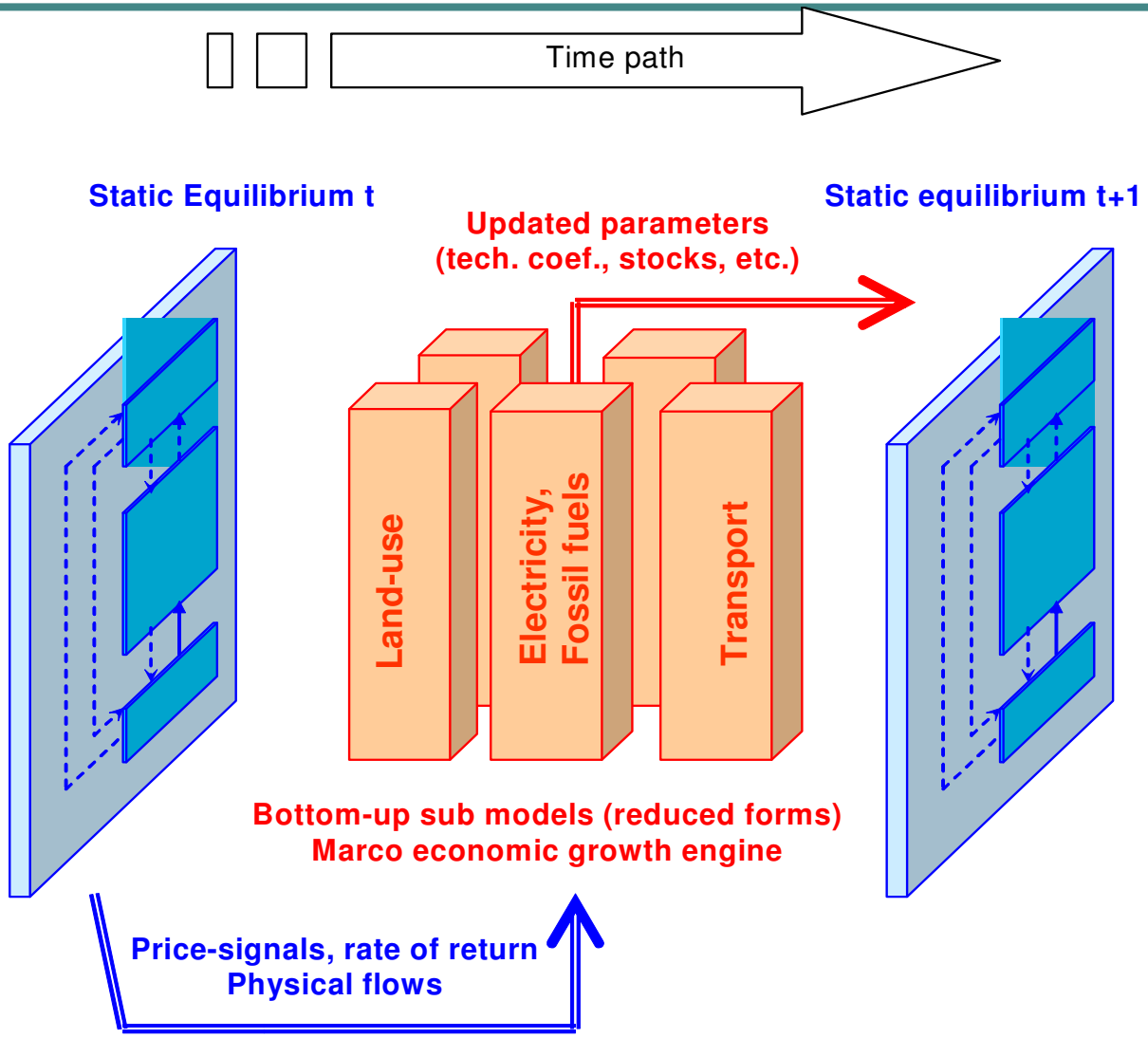
- A **growth engine with disequilibrium**:
  - With imperfect foresight and routine behaviours
  - Allowing for structural imbalances (endebtedness, unemployment and informal economy) and endogenous shocks

- An **endogenous growth framework** to minimize the trap of the combinatory explosion

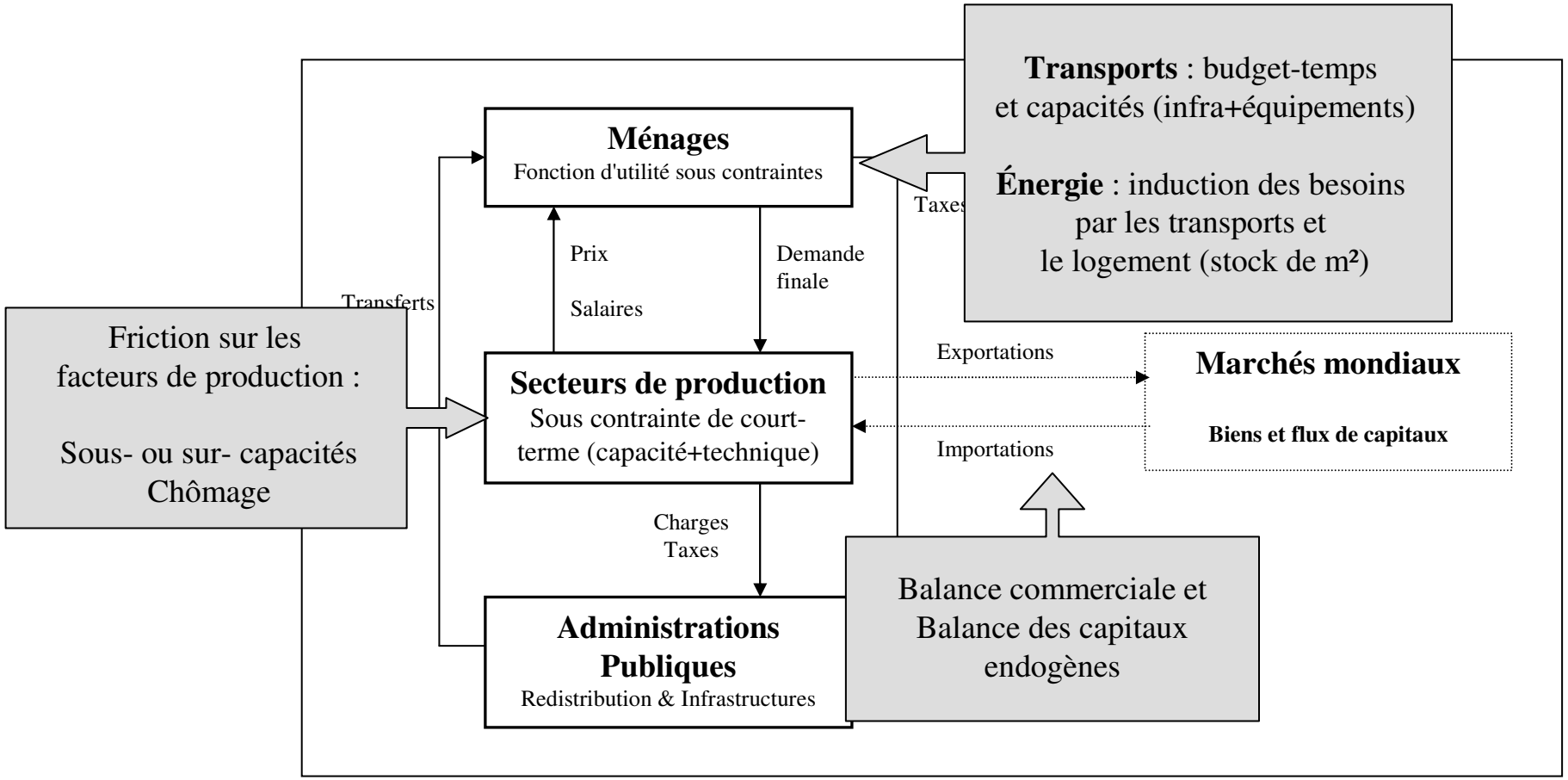
A risky departure from the Golden Age growth paradigm?

- The Solow's advices (1988):
  - a) economic cycles are not optimal responses to random shocks around an optimal pathway
  - b) progress in growth theory requires to better capture the evolution of the structure of final demand
- Computational capacity now exists of overcoming the Harrod-Domar's knife-edged versus steady growth Solow's paradigms
- Back to "Kaleckian" dynamics with equipment vintages and flexibilities in a) the "equipment intensity" of growth b) the use of energy, labour and other inputs

A recursive and modular architecture: static equilibria + dynamic relations informed by sector based expertise



Static equilibria under constraints stemming from technical endowments and routine micro and macro behaviors



Suming up : Main features of the system

- **Production functions** conditional upon **sector – based expertise**
- (Partially) **Endogenous Structural Change**: induced interactions between demand and supply that affect the growth engine
- **Endogenous Capital flows** function of savings, returns on investment and country-risk and national public policies (amount of domestic savings put in an international pool)
- Representation of **phases of over and under investment** in production capacities; the timing of policies matter

An illustration with the transportation sector

➢ **Côté consommation finale**

Maximization d'utilité **:**

$$U_k\left(\vec{C}_k,\vec{S}_k\right)=\prod_{\substack{\text{goods } i\\ \text{services } j}}\left(\mathrm{C_{k,i}}-bn_{k,i}\right)^{\xi_{k,i}}\left(S_{\mathrm{k,j}}-bn_{k,j}\right)^{\xi_{k,j}}$$

$$S_{k,mobility}=\left(\left(\frac{pkm_{k,air}}{b_{k,air}}\right)^{\eta_k}+\left(\frac{pkm_{k,public}}{b_{k,public}}\right)^{\eta_k}+\left(\frac{pkm_{k,cars}}{b_{k,cars}}\right)^{\eta_k}+\left(\frac{pkm_{k,nonmotorized}}{b_{k,nonmotorized}}\right)^{\eta_k}\right)^{-\eta_k}$$

Sous double contrainte :

$$ptc_k\cdot Income_k=\sum_i pArmC_{k,i}\cdot C_{k,i}+\sum_{\text{Energies } Ei} pArmC_{k,Ei}\cdot\left(S_k^{cars}\cdot\alpha_{k,Ei}^{cars}+S_k^{m^2}\cdot\alpha_{k,Ei}^{m^2}\right)$$

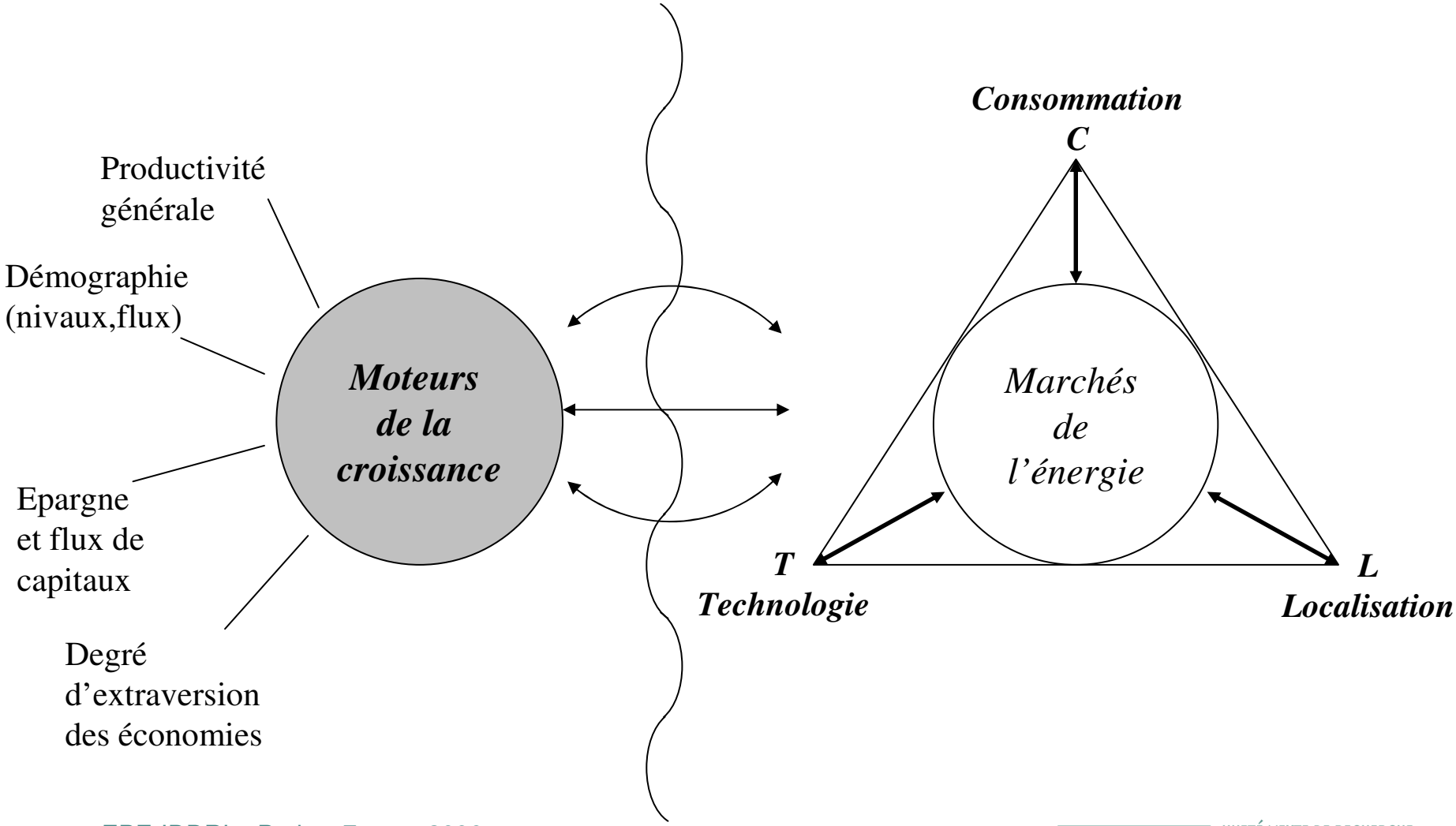
$$Tdisp_k=\sum_{\text{means of transport } T_j}\int_0^{pkm_{k,T_j}}\tau_j(u)\,du$$

Capacité=f (infrastructures, équipements)

Steps of the development of reduced forms (with the collaboration of industry)

- Energy sector (2005 – 2006)
- Energy intensive industry (2006 – 2007)
  - Steel
  - Cement
  - Aluminium
  - Glass
  - Refining industry
- End-use products including transport and buildings Infrastructures (2007)

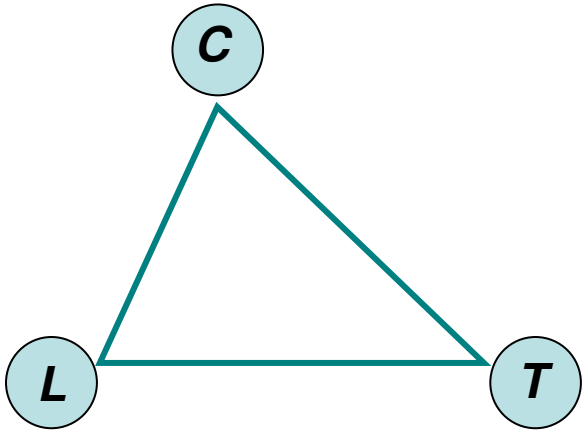
Scenarisation principles: articulating three main sets of 'visions'



Picturing development patterns

Consumption Patterns

- **Buildings, housing equipments**
- **Obsolescence rates**
- **Mobility**



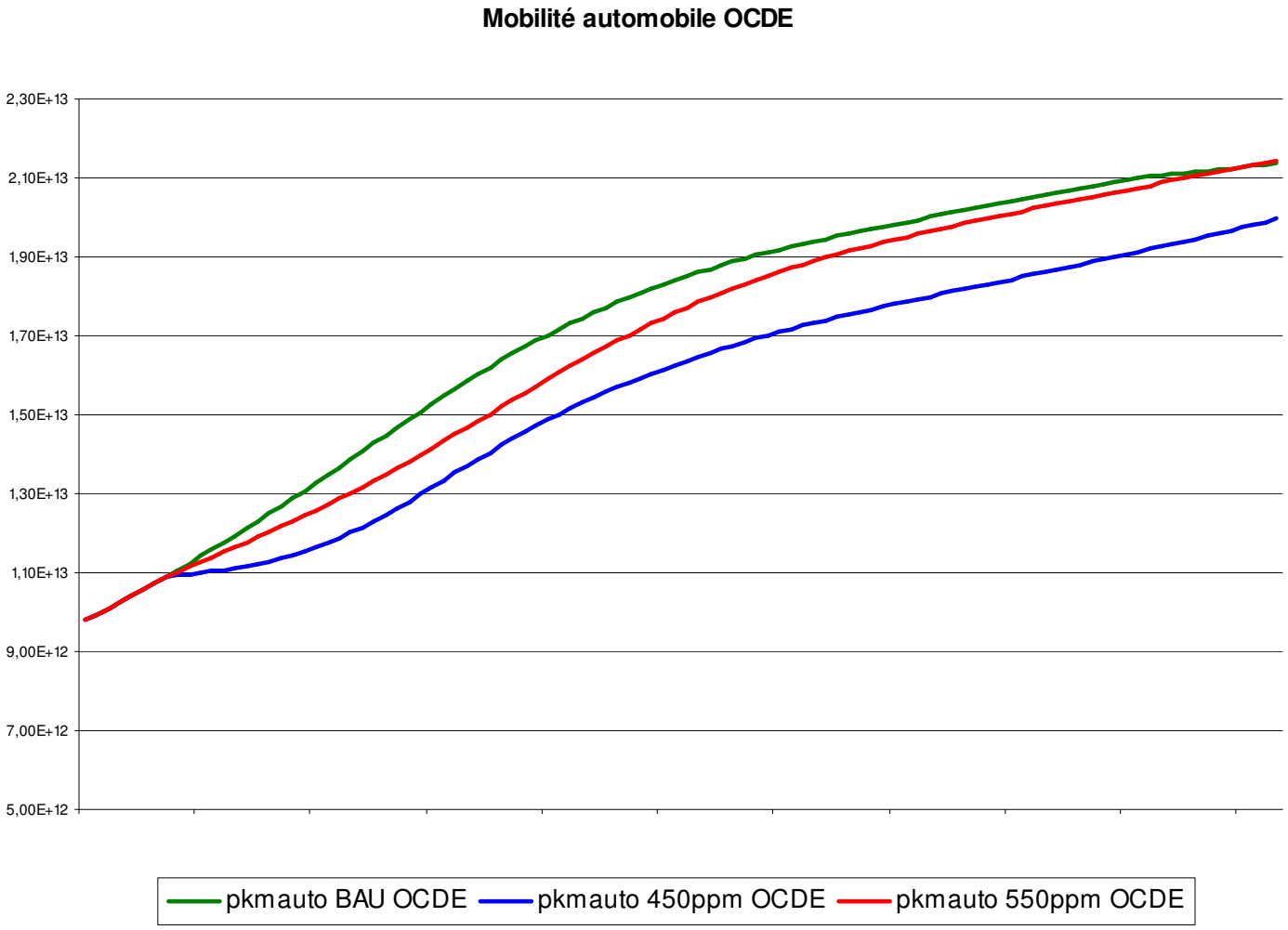
Location patterns

- **Urban forms**
- **Sea-side vs continental**

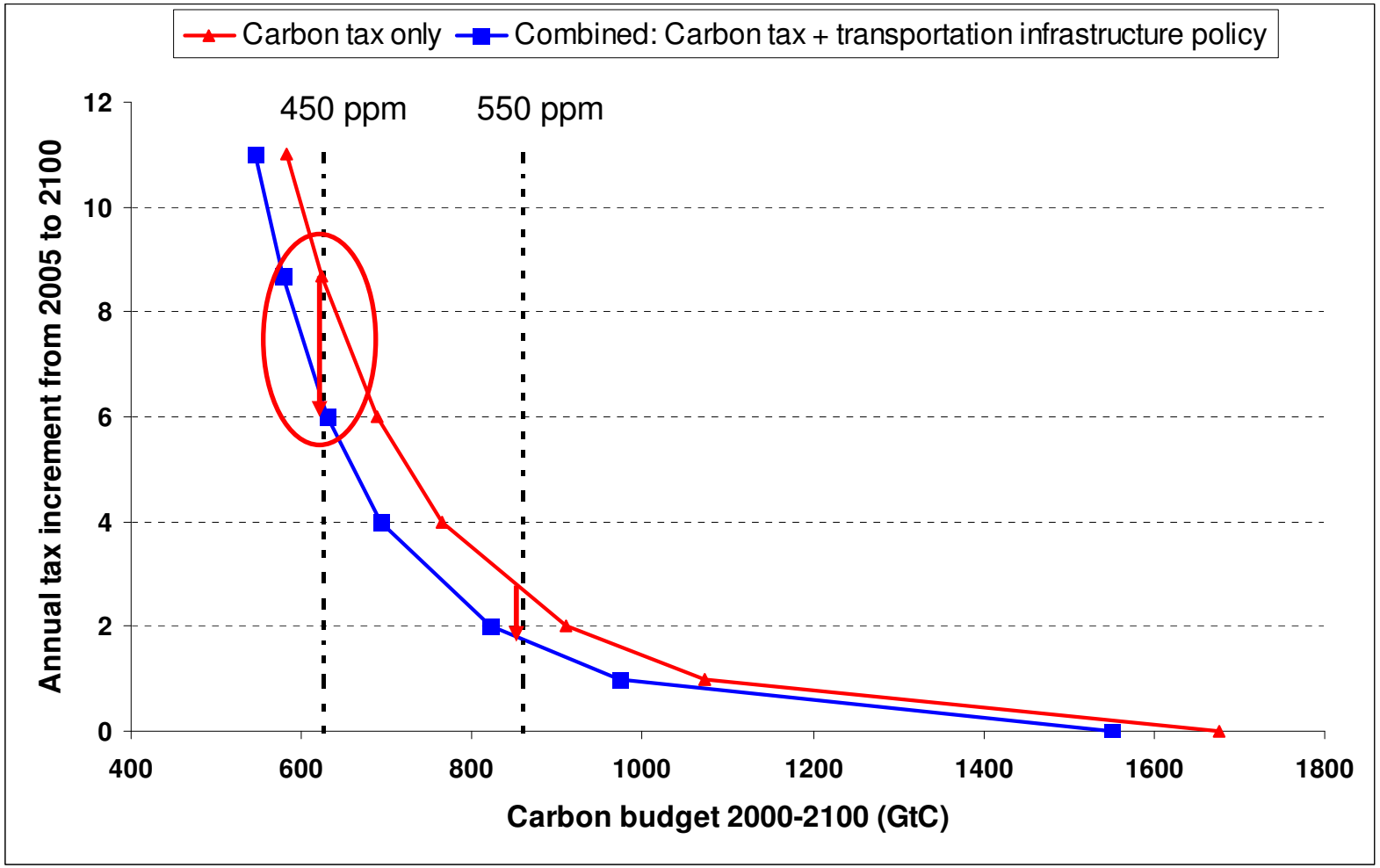
Technological patterns

- **Economies of scale vs distributed technologies**
- **Material efficiency vs renevable**
- **Recycling**

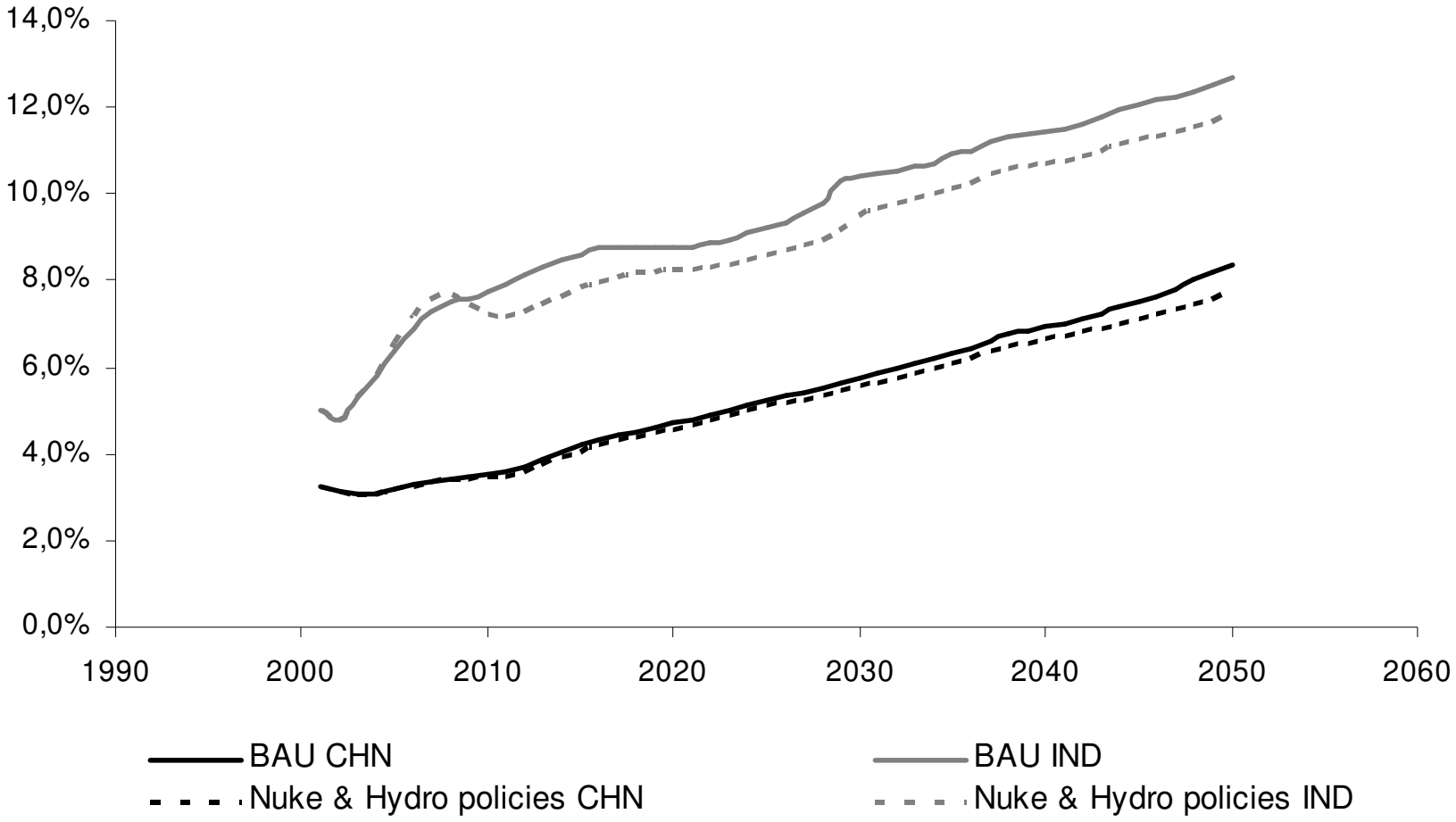
Illustrative results: the induction of mobility through higher efficiency of cars

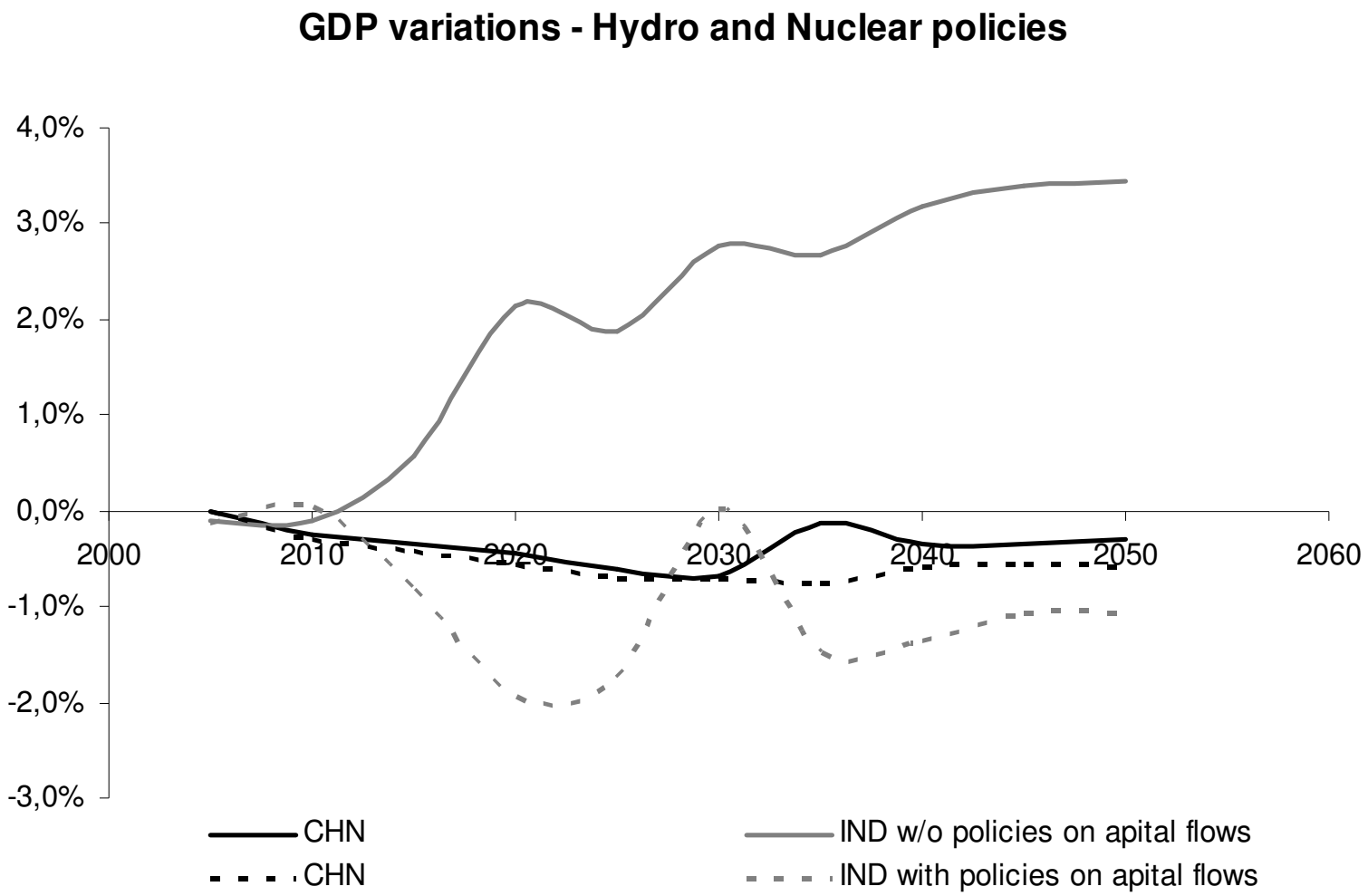


Infrastructure policy lightens the required tax burden.



Energy burden for households - Hydro and Nuclear policies




GDP variations - Hydro and Nuclear policies
4,0%
3,0%
2,0%
1,0%
0,0%
-1,0%
-2,0%
-3,0%
2000
2010
2020
2030
2040
2050
2060
CHN
CHN
IND w/o policies on apital flows
IND with policies on apital flows