Are very carbon-intensive pathways plausible?

Insights from the Imaclim-R modeling framework

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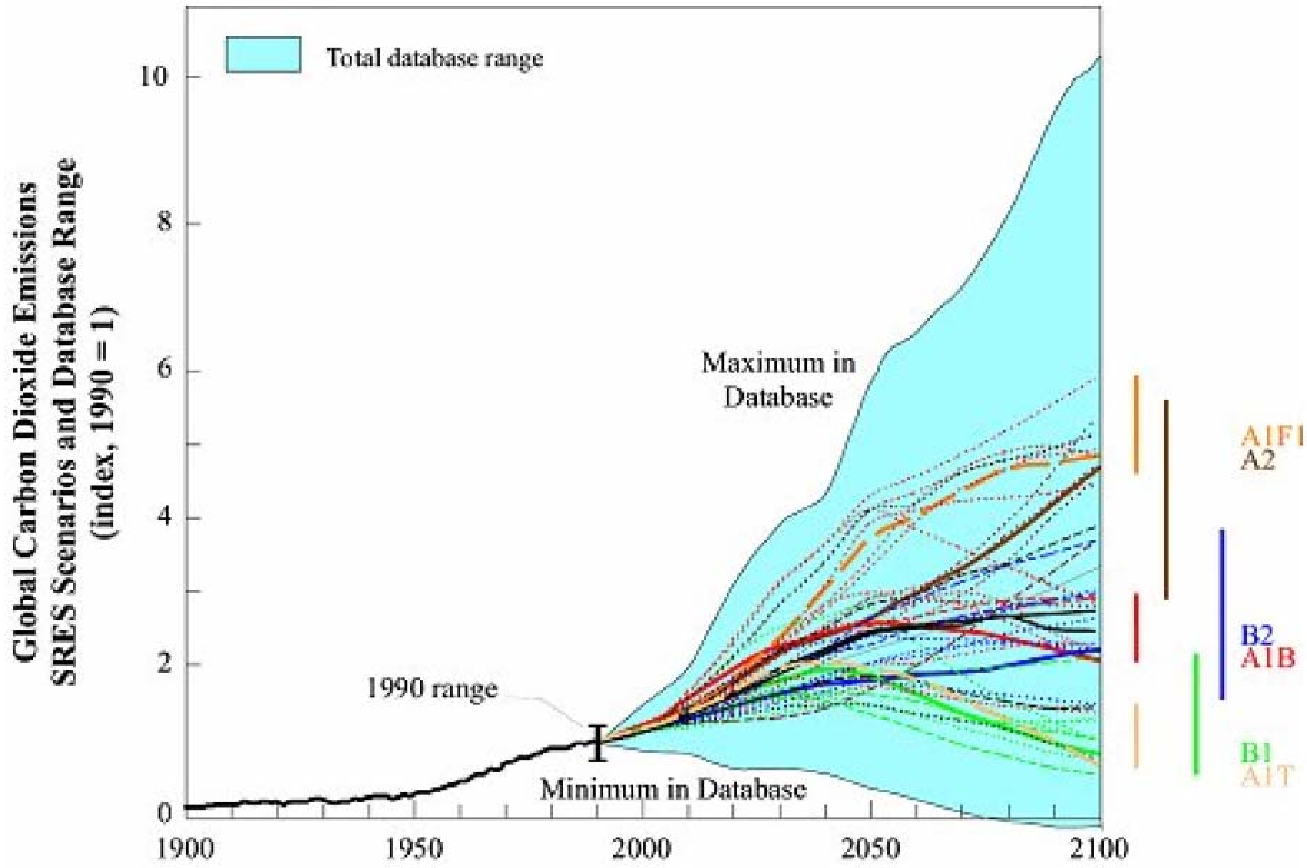
Mixed dissatisfactions
with current modeling practices and ongoing trends

- Non Plausible spread of SRES scenarios ?
- Recent criticism of Pielke et al. about BAU efficiency gains



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‘Kaya’ identity

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

Economic growth: productivity, catch-up

Energy intensity : efficiency gains, dematerialization, structural change

Carbon intensity : energy mix, sequestration

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		Rate of decoupling between GDP and Emissions		
		1.9 % /an	**2.0 % /an**	**2.1 % /an**
Mean Productivity growth rate	**0.9 % par an**	1733 GtC	1628 GtC	**1530 GtC**
	1.0 % par an	1992 GtC	1868 GtC	1753 GtC
	1.1 % par an	**2229 GtC**	2152 GtC	2016 GtC

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- The intuition that the future drivers of growth and of its physical content are likely to be very carbon intensive
  - Growth dynamics in emerging and developing countries will require an extraordinary amount of materials and energy (consumption + investments)
  - Fossil fuels have a large competitiveness margin
  - Transportation demand is likely to grow steeply despite tensions on oil prices

- Recently observed trends warns us against global optimism (Raupach et al.)
  - Current emissions profile is to exceed upper SRES bound
  - Current stagnation of carbon intensity

An improved consistency requires to represent underlying mechanisms

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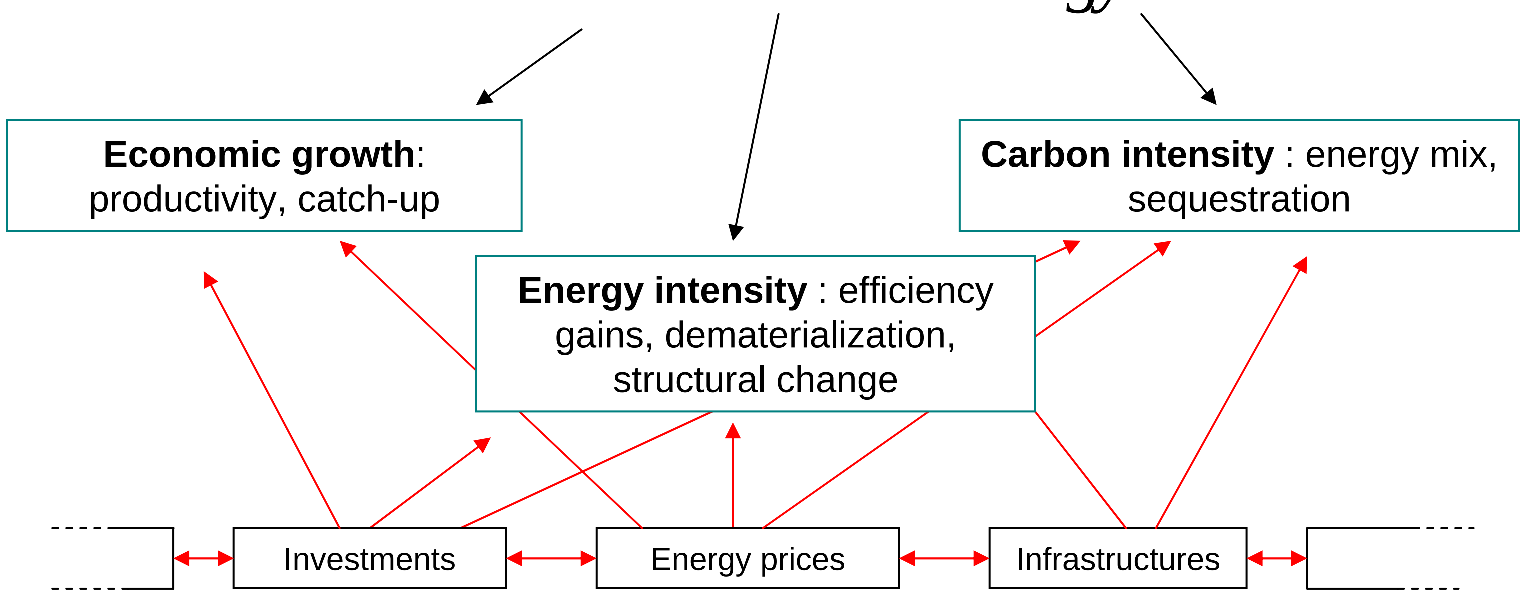
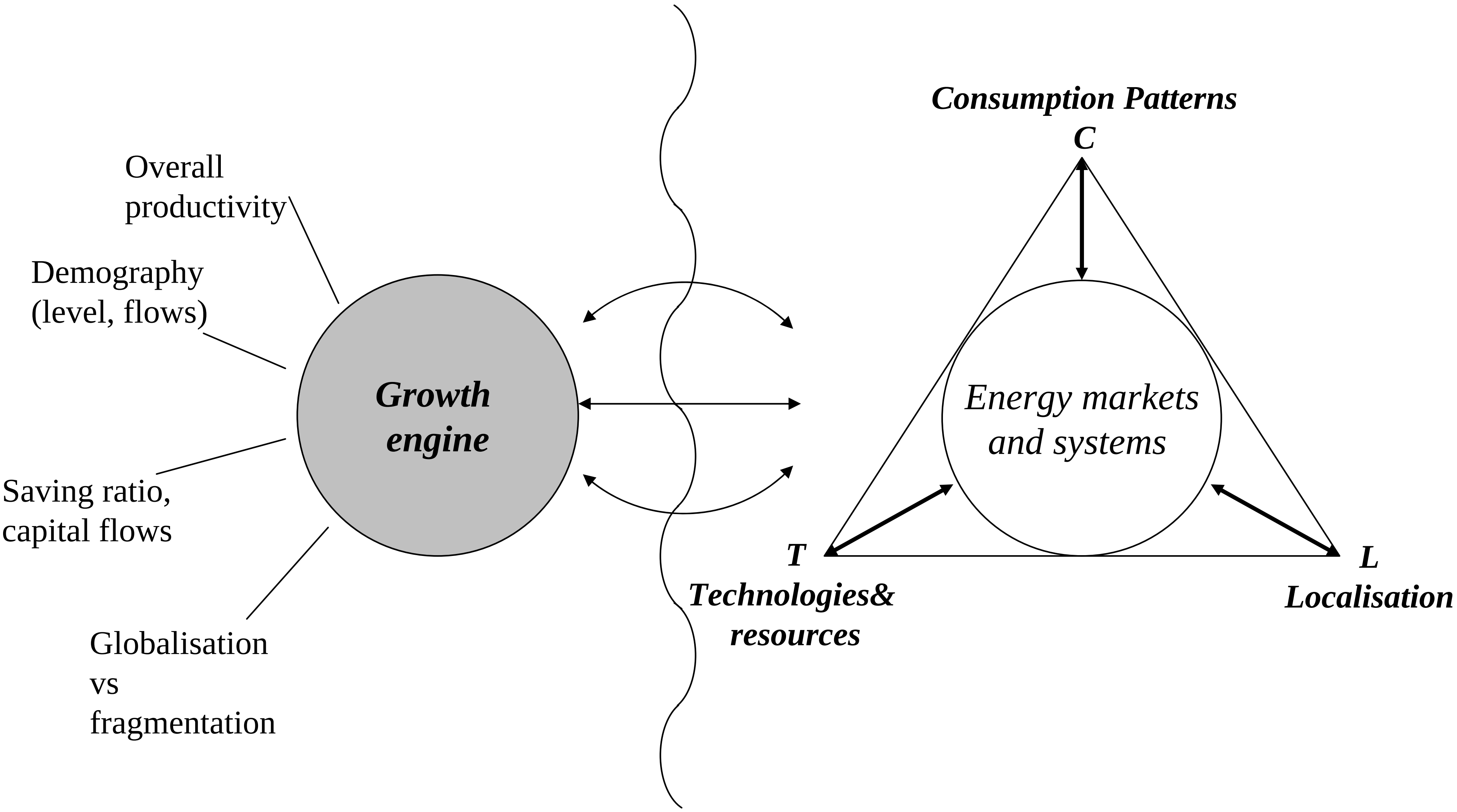


What would we like to represent?



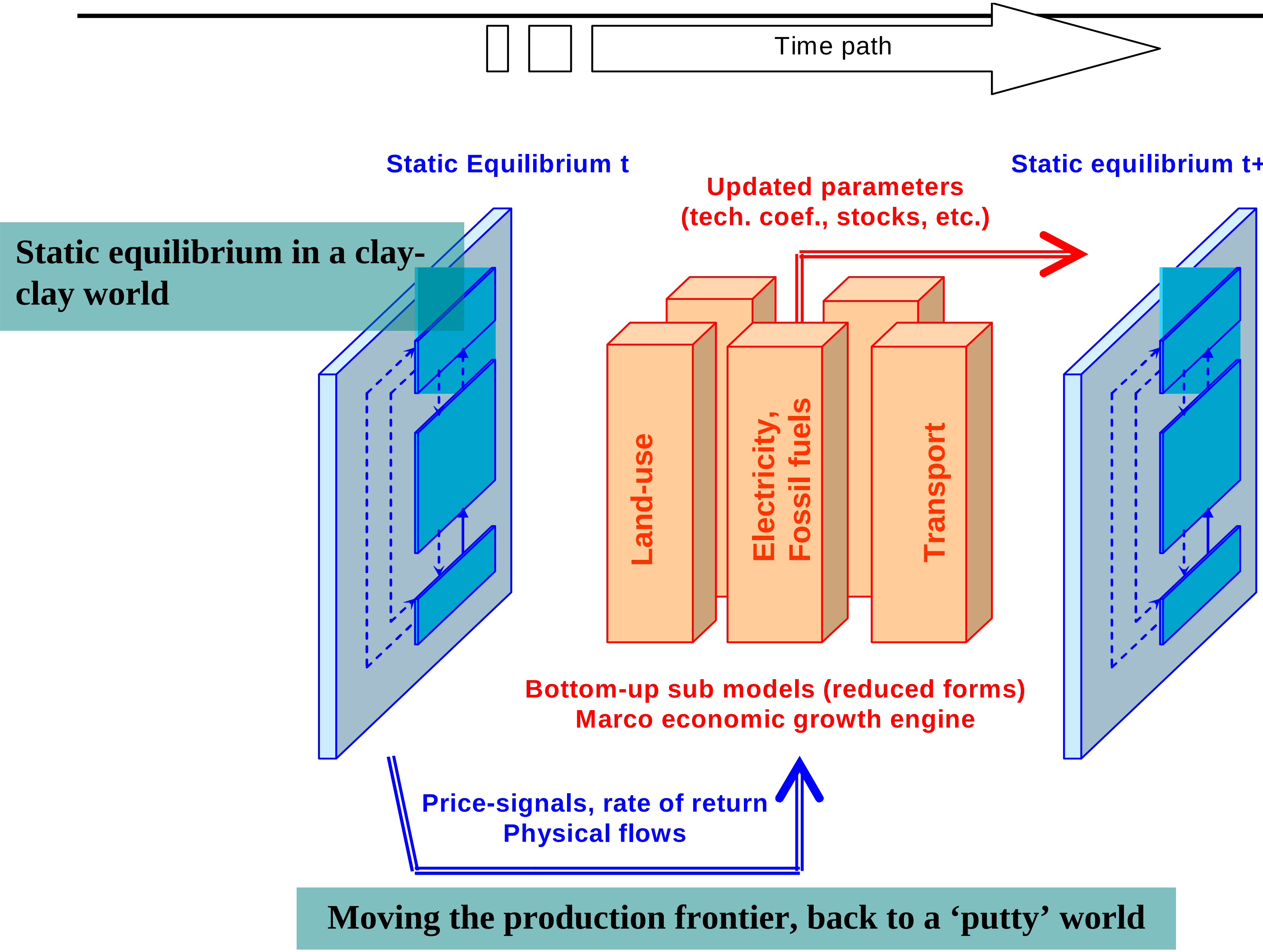
Main modeling principles

- An **hybrid modelling** in physical and money flows so as to
  - Ensure that the technological progress embodied in global growth is consistent with sector - based expertise
  - Ensure global macroeconomic consistencies and inter-sector feedbacks

- A **growth engine with disequilibrium …**
  - With imperfect foresight and routine behaviours
  - With energy (and other) price cycles
  - Allowing for structural imbalances (unemployment…) and endogenous shocks

- Endogenized structural and technical changes in order to represent internal macro economic feedbacks

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



An ‘agnostic’ attitude toward BAU scenarii

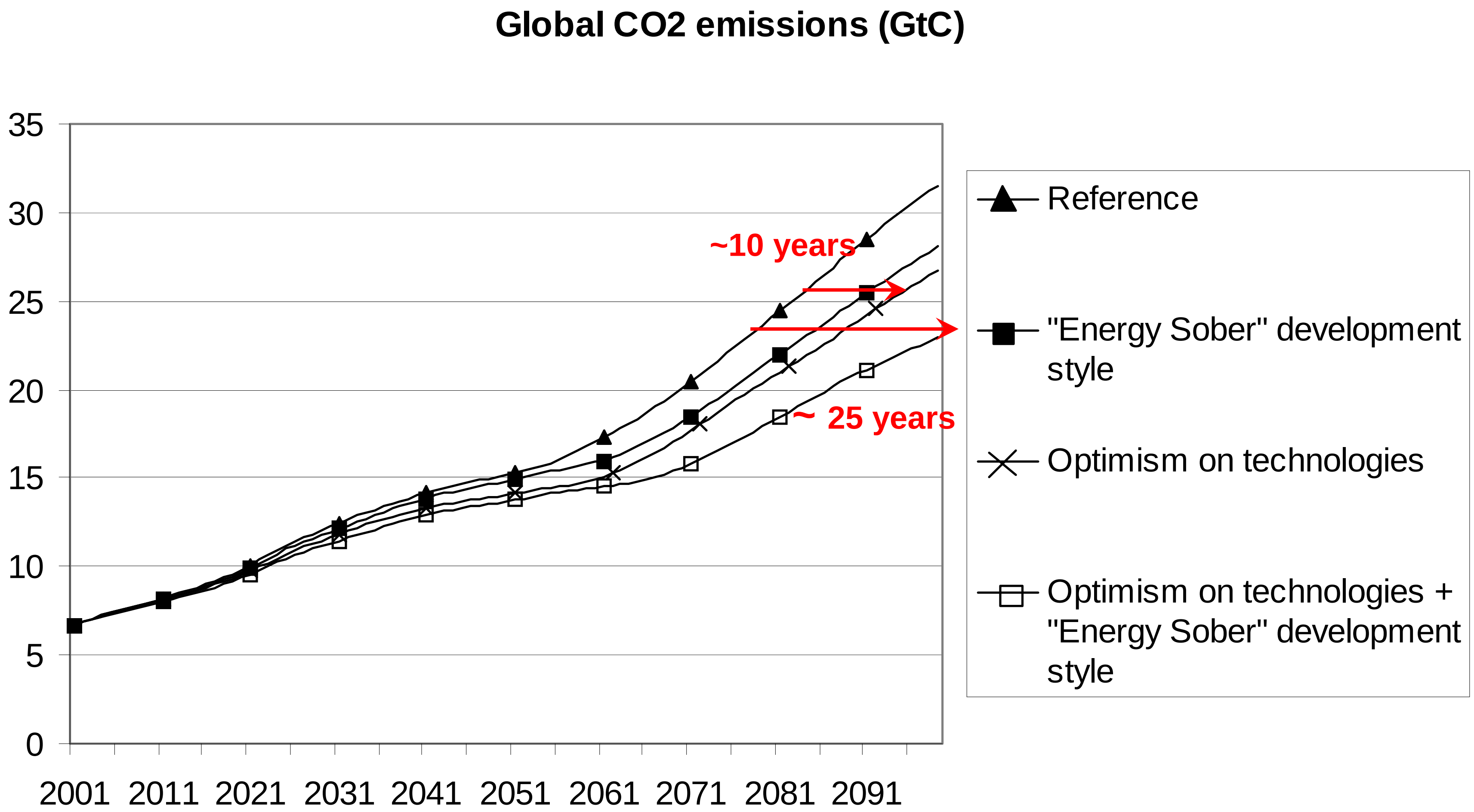
- The model allows for
  - Consistent interactions of various assumptions
  - A complex computation

- Change the procedure: from assumptions to unknown results
  - Demography from UN 1998 central scenario.
  - Mimetic catch-up of development styles.
  - Central assumptions on technologies costs and oil reserves (3.4 Tbl)
  - Median GDP growth, world GDP x7.7 between 2001 and 2100

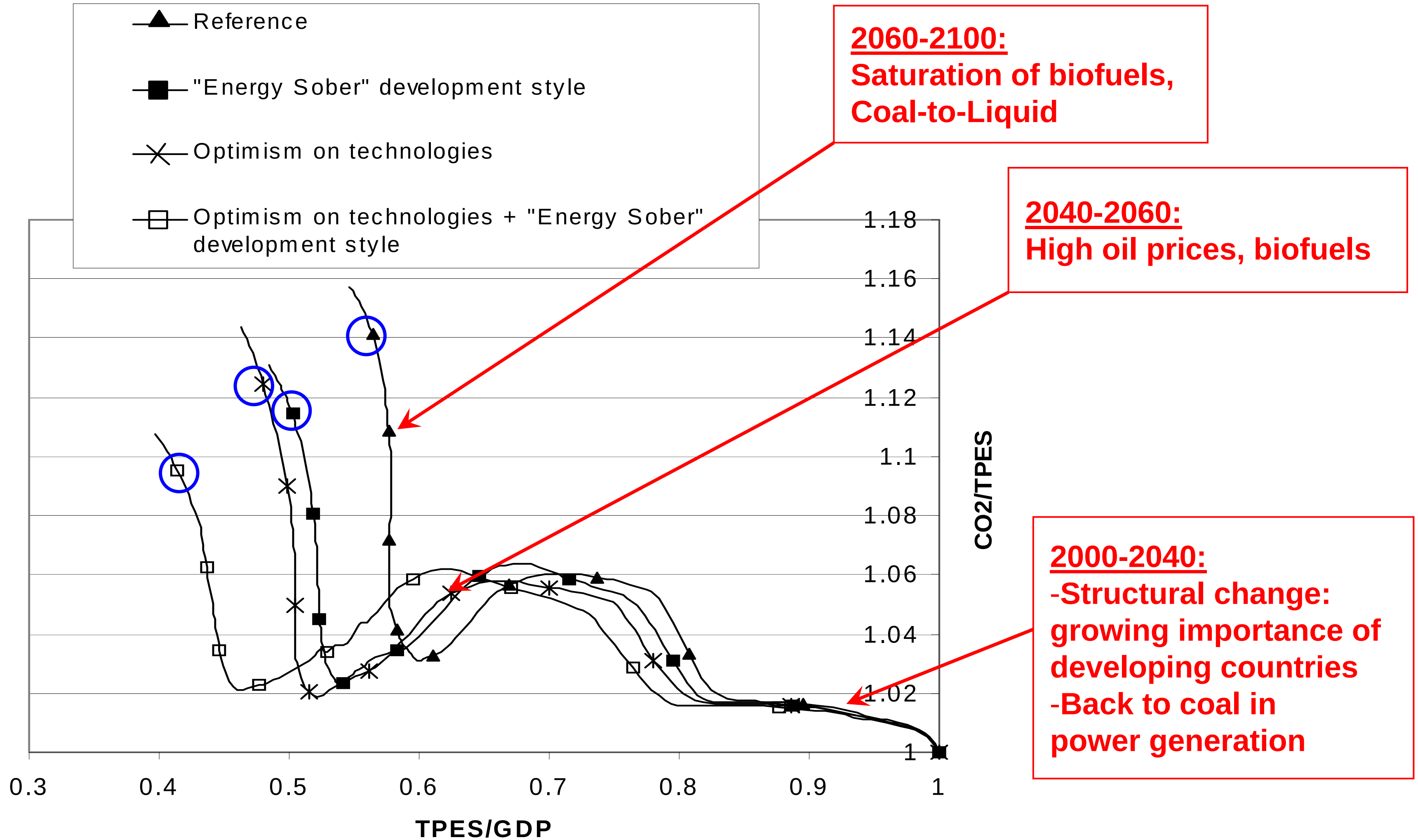
A Sensitivity Test on underlying drivers of emissions

	Scenarios	Assumptions
Optimism on energy supply	Optimism on oil reserves	+30% reserves
Optimism on end-uses technologies	Optimism on AEEI	AEEI*1.5
	Optimism on truck, bus and train technologies	Energy efficiency improvement: speed*1.33
	Optimism on car technologies	Learning rate*3
	Optimism on residential end-uses technologies	Energy efficiency +30% in 2050
"Energy sober" development style	Lower freight content of growth	Decrease following AEEI
	Lower material content of consumption	Saturation level*0.66
	Slower car equipment	Elasticity to revenue*0.66

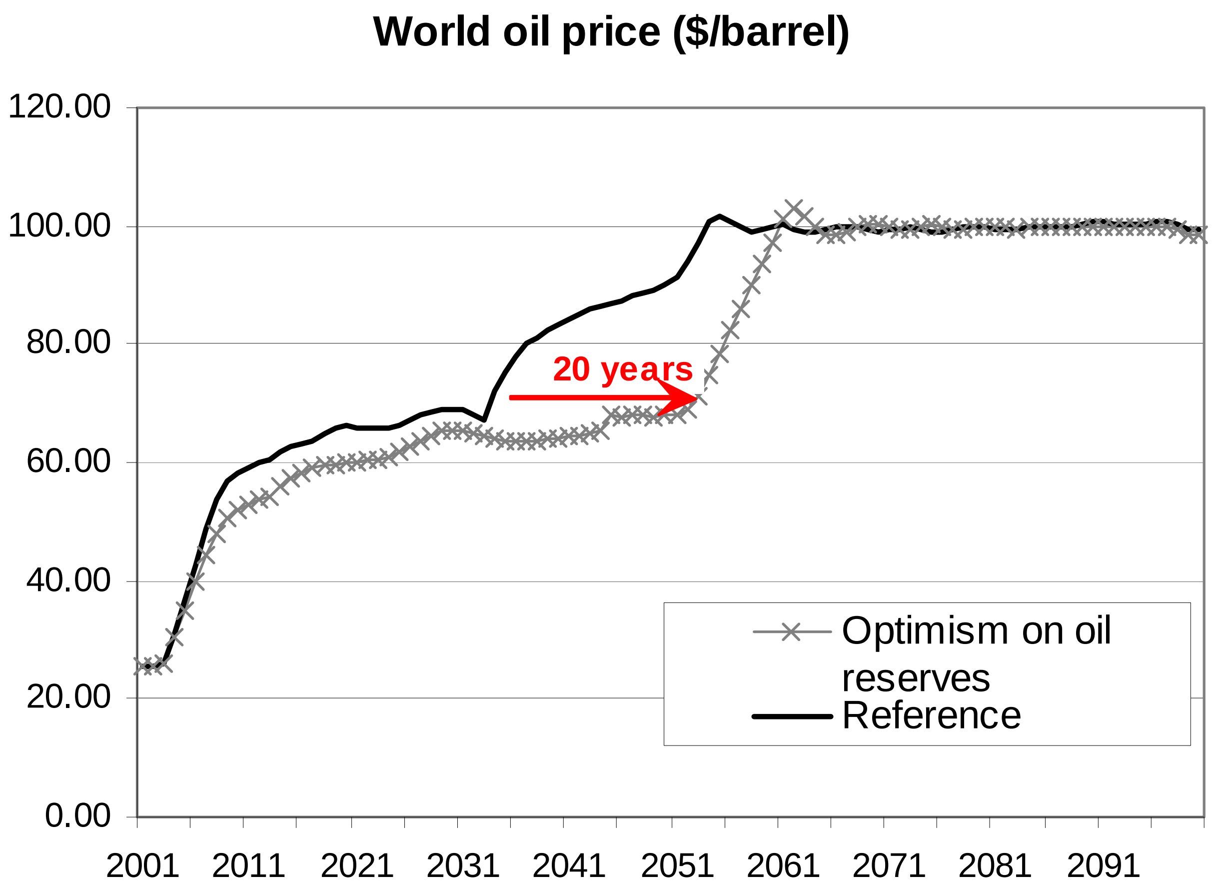
Overall look on global CO2 emissions



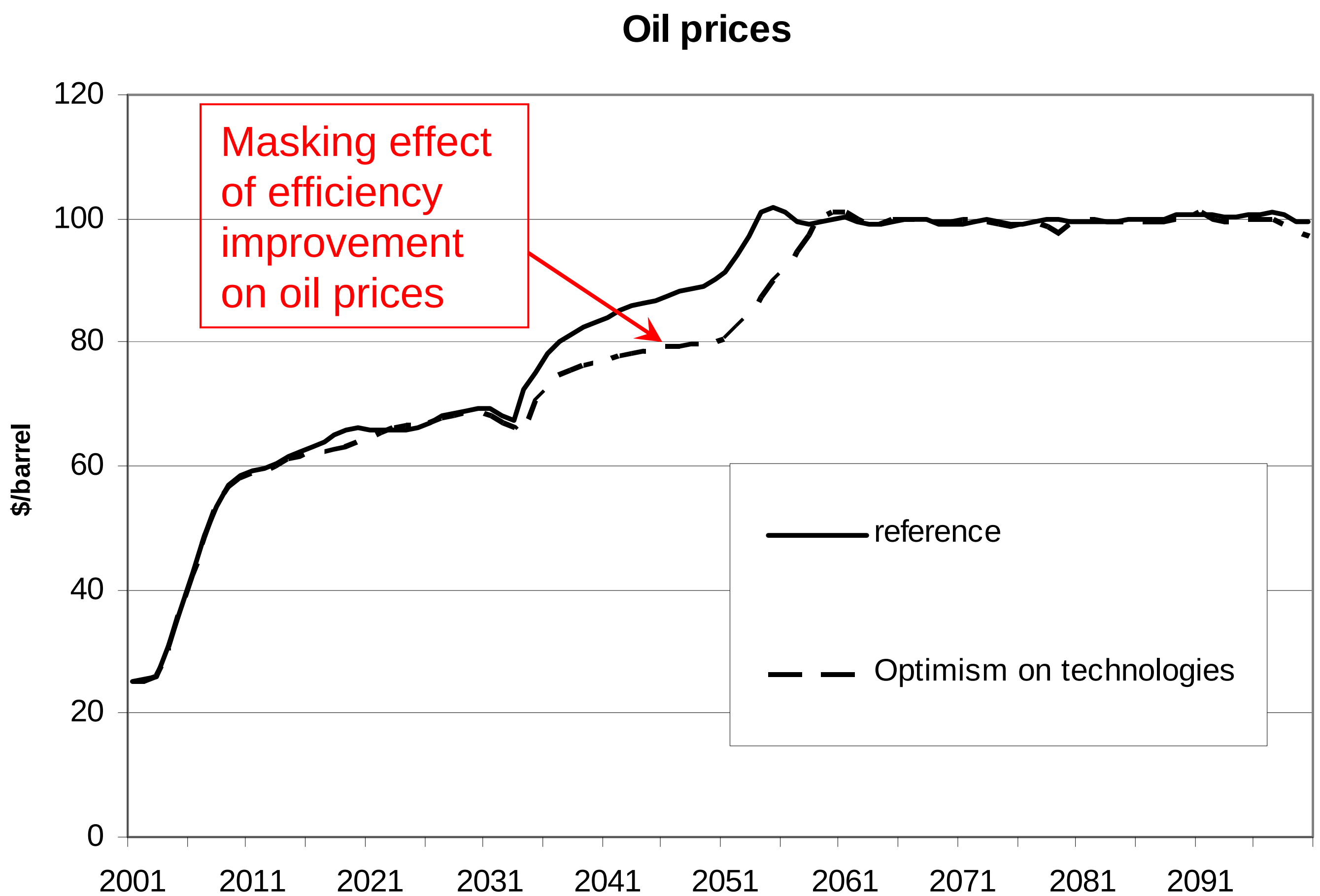
“Kaya” diagram: non trivial interactions!



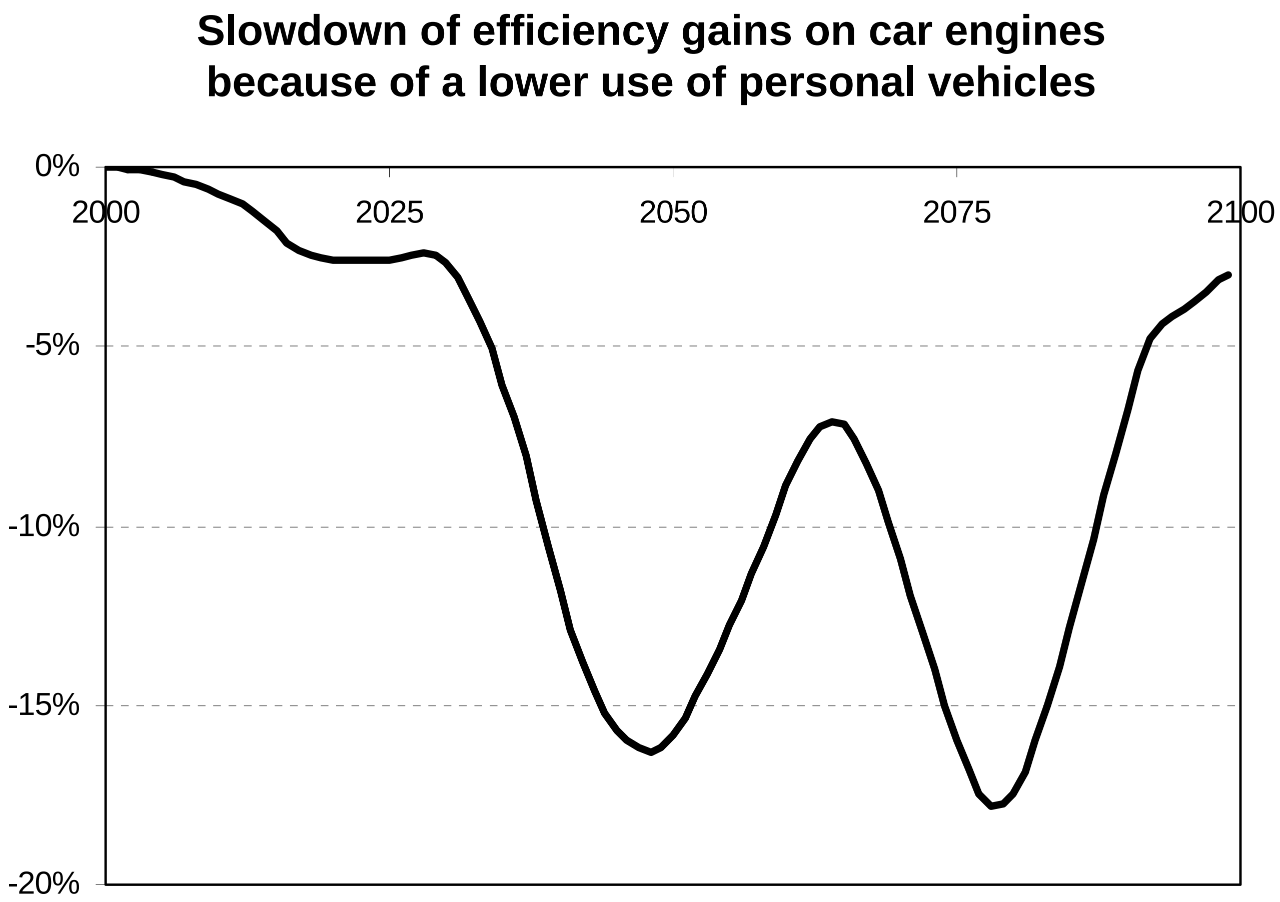
The risks of carbon-intensive lock-in are highly dependent on signals from energy markets and regulatory uncertainty



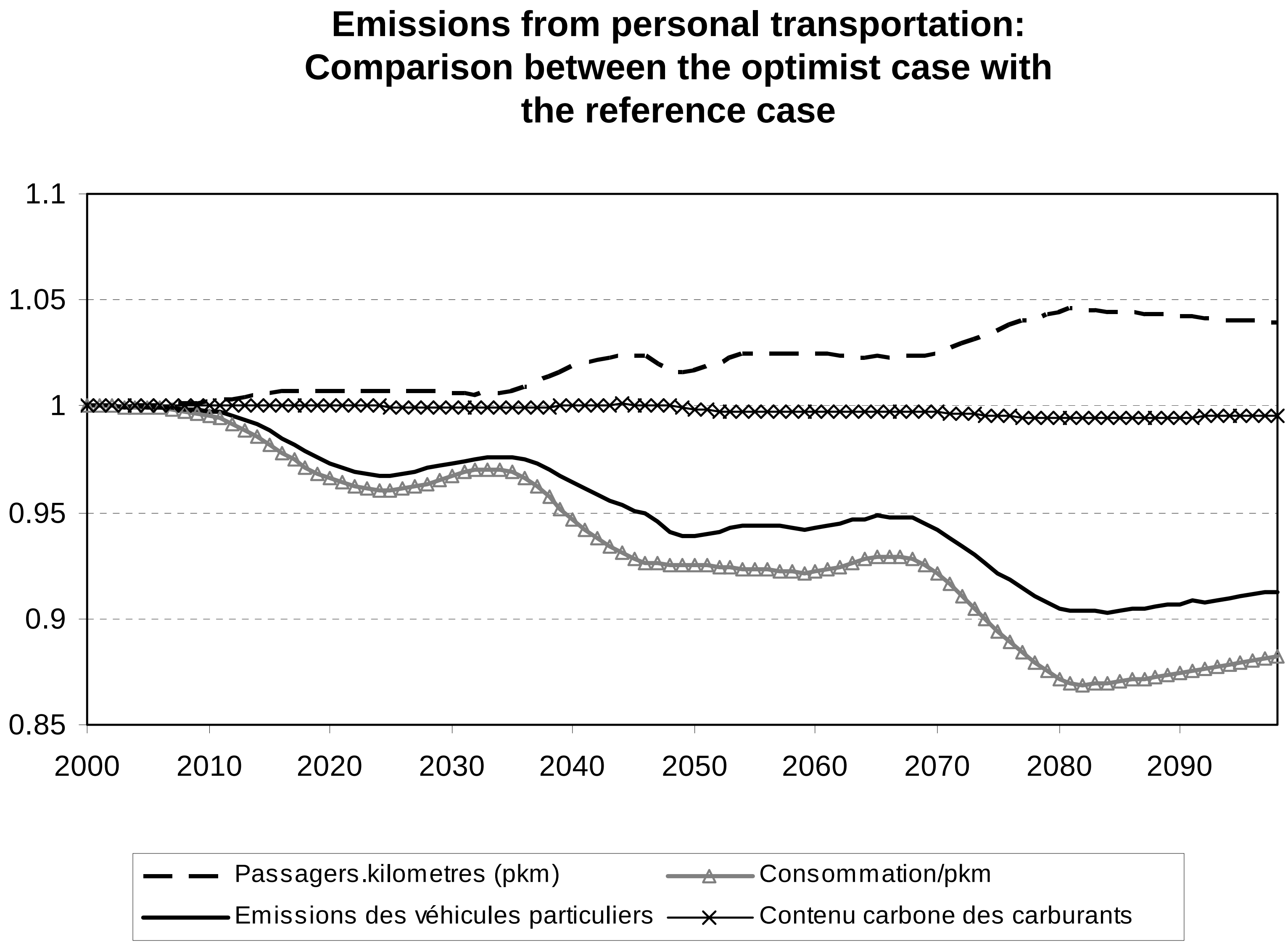
Efficiency improvement may have a masking effect on oil prices



Controlling upstream emissions drivers could slow down technical progress to low carbon technologies



Sectoral Rebound effects



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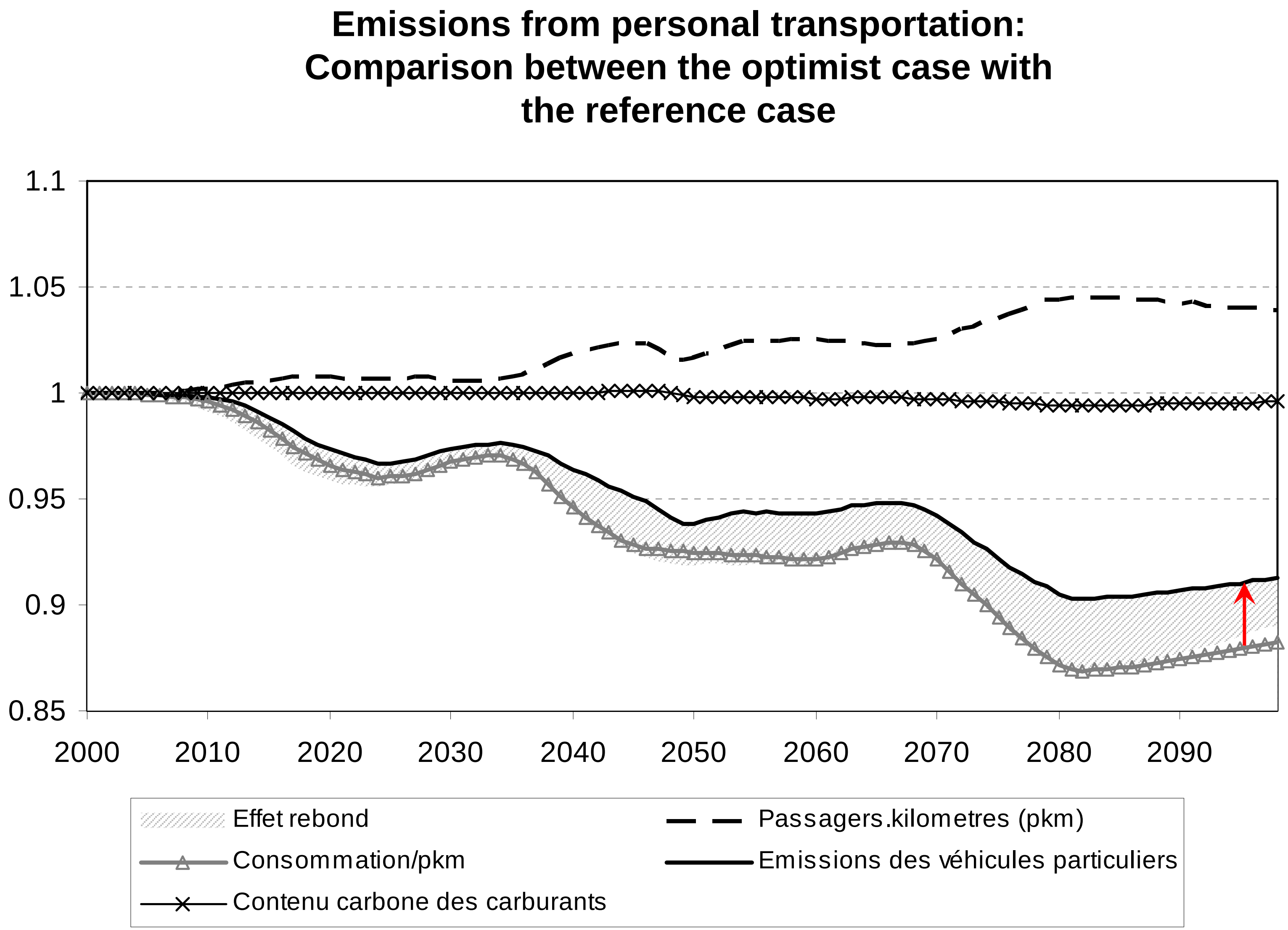
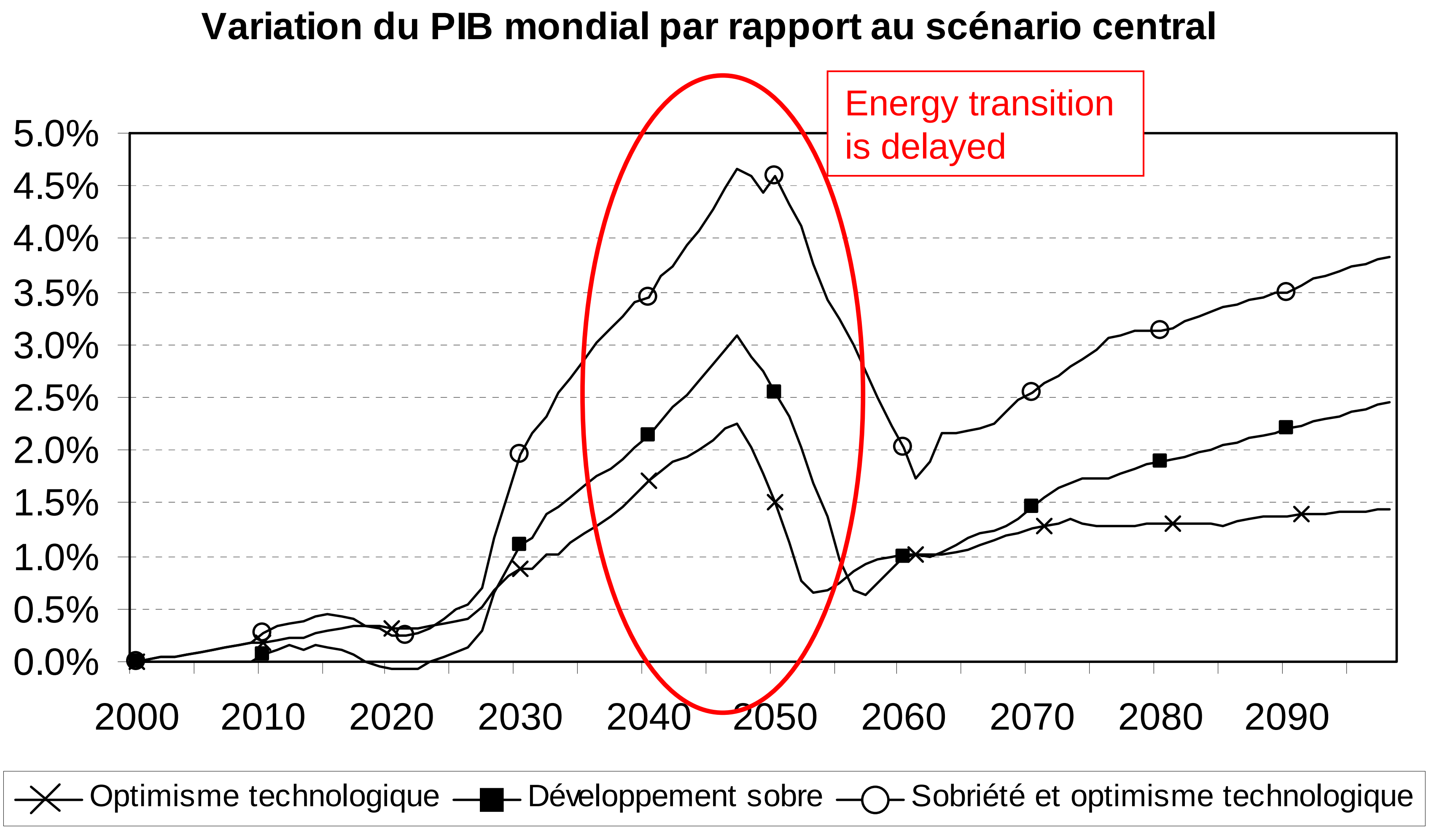


Macroeconomic Rebound effects



A challenging transition for an attractive future

Category	Radiative forcing (W/m²)	CO_2 concentration[c)] (ppm)	CO_2-eq concentration[c)] (ppm)	Global mean temperature increase above pre-industrial at equilibrium, using "best estimate" climate sensitivity[b), c)] (ºC)	Peaking year for CO_2 emissions[d)]	Change in global CO_2 emissions in 2050 (% of 2000 emissions)[d)]
I	2.5-3.0	350-400	445-490	2.0-2.4	2000-2015	-85 to -50
II	3.0-3.5	400-440	490-535	2.4-2.8	2000-2020	-60 to -30
III	3.5-4.0	440-485	535-590	2.8-3.2	2010-2030	-30 to +5
IV	4.0-5.0	485-570	590-710	3.2-4.0	2020-2060	+10 to +60
V	5.0-6.0	570-660	710-855	4.0-4.9	2050-2080	+25 to +85
VI	6.0-7.5	660-790	855-1130	4.9-6.1	2060-2090	+90 to +140

IPCC, 2007