Hybrid Modeling of Economy-Energy-Environment Scenarios

The Impact of China and India's Economic Growth on Global Economy and Energy Use

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Motivations and objectives

- Emerging countries' (China and India in particular) growth recently created tensions on energy markets and led to faster CO2 emissions growth than forecasted

- Past projections have often significantly underestimated growth rates

- Investigate the impacts of China and India's growth on energy use and CO2 emissions – WEO 2007 (IEA)
  - What may be the impact on fossil fuel prices?
  - How the economy and energy consumption in each region of the world may be affected by higher GDP growth assumptions in China and India?

Approach and Modeling issues

- Scenario approach: Reference vs. High Growth (China/India)

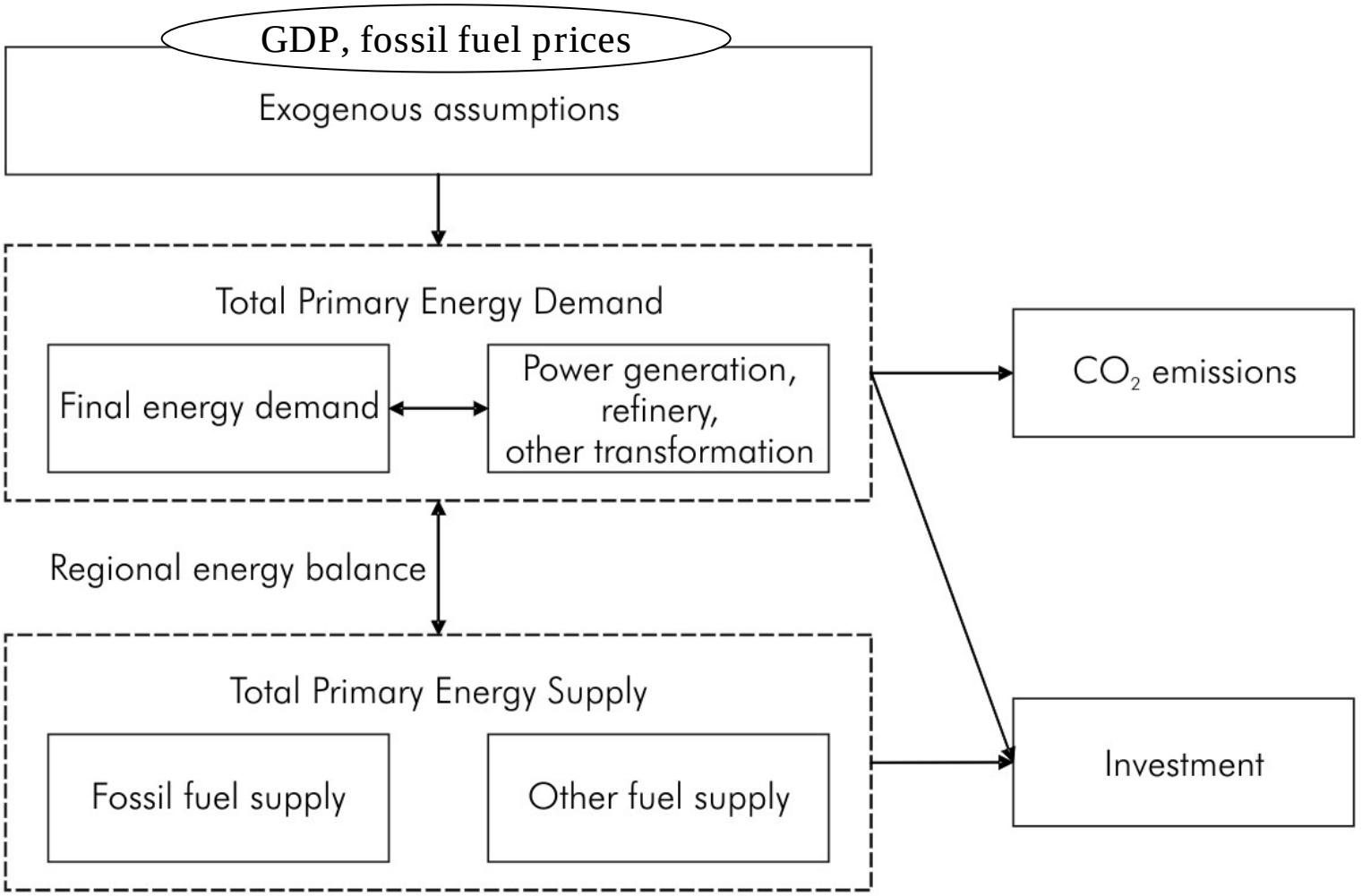
- Need to :
  - Capture a detailed representation of energy use and supply
  - Ensure macroeconomic consistency of the scenarios
    - Introduce consistent prices and energy flows
    - Evaluate feedback between the energy system and economic mechanisms

- Two models:
  - World Energy Model: partial equilibrium model of the world energy sector (Bottom-Up)
  - IMACLIM-R: hybrid recursive general equilibrium model of the world economy

The need for macro-consistent modeling in the IEA context

- Integrating experts says in a common framework and facilitating dialogue between experts communities
  - Energy experts, macroeconomists, modelers
  - A common tool to:
    - Share the same vision of the future economic context
    - Reveal the underlying assumptions and mechanisms behind a specific projection
- Taking into account macroeconomic feedbacks
  - International trade
  - Households revenue and consumption…

World Energy Model Overview



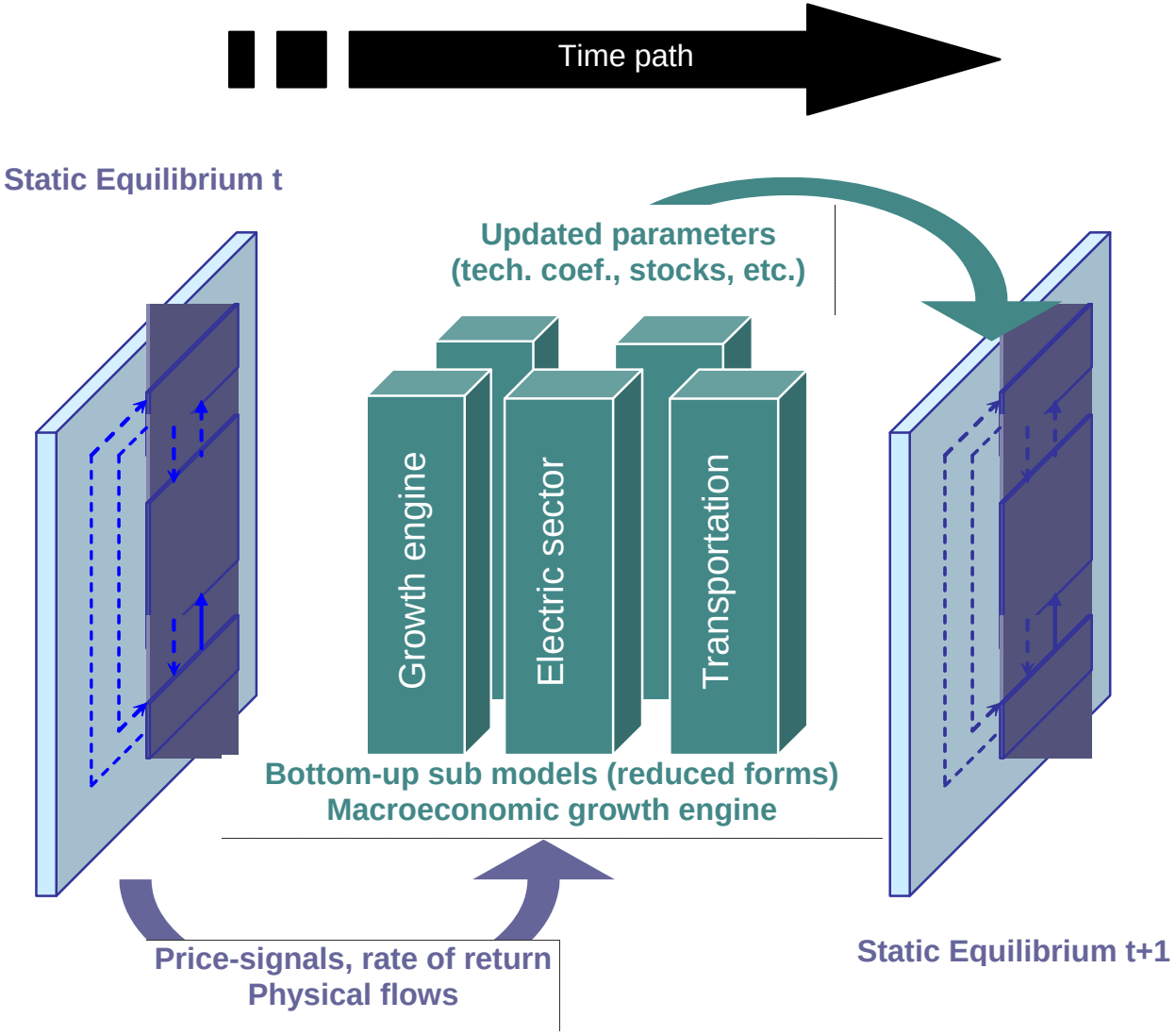
The hybrid structure of IMACLIM-R

A recursive and modular architecture :

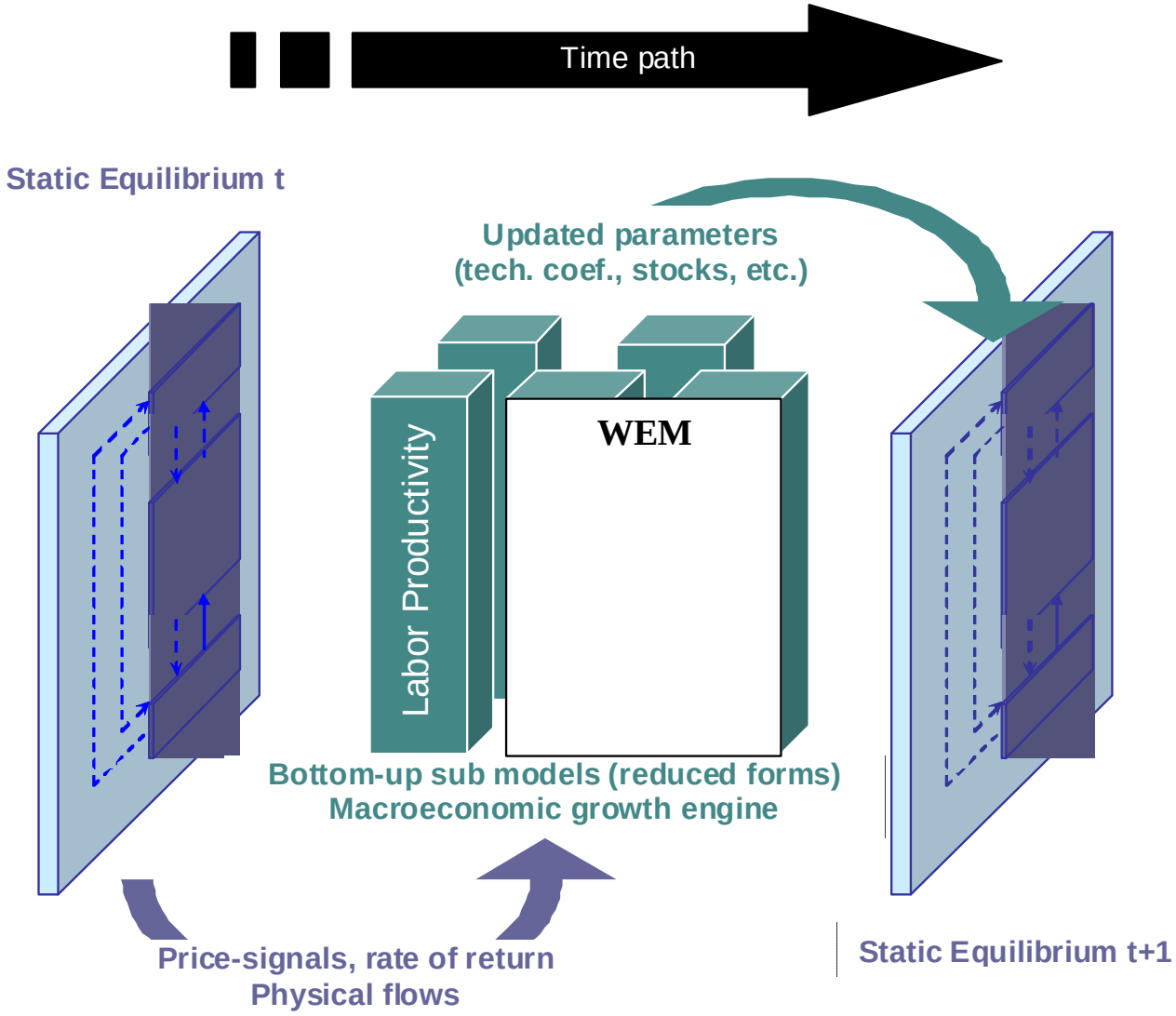
- A sequence of **static equilibriums** under short-term constraints
  - Capture macroeconomic feedbacks (rebound effects, crowding-out effects...)
  - Constraints of technologies, capacities and equipment level (putty-clay)

- **Dynamic modules**: evolution of constraints
  - Technological choices, new productive capacities, new technical coefficients, new equipment
  - Reduced forms of Bottom-Up models

IMACLIM-R modular and recursive architecture



The coupling philosophy



The coupling procedure (1)

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  - Calibrate Imaclim-R parameters to reproduce:
    - GDP assumptions (labor productivity growth)
    - Fossil fuel prices (energy producing regions behavior)
    - Regional and sectoral energy consumption (technical coefficients)

The coupling procedure (2)

- Iterations on the High Growth Scenario
  - Higher GDP growth assumptions for India and China in WEM
    - On average 1.5 percentage points per year higher than in the Reference Scenario.
    - An average growth rate to 2030 of 7.5% for China and 7.8% for India.

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  - … Iterations until convergence

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  - The energy intensity in 2030 is respectively 12.5% and 16.7% lower than in the Reference Scenario.
- Taking into account all macroeconomic feedbacks, the **demand for primary energy worldwide increases by 6%** compared to Reference Scenario in 2030 (and CO2 emissions are 7% higher, at 44.8 GtCO2)

Results (2): Higher fossil fuel prices

- Higher energy demand drives the exploitation of more expensive resources,
- While the investments in new production capacities by coal, oil and gas producers only partially adjust to the changing context.

	2006	2010	2015	2020	2030
Oil price	0%	9%	17%	21%	40%
Natural gas price	0%	9%	17%	21%	40%
Coal price	0%	3%	7%	11%	19%

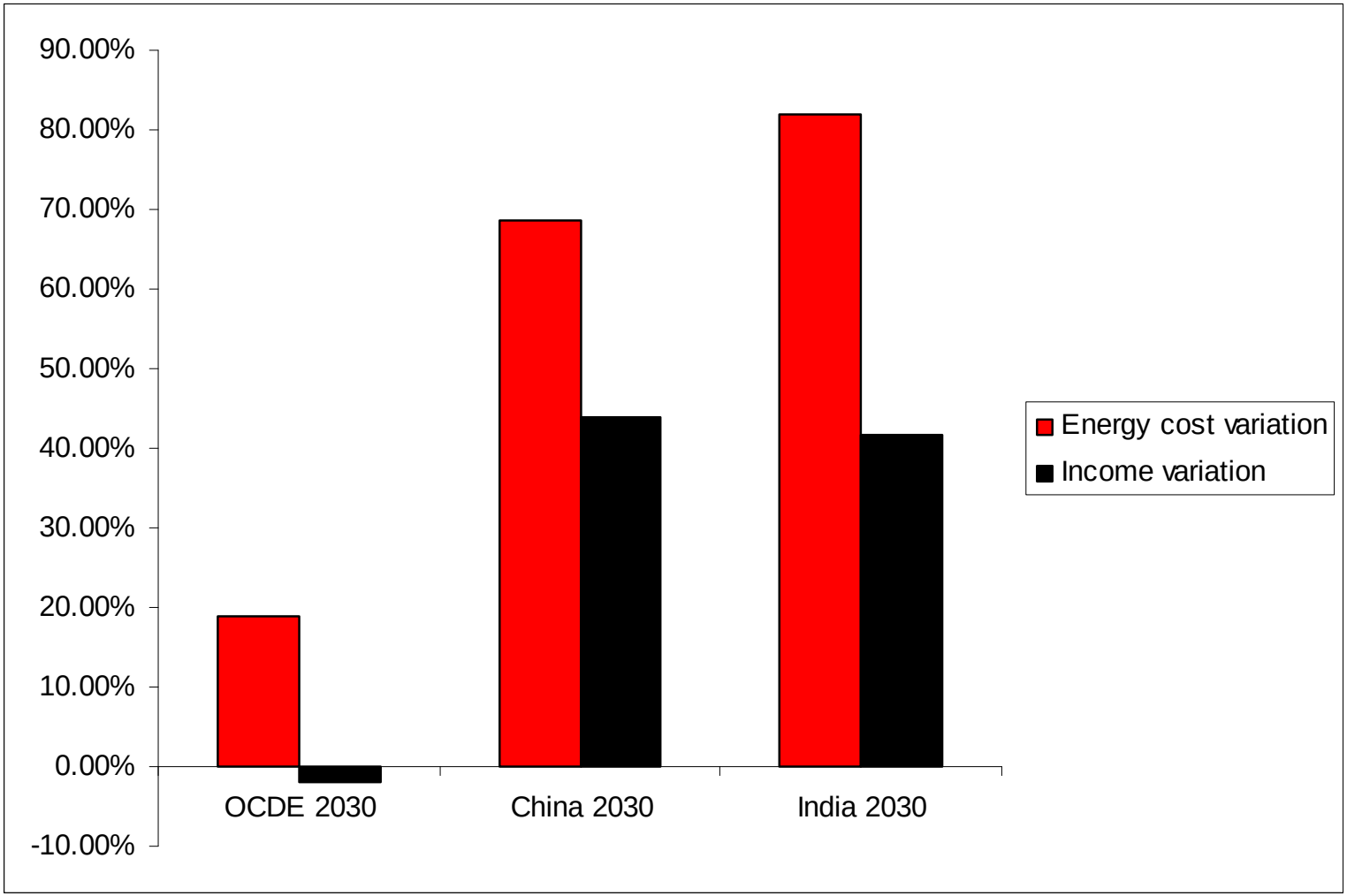
Relative fossil fuel prices increase in the High Growth scenario w.r.t. the Reference scenario

Results (3): Macroeconomic impacts matters!

	Average annual growth rate, 2005-2030	Difference from Reference Scenario	
		Average annual growth rate, 2005-2030	Level of GDP in 2030
OECD	2.1%	-0.06%	-1.4%
CIS	3.5%	0.03%	0.6%
Developing Asia	6.9%	1.28%	37.3%
China	*7.5%*	*1.50%*	*45.2%*
India	*7.8%*	*1.50%*	*45.1%*
Middle East	4.4%	0.41%	10.9%
Africa	4.0%	0.05%	1.4%
Latin America	3.3%	0.06%	1.4%
Brazil	*3.1%*	*-0.00%*	*-0.1%*
World	**4.3%**	**0.61%**	**16.3%**

Disentangling the mechanisms at play (1)

- Households' consumption



Variation in real households' income and energy spending in HGS w.r.t. RS

Disentangling the mechanisms at play (2)

- Regional competitiveness and international trade

1. Transmission of higher energy prices to production costs

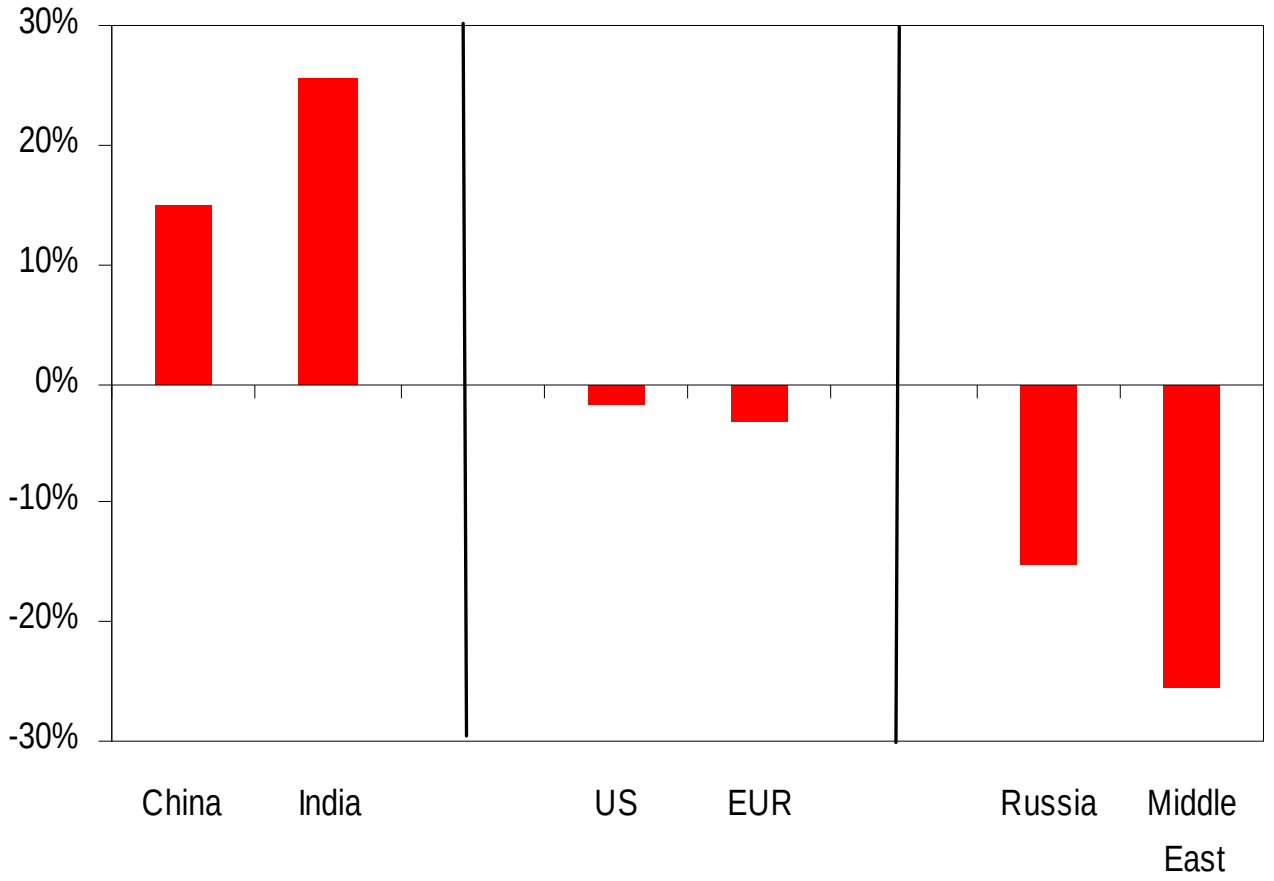
	Reference scenario	High Growth scenario	Difference
China	5.3%	6.0%	0.7%
India	12.1%	15.0%	2.9%
OECD	5.5%	6.6%	1.1%

Shares of energy costs in total industrial production costs in 2030.

Disentangling the mechanisms at play (3)

- Regional competitiveness and international trade

2. From production costs to competitiveness index: the role of real exchange rates

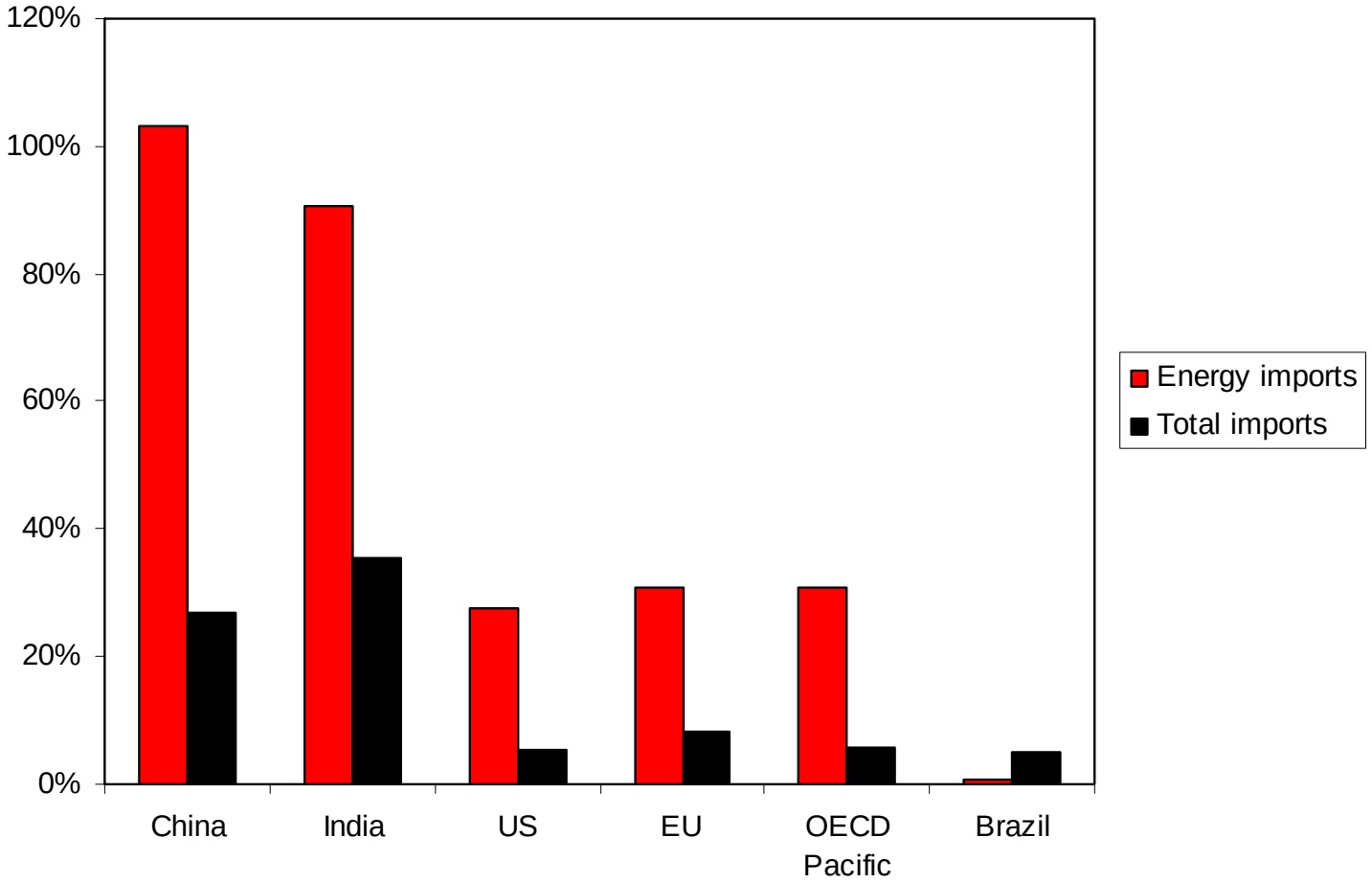


Variation in competitiveness index (ratio of the local production cost to the selling price on international markets) in 2030, HGS w.r.t. RS

Disentangling the mechanisms at play (4)

- Regional competitiveness and international trade

3. Effects on international trade



Evolution of imports of goods and energy in the HGS relatively to the RS

Conclusion

- Methodology:
  - Improving the consistency of energy scenarios
  - Facilitating dialogue with experts
- Macroeconomic feedback matters.
- A first attempt, an illustrative example that gave encouraging results
- Further development and improvement of the modeling framework for WEO2008.

For a detailed description of the models and the coupling procedure:

http://www.worldenergyoutlook.org/docs/weo2007/WEM-ECO_Description.pdf

Thank you for your attention!

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