



# Long-term macroeconomic impacts of US unconventional Oil & Gas production : A general equilibrium perspective

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# Context

- Countries supposedly rich in shale gas are looking forwards to produce their own resources (energy security, lower energy costs, etc..)
- One of the political argument for shale gas in France has been :
  - Support employment in industries through increasing competitiveness

-> Does it hold in a general equilibrium context ?

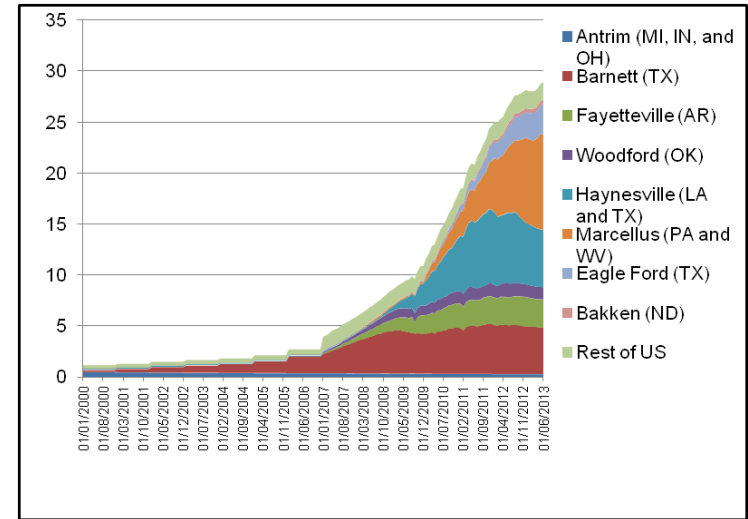
# Outlines

- A decade of unconventional resource production in the US
- The Imaclim-R framework
  - General architecture
  - Endogenising resource production
- Long-term scenarios on the US
  - Impacts on the US GDP
  - Competitiveness implications and global strategic choices of the US economy

# The unconventional boom

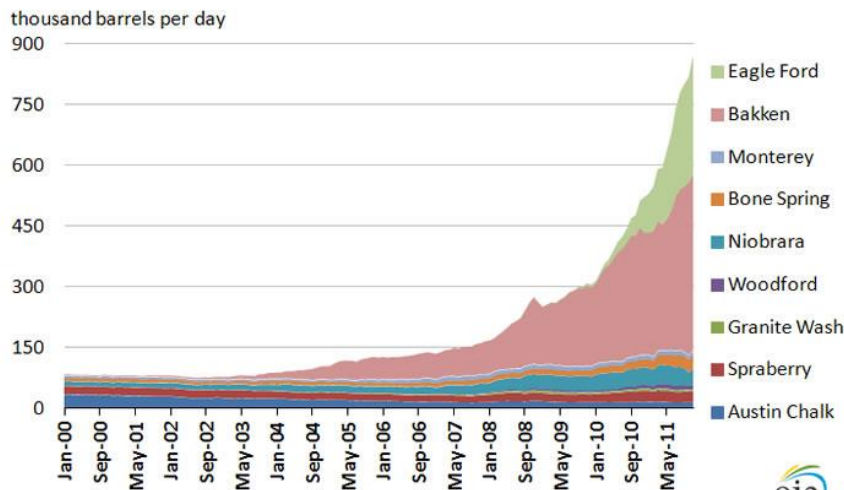
## Shale gas

- A 30% increase of gas production between 2005-2014
- 35% of total gas production
- Well-head gas price : from 6,73 \$/Mbtu (2006) to 3,73 \$/Mbtu (2013)



Source : EIA, Annual Energy Outlook 2013

Figure 2. Tight oil production for selected plays



Source: U.S. Energy Information Administration based on HPDI, LLC; 2011 is through November



## Light tight oil

- 4,8 bbl/day in 2015 : the US first world oil producers (9,3 bbl/day)
- One of the reasons for the 2014 50% oil price drop

# The economic impact of shale gas in the literature

- Early studies find a positive impact on local income/employment :
  - BUT : overstated according to (Kinnaman, 2011).
  - Less optimistic conclusions in recent peer-reviewed studies (Weber, 2012; Paredes et al., 2015):
- As for the manufacturing sector :
  - 33 % drop in employment (2000-2011) (Baily and Bosworth, 2014)
  - Recent rise of exports
  - 6% increase in exports due to the gas price gap ( IMF, 2014)
  - Gas intensive industries : 8,7% of total manufacturing sectors in term of GDP (Spencer et al, 2014)

# Endogenous resource production within the Imacsim-R framework

# The IMACLIM-R model

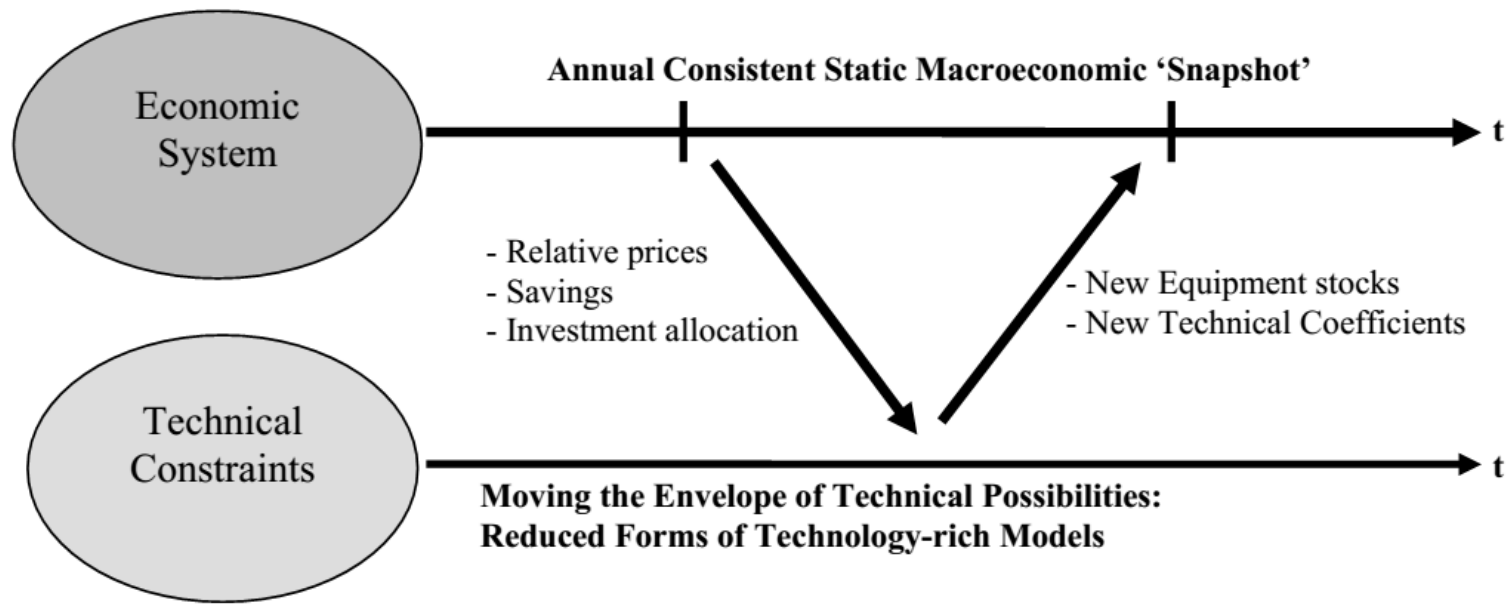


Figure 1 : Iterative Top-down / Bottom-Up dialogue in IMACLIM-R

# The oil module :

## geological constraints & producers' decisions

- Resource : 12 oil categories (conventional and unconventional)
  - **Maximum rate of increase of production** capacity for each category, given geological constraints, depending on :
    - Endogenous remaining reserves
    - breakeven price (exploration/exploitation and accessibility)
    - steepness of the bell-shape profile reflecting a geological constraint (Rehrl and Friedrich 2006)
  - Light tight oil : exogenous trajectory from (EIA, 2015), if profitable
  
- Producers' behavior
  - All regions except Middle-East = “Fatal producers”
    - Maximum deployment if profitable
  - Middle-East = “Swing producers”
    - Fill the gap between demand and other suppliers
    - World price depends on the utilization rate of production capacities
    - Deployment of production capacities in function of their price objective



# Modeling monopolistic behaviors of oil markets

Waisman et al. (2012) studies two Middle East stylized strategies as a tradeoff between short-term costs and long-term benefits :

*(Peak oil profiles through the lens of a general equilibrium assessment, Energy Policy)*

Market Flooding strategy :

- ME expands production capacities to maintain oil price low

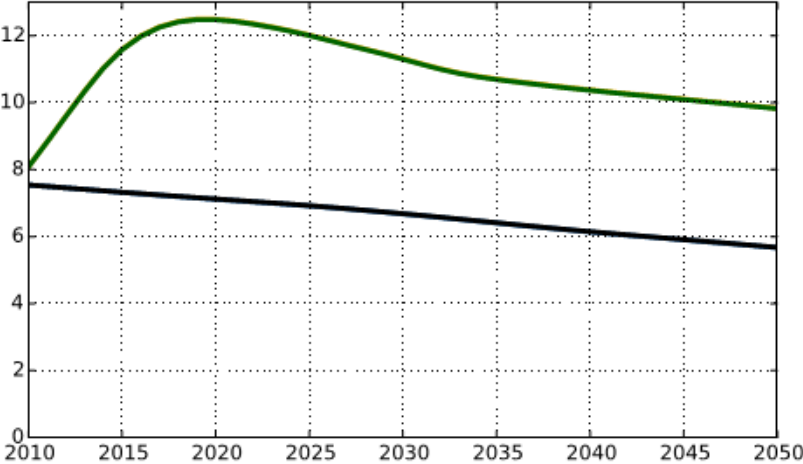
Limited Deployment strategy :

- ME restricts capacity expansion to maximize short-term rents

○ In this exercise

- Middle East turns to *Market Flooding* strategy when the US produces light tight Oil

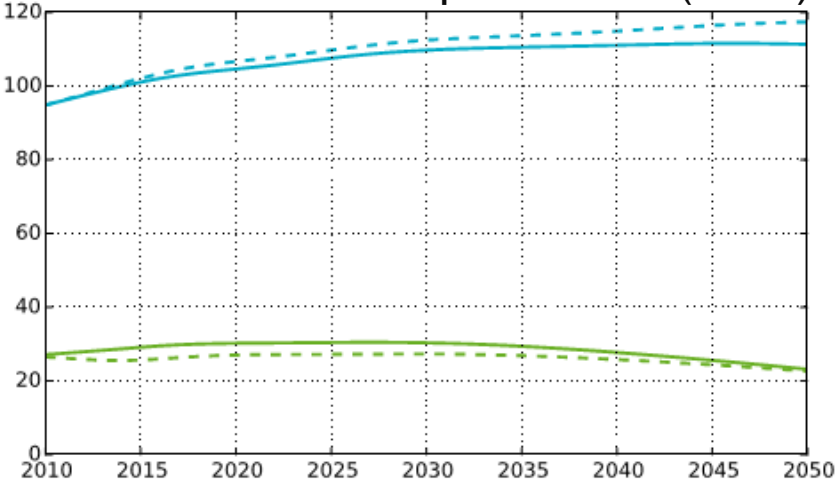
# Oil production profiles of the model



- (ii) US shale gas
- (iii) US LToil
- (iv) US shale gas and LToil
- (i) No US unconv. production

USA conv. and Light tight oil (bbl/d)

World and MDE oil production (bbl/d)



- World oil prod - no Ito
- - World oil prod - with Ito
- OPEC oil prod - no Ito
- - OPEC oil prod - with Ito

# The impacts on US GDP

Four scenarios :

- (i) A reference : No unconventional production
- (ii) US Shale case only
- (iii) US Light tight oil only
- (iv) US Shale gas and light tight oil

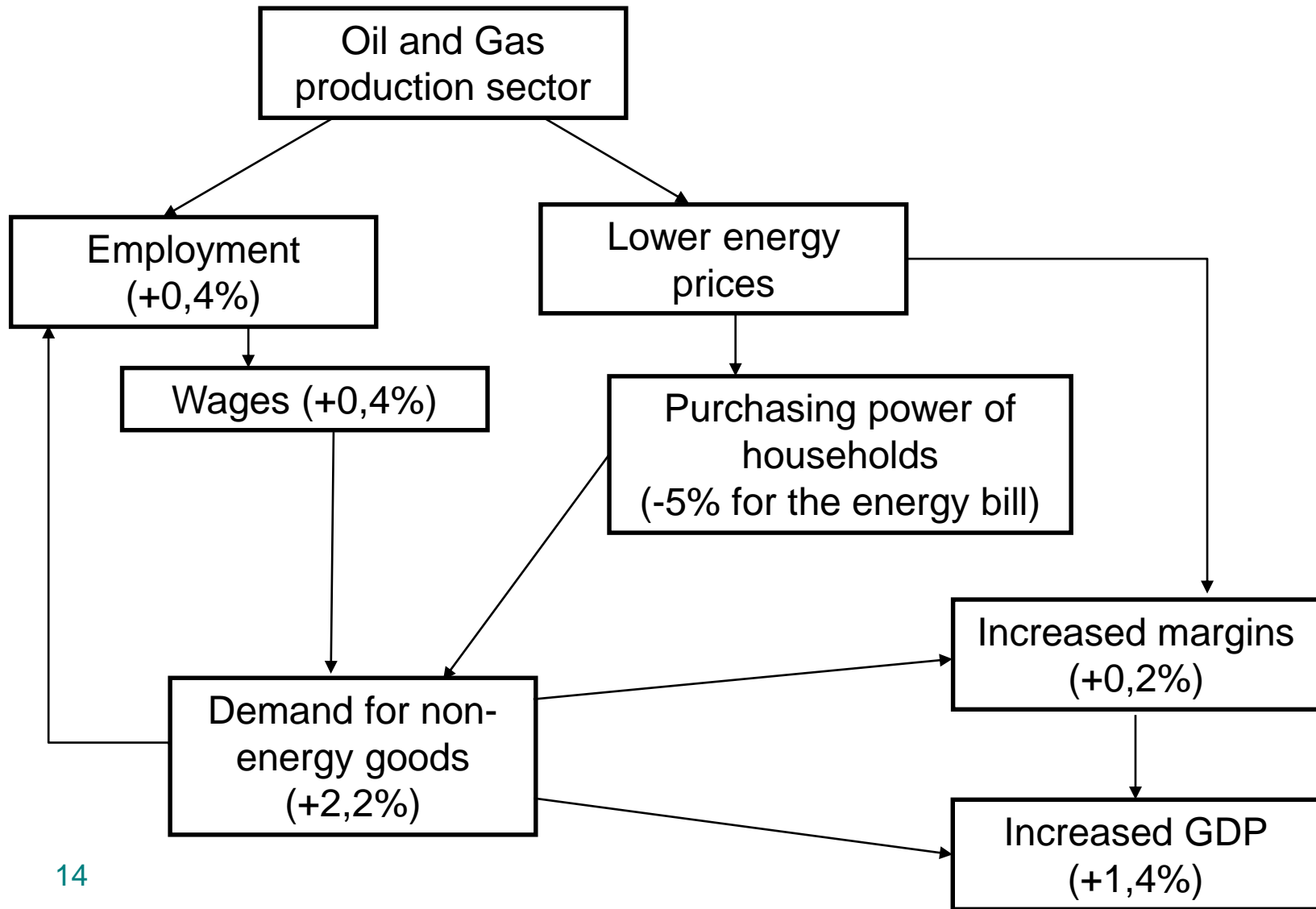
# Main results

- GDP in 2050 :
  - 1 % (shale gas), 0.7% (Lto), 1.7% (both)
- Similar studies
  - 1.5% GDP increase for of both resources production (Hunt et al., 2015)
  - 0.84% GDP increase for shale gas only (Spencer et al., 2014)
- Energy account for 5,4% in US GDP (2050), this share increase by 11.8% because of unconv. resource production :
  - > The direct effect of the energy boom accounts for a third of the 1.7% increase
- Indirect mechanisms :
  - +1% increase of investments
  - +1.9% of households and public expenditures
  - -0.2% decrease of exports
    - -1.5% of non-energy exports in the medium-term (2030)

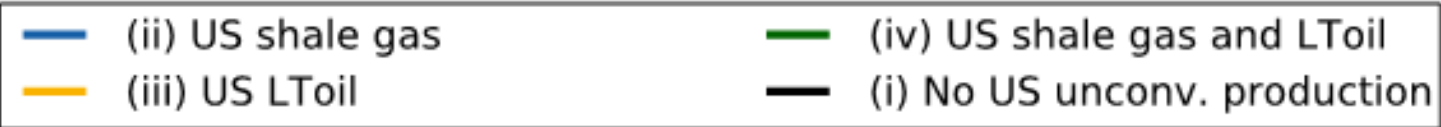
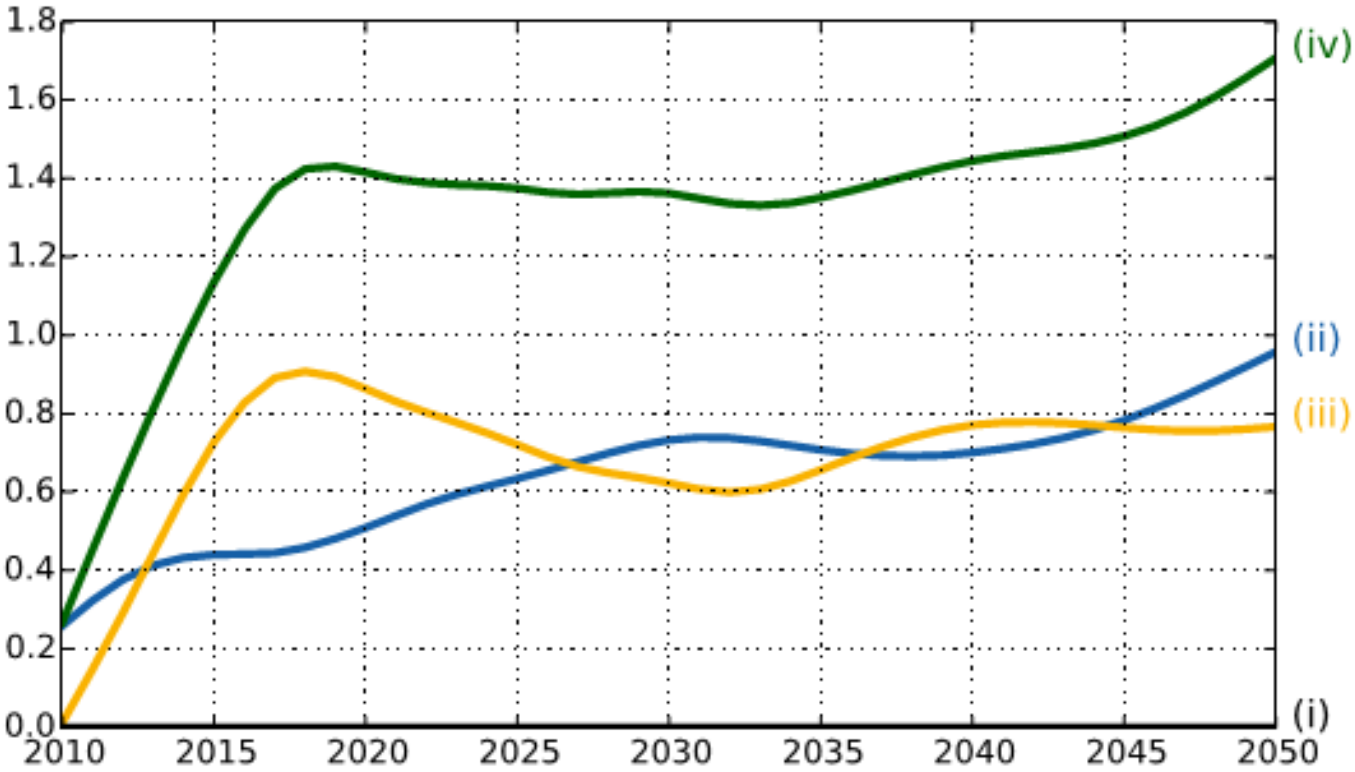
# The medium-term (2030) effect on exports

- Term of trade increase
  - +0.5% for energy intensive industries' production costs relatively to world prices
  - +1.1% for non-energy intensive industries' production costs relatively to world prices
- Despite lower energy costs
  - -3% for electricity, -8% for gas
- Because of higher wages (+4%) : unemployment reduced in a more domestic-oriented economy
- Non-energy exports decrease (52% share for energy intensive industries, 26% for non-energy intensive industries)
  - More than offset the rise of energy exports

# GDP : two main general equilibrium channels (2030 – sc (iv) )



# Sudden GDP increase, offset in the medium-term by depletion and lock-ins



US GDP (PPP real) – in %

# Competitiveness implications and global strategic choices of the US economy

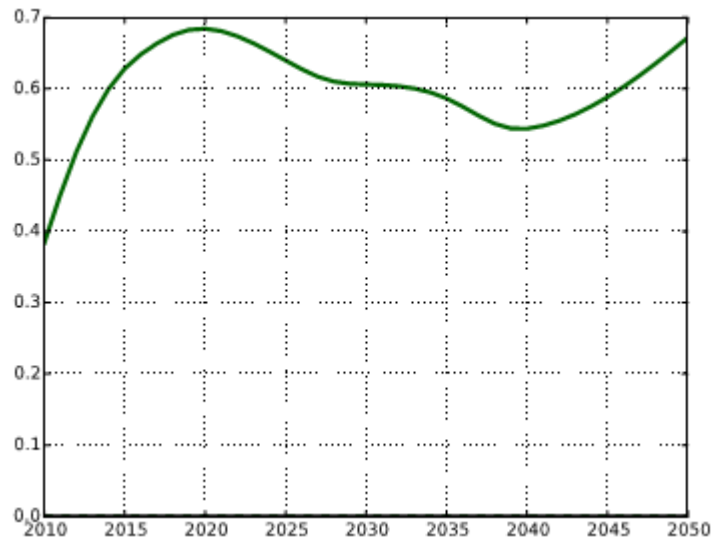


# Conditions upon two strategical policies

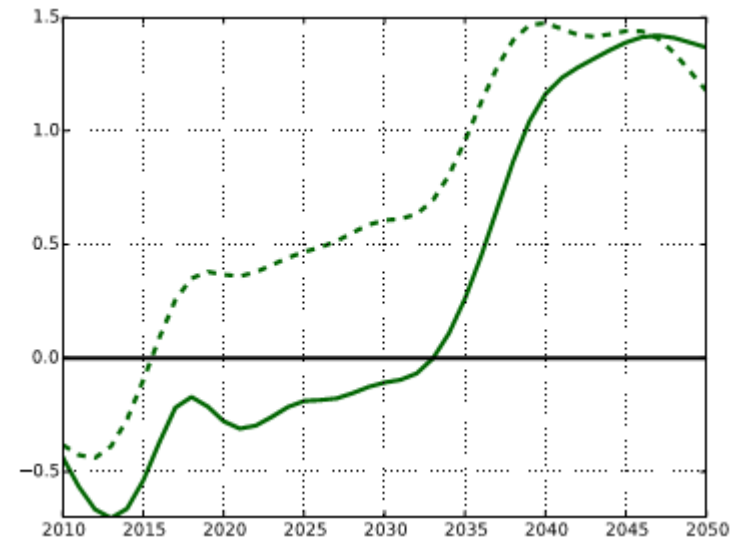
- A more inwards-oriented strategy :
  - No “currency” policy
  - Better terms of trade allows for raising wages and purchasing power
  - Penalizes export-oriented sectors
  - BUT benefits the other sectors
  - At the expense of non-energy goods exports
- An export-oriented strategy :
  - Towards a monetary policy supporting the law exchange rate value of the US \$
  - It benefits export-oriented activities
  - BUT penalizes domestic-oriented activities

# The impact on competitiveness

Real exchange rate - %.



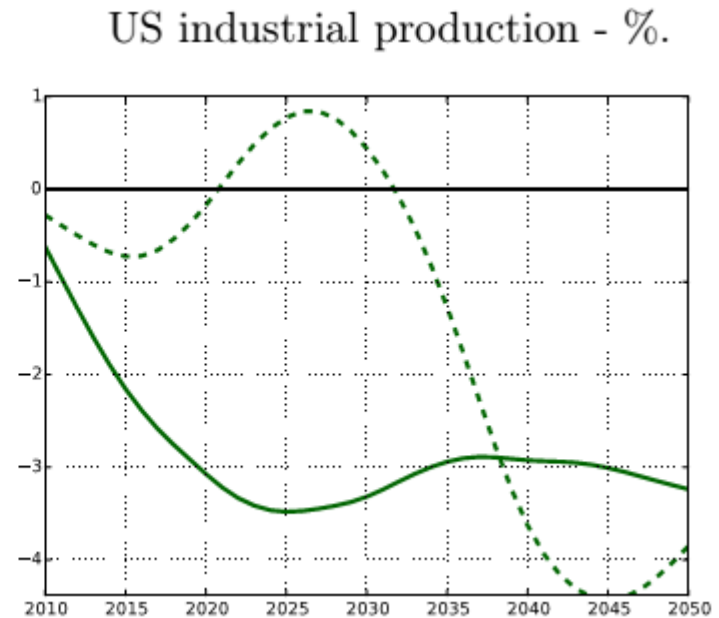
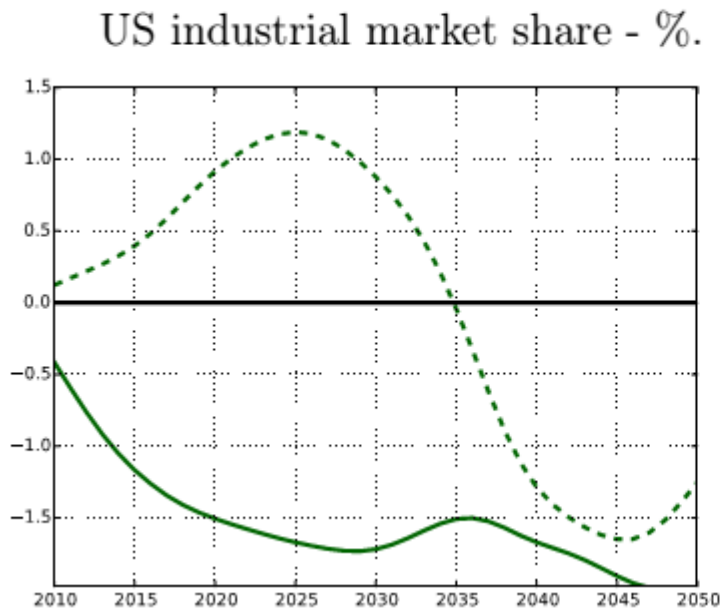
US industrial exports - %.



- - (iv) US shale gas and LToil - export-oriented
- (i) Reference : No unconv
- (iv) US shale gas and LToil - domestic-oriented

- Inwards-oriented strategy :
  - At the expense of non-energy goods exports in the medium term
- Export-oriented strategy :
  - Possibly raise energy-intensive industrial exports in the medium-term, because of unchanged terms of trade

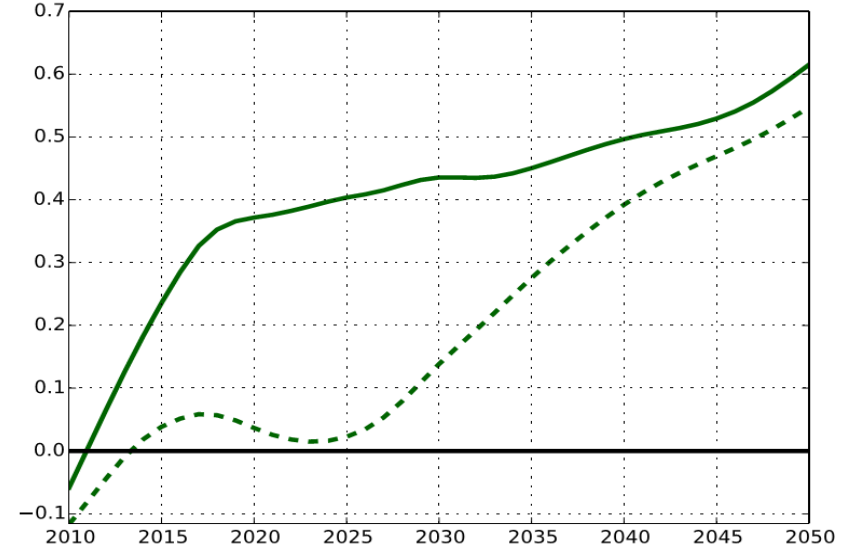
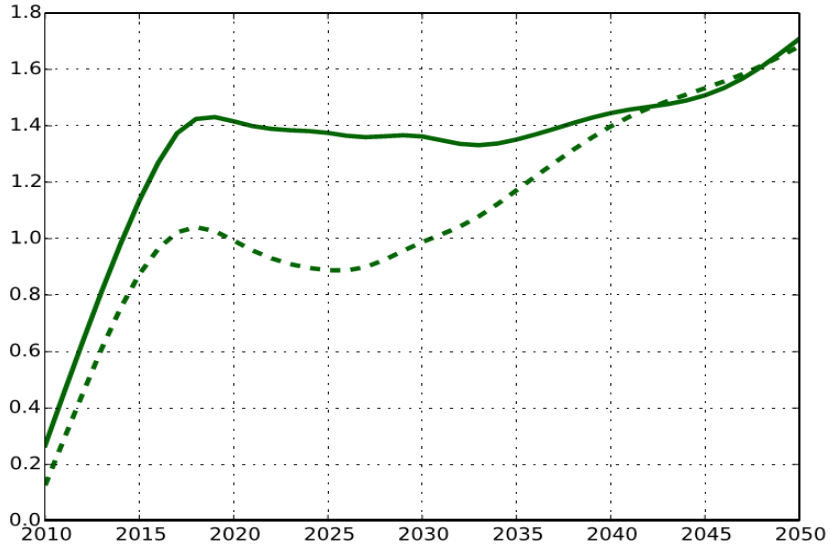
# The impact on competitiveness



--- (iv) US shale gas and LTOil - export-oriented      — (i) Reference : No unconv  
— (iv) US shale gas and LTOil - domestic-oriented

- Export-oriented strategy :
  - Increased market shares in the short-term
  - But still a decrease of total non-energy goods production
    - > wages still increase in the long-run, favoring imports

# The second strategy partially offset the positive effects on GDP and employment



- - (iv) US shale gas and LToil - export-oriented
- (i) Reference : No unconv
- (iv) US shale gas and LToil - domestic-oriented

- Export-oriented strategy :
  - Lower GDP increase and employment :
    - Constraints terms of trade partially offset the purchasing power increase of households in terms of final goods

# Conclusions

- We assess the GDP impact of US unconventional resource production
  - +1.7% US GDP increase in 2050
  - Long-term positive effect because of increase resource availability
  - But with an adverse effect due to partial lock-ins (higher energy content) in the medium-run
- The competitiveness effect depends on strategic choices of the US :
  - Main parameters :
    - Relative share of labor and energy costs in production costs
    - Households preferences for imported goods, Share of imported goods in production inputs
- Next step : the case of Europe, China ?
  - > the competitiveness implications of shale gas depends upon the strategic relations of those regions in response of US policy choices

# Thank you for your attention !

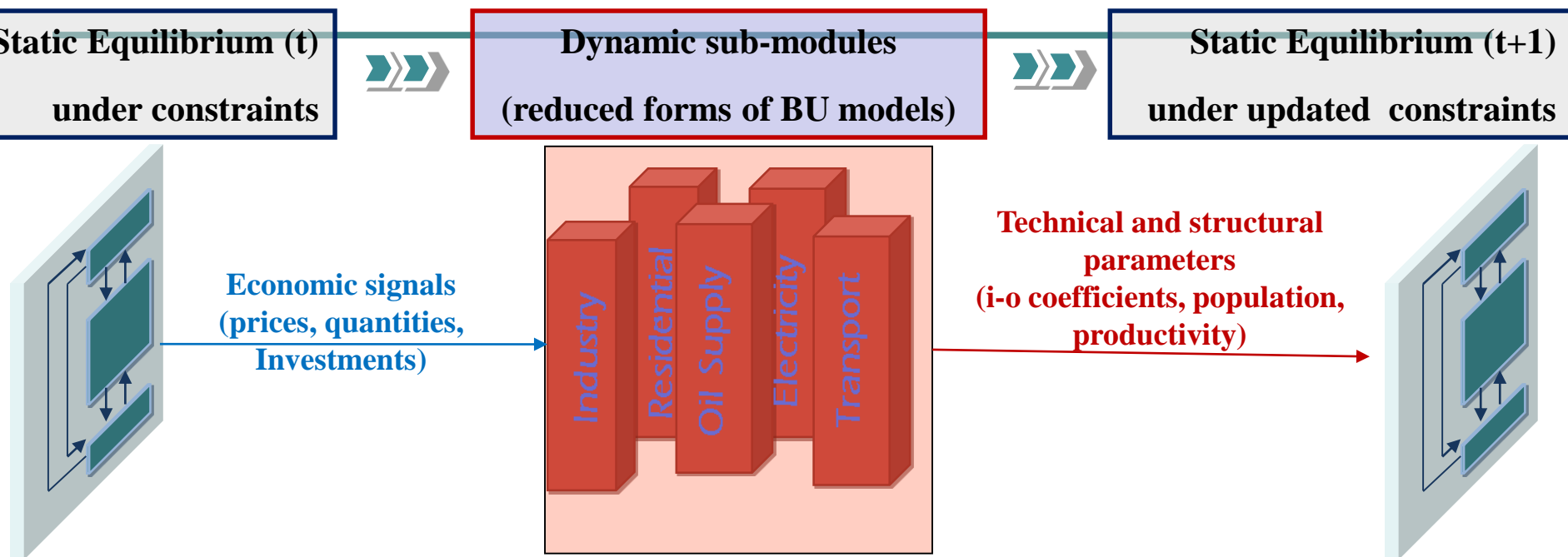
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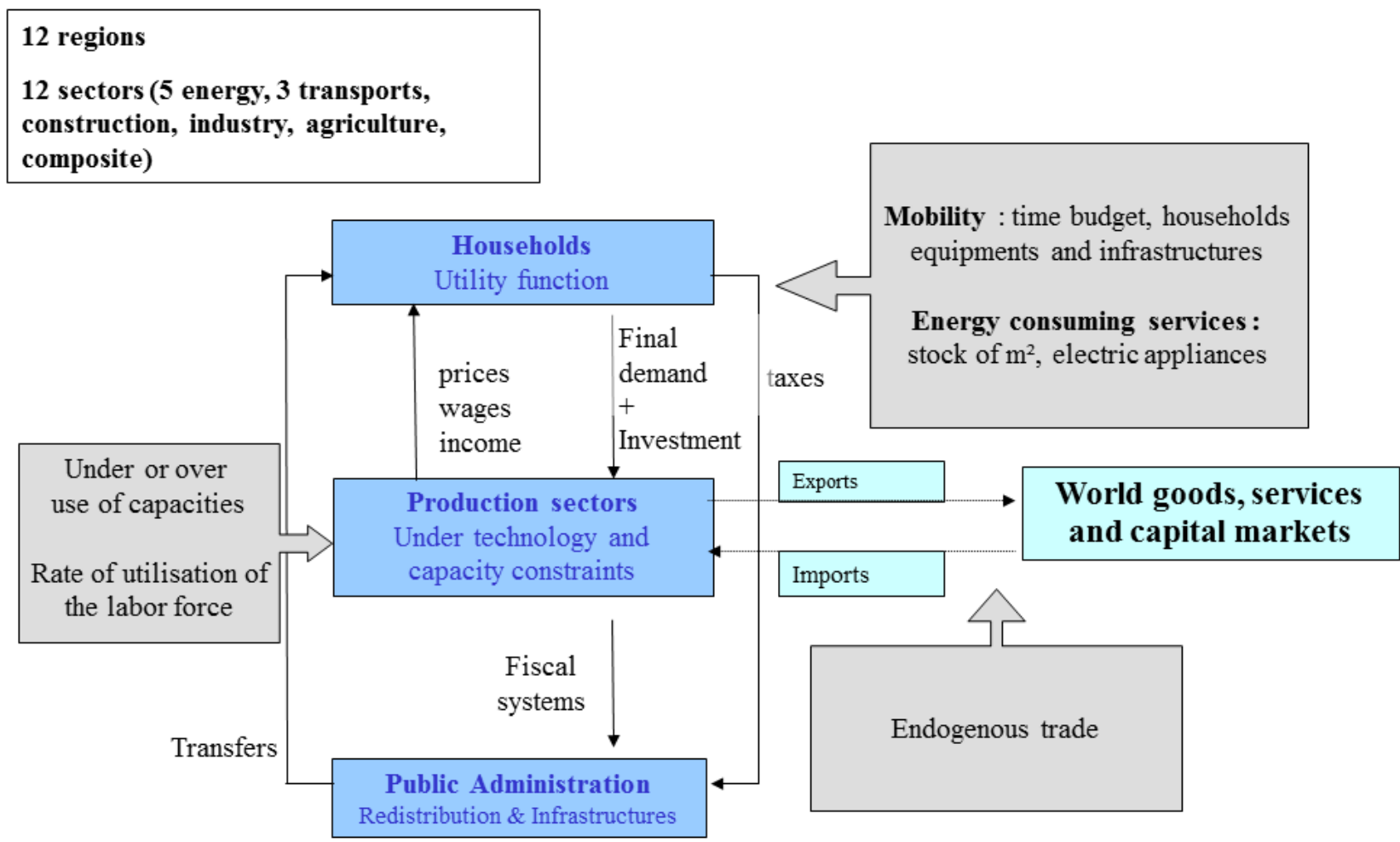
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# The IMACLIM-R model - dynamic



- *Hybrid matrices in values, energy and « physical » content (Mtoe, pkm)*
  - Secure the consistency of the engineering-based and economic analyses
  - Explicit accounting of inertias on equipment stocks
  - Endogenous and exogenous TC, technical asymptotes, basic needs
- *Solowian growth engine in the long run but transitory disequilibrium*
  - Unemployment, excess capacities
  - Investments under imperfect foresight (informed by sectoral models)
  - Trade and capital flows under exogenous assumption about debts

# The IMACLIM-R model – static equilibrium





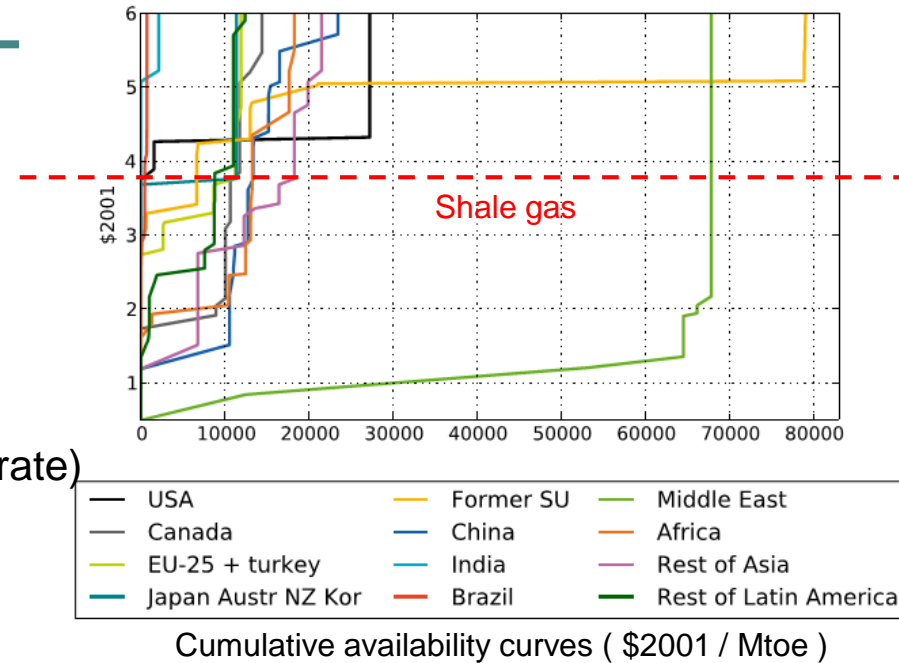
# Final energy and demand - fuel

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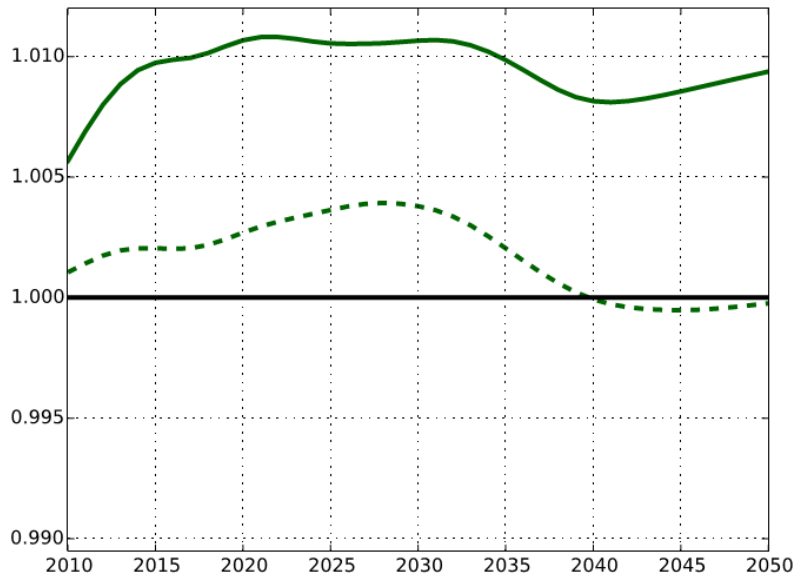
- Alternatives to oil
  - Biofuels
    - Competition over oil-based fuels: supply curves increasing with oil price
    - Asymptotes on BF production at a given year (competition of land uses)
    - Evolve in time to represent induced technical progress
  - Coal-To-Liquid
    - backstop technology with capacity constraints
    - enter the market at high oil price
    - production costs governed by the cumulated past investments
  
- Demand for liquid fuels (residential, industry, transport)
  - Utility and profit maximization under constraints
    - Short-term : inertia in the renewal of equipments and LBD
    - Long-term : consumption styles (preferences), technical potentials (technology availability, asymptotes), location patterns

# The gas module

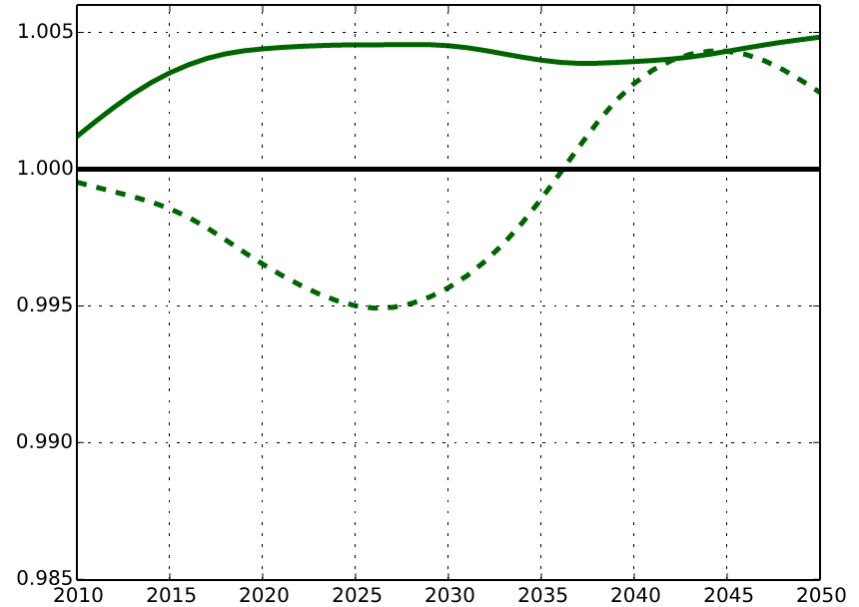
- Supply curve for conventional gas
- A single breakeven price for shale gas
- International market shares depends on :
  - Profitability (breakeven price, utilization rate)
  - Available reserves (R/P ratio rule)
- Production prices driven by
  - Local production costs
  - A profit margin elastic to the demand increase



# Terms of trade



Non-energy intensive industries' production costs relatively to world prices



Energy intensive industries' production costs relatively to world prices