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

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The competitiveness question

- Countries supposedly rich in shale gas (Europe, China) 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 ?

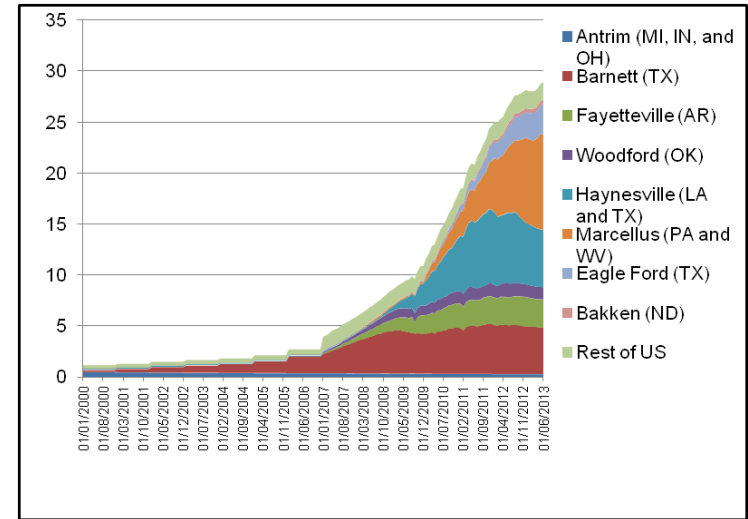
Outlines

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

The unconventional boom

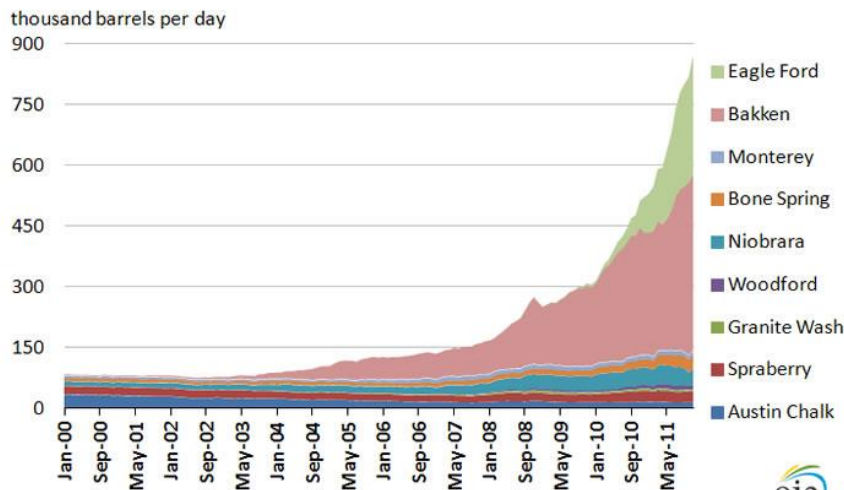
Shale gas

- 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 is 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

- 33 % drop in employment (2000-2011) (Baily and Bosworth, 2014) in the manufacturing sector
- The competitiveness effect :
 - 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)
- Early studies find a positive impact on local income/employment :
 - Shale gas : 600 000 jobs in 2010,1.6 million for 2035, (IHS, 2011).
 - Locally, shale gas has a modest positive impact on jobs (Weber, 2012; Paredes et al., 2015), confornting (Kinnaman, 2011) : “overstated early studies”.
- 5 ▪ Shale gas and LTO : +0.4 % in 2012 (Fetzer 2014)

Endogenous resource production within the Imacsim-R framework

The IMACLIM-R model

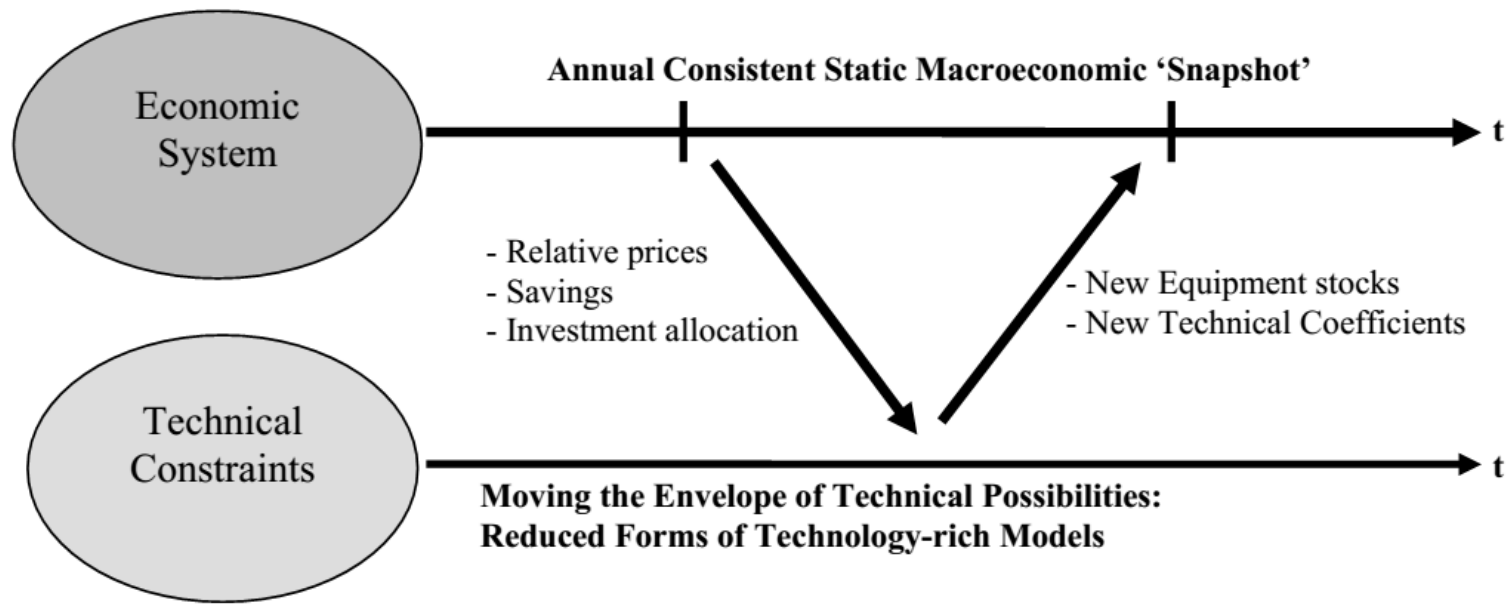


Figure 1 : Iterative Top-down / Bottom-Up dialogue in IMACLIM-R

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

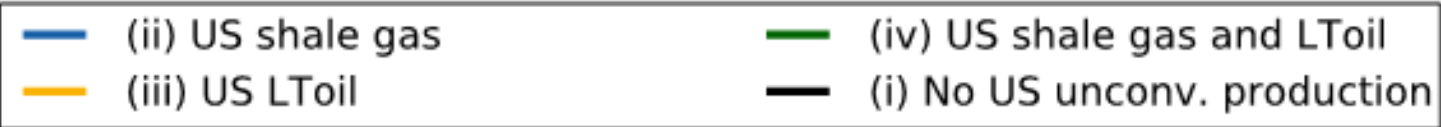
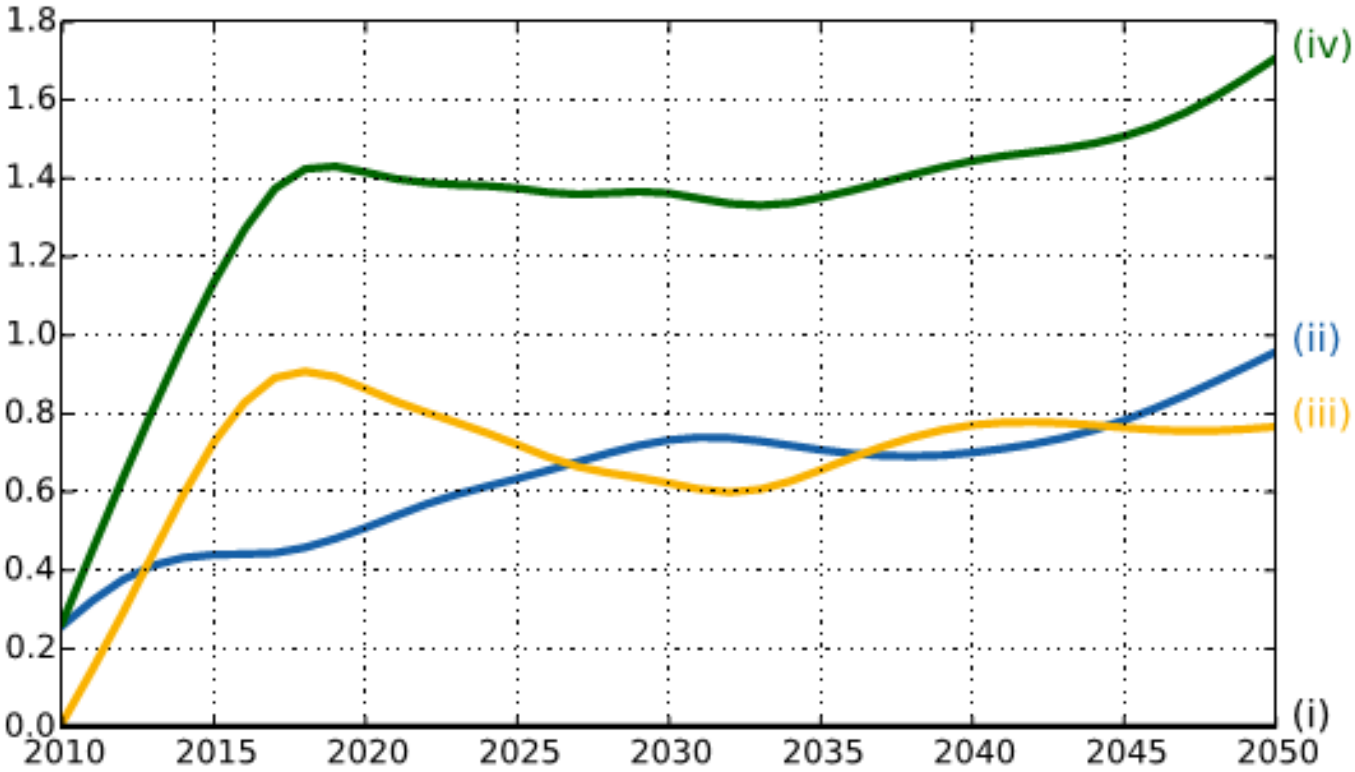
- Middle East turns to *Market Flooding* strategy when the US produces light tight Oil

The macroeconomic impacts

Four scenarios :

- (i) A reference : No unconventional production
- (iv) US Shale gas and light tight oil

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

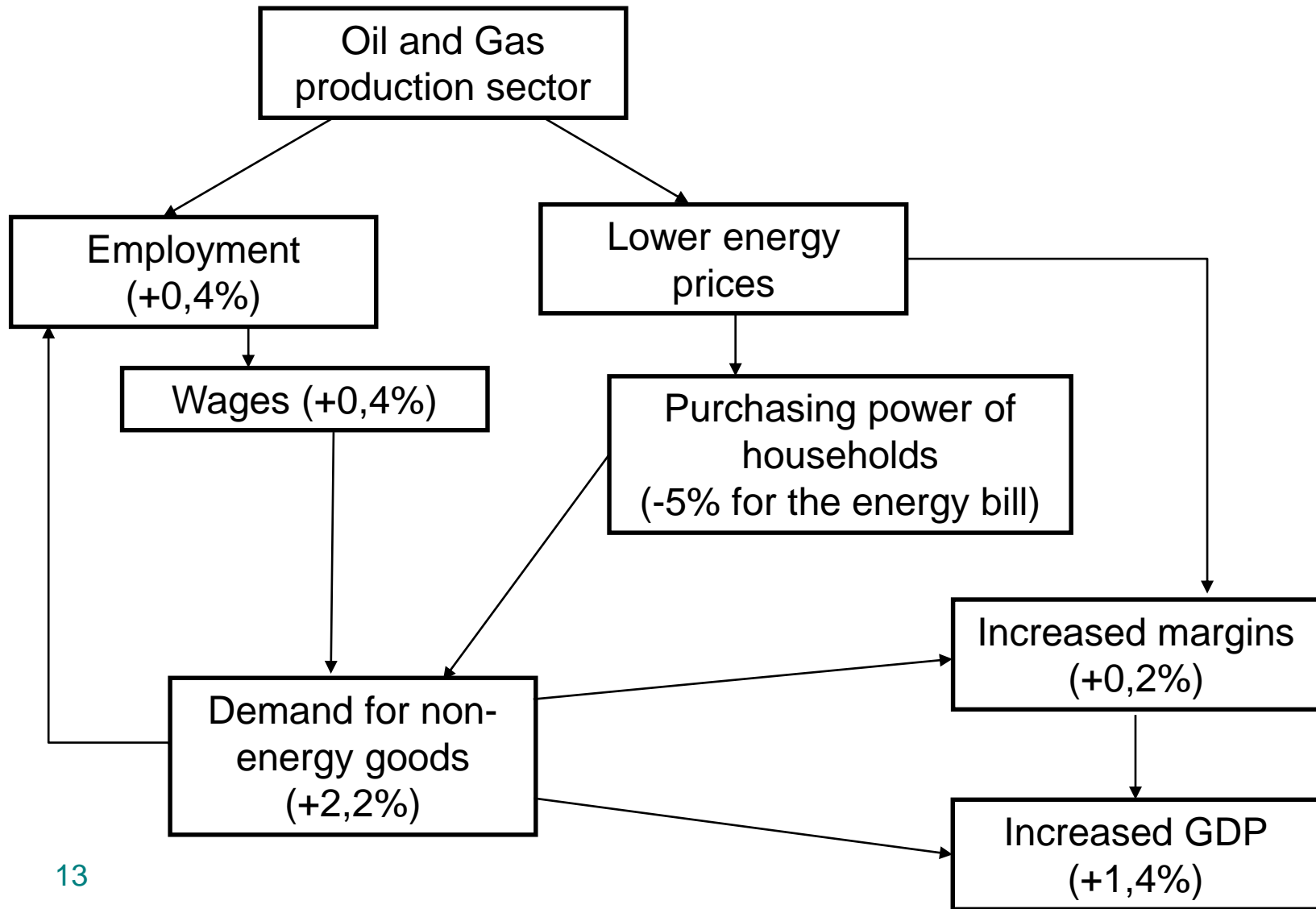


US GDP (PPP real) – in %

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)
- The value added of energy sectors is increased by 11.8% in 2050, and account for for 5.4% of the US GDP :
 - > The direct effect of the energy boom accounts for 1/3 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)

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



The effect on exports in medium-term (2030)

- For identical trade deficits trajectories, 2 strategies to increase PP :
 - Conserve competitiveness gains with unchanged wages
 - Increase wages and shrink the surplus of non-energy goods production
- In the model, higher wages (+4%) despite lower energy costs (-3% for electricity, -8% for gas)
 - Unemployment reduced in a more domestic-oriented economy :
 - Non-energy intensive industries and services : more labor intensive
- 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
- Non-energy exports decrease (52% share for energy intensive industries, 26% for non-energy intensive industries)
 - More than offset the rise of energy exports
 - Over compensated by GDP growth

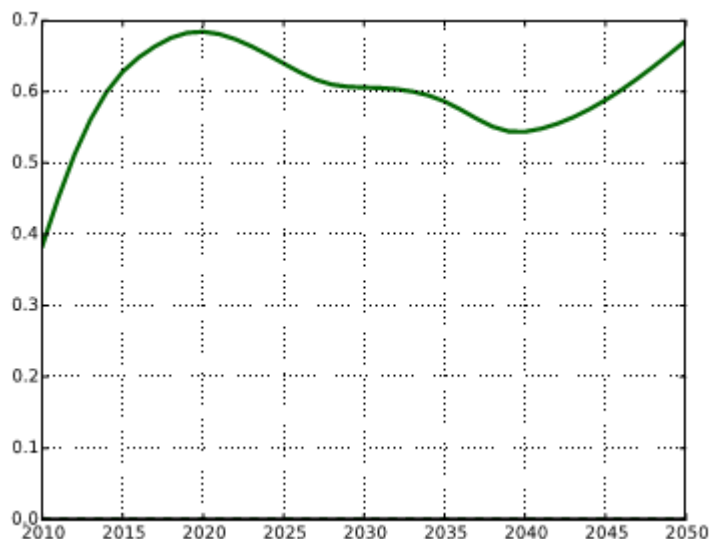
Competitiveness and the global strategic choices of the US economy

Conditions upon two strategical policies

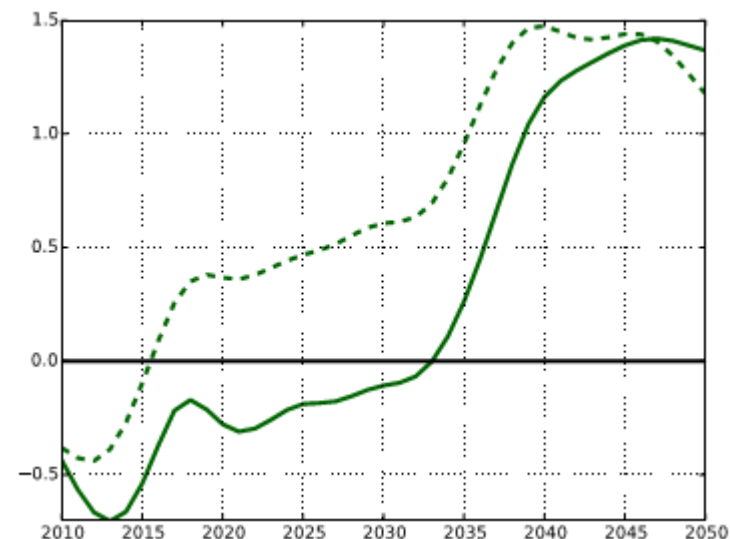
- A more inwards-oriented strategy :
 - No “currency” policy, constant current account deficit
 - Better terms of trade allows for raising wages and purchasing power
 - Penalizes export-oriented sectors
 - BUT benefits the other sectors
- An export-oriented strategy :
 - Towards a monetary policy supporting the low exchange rate value of the US \$
 - It benefits export-oriented activities
 - BUT penalizes domestic-oriented activities

The impact on competitiveness

Real exchange rate - %.



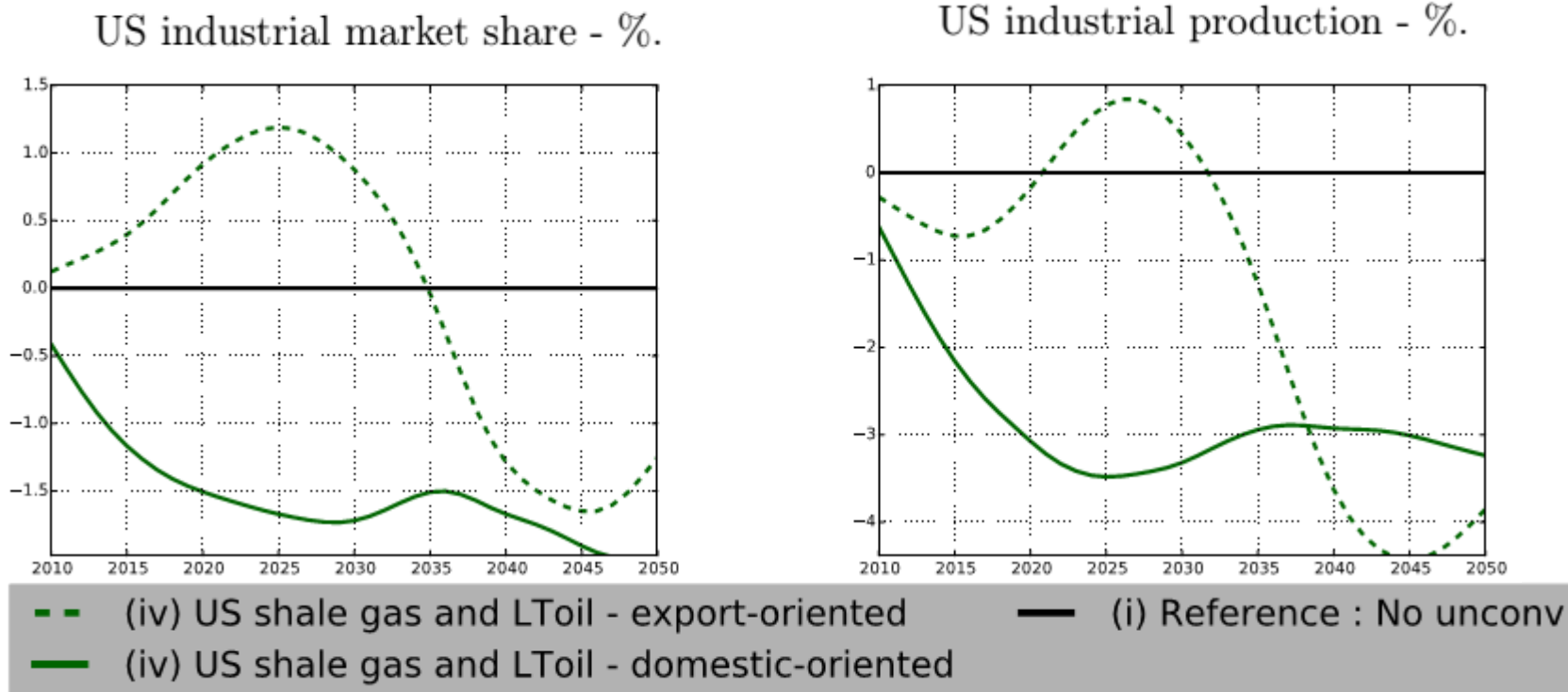
US industrial exports - %.



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

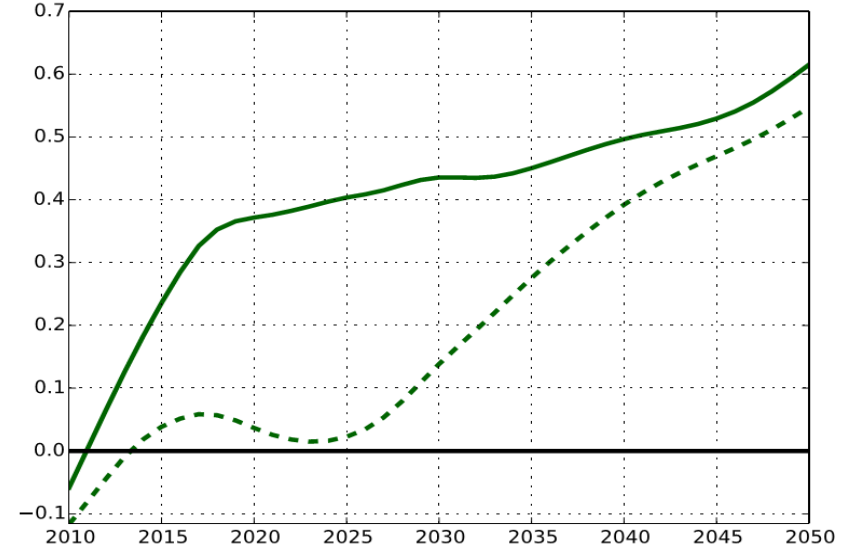
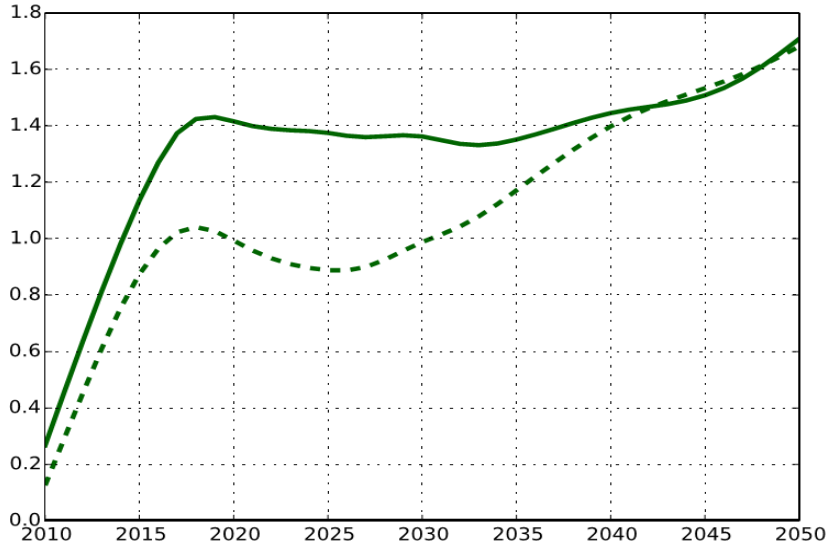
- Inwards-oriented strategy :
 - At the expense of non-energy goods exports in the medium term
- Export-oriented strategy :
 - Possibly raise energy-intensive industrial exports in the medium-term, because of unchanged terms of trade

The impact on competitiveness



- Export-oriented strategy :
 - Increased market shares in the short-term
 - But still a decrease of total energy intensive 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
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- Export-oriented strategy :
 - Adverse effect on the GDP and employment increase :
 - Constraints terms of trade and raised interest rates partially offset the purchasing power increase of households in terms of final goods
 - Reduced current account shrink investments

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
 - Wage elasticity to employment
 - Households preferences for imported goods
 - Households preferences for non-energy intensive goods
- 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

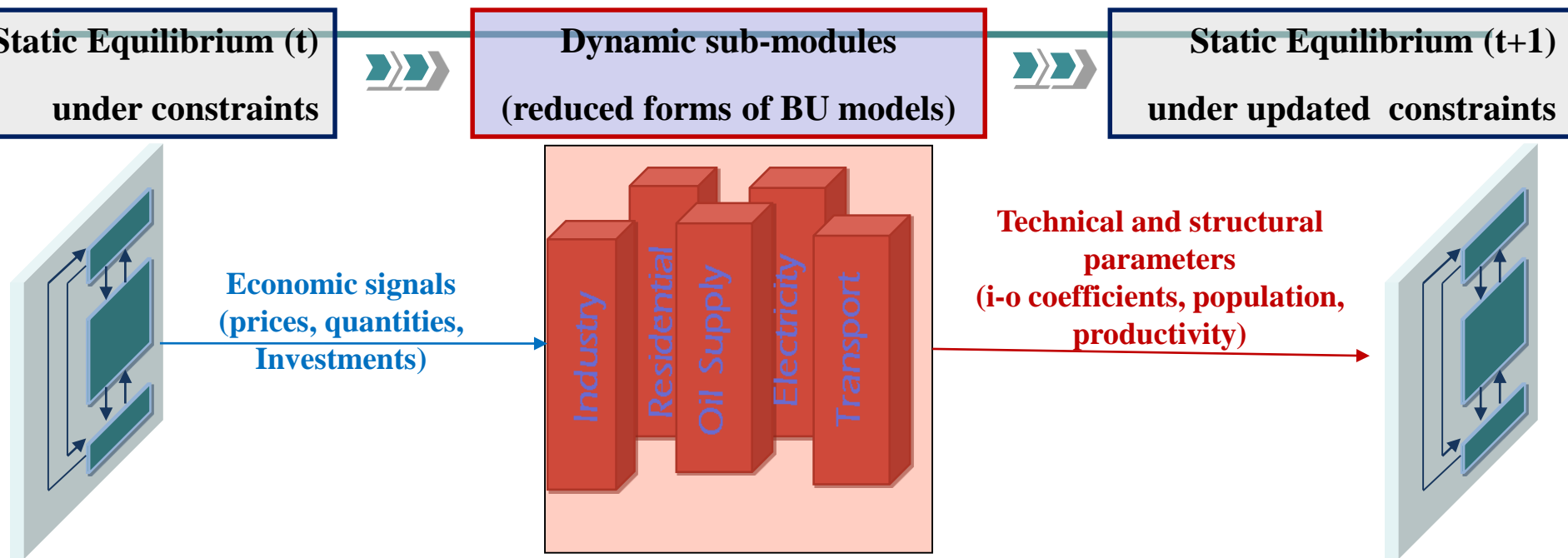
Thank you for your attention !

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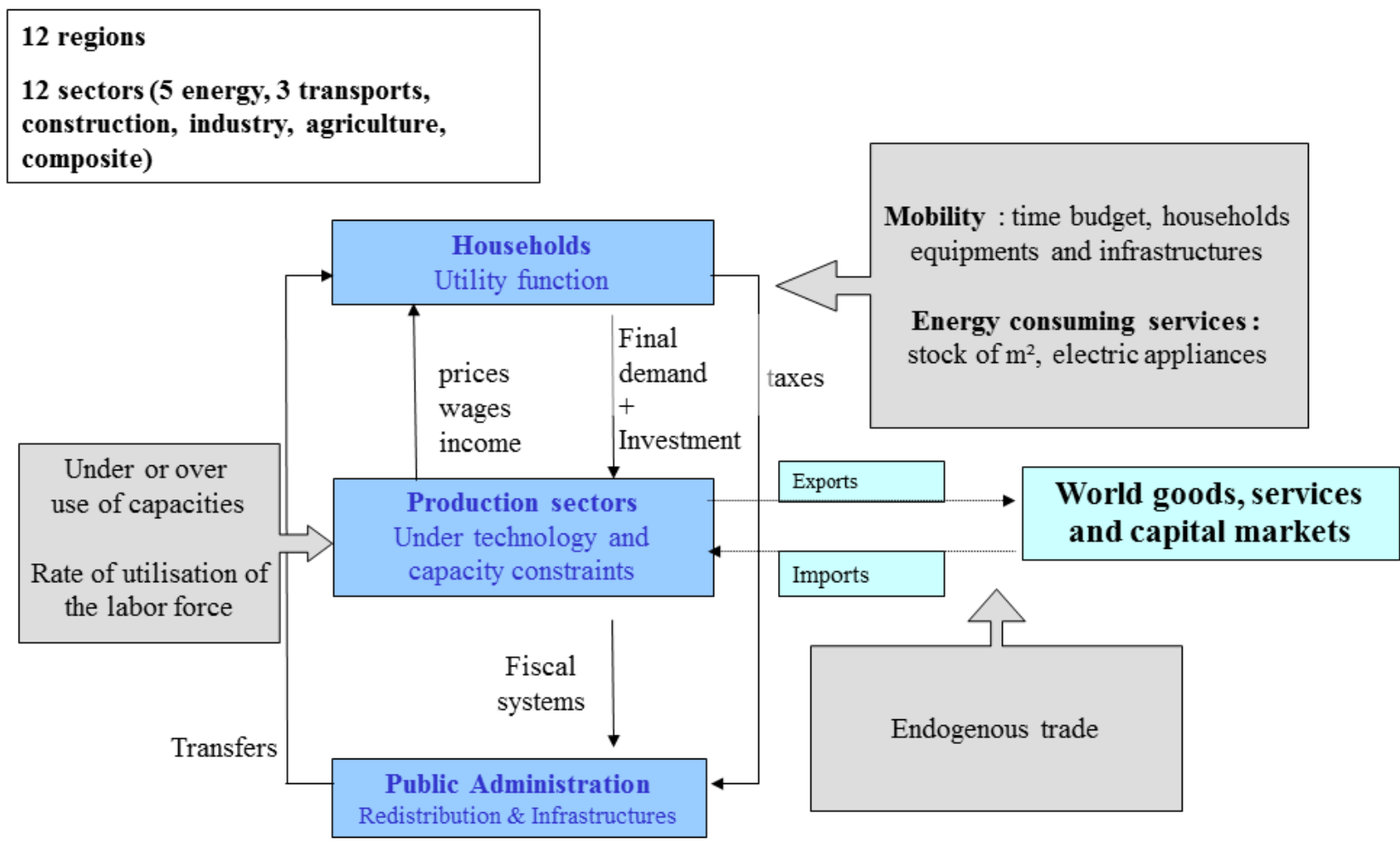
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The IMACLIM-R model - dynamic



- *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



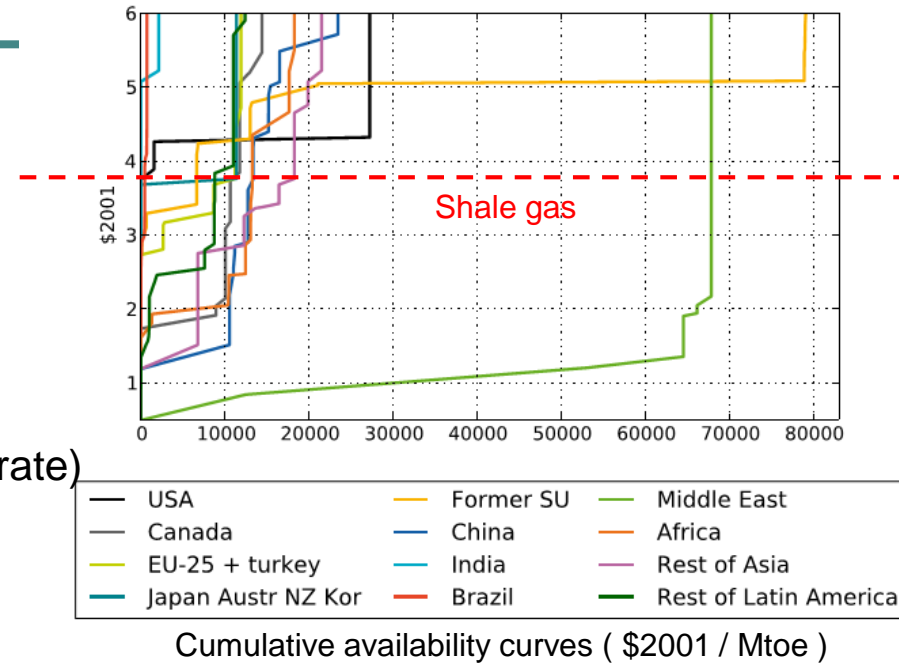
Final energy and demand - fuel

- 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

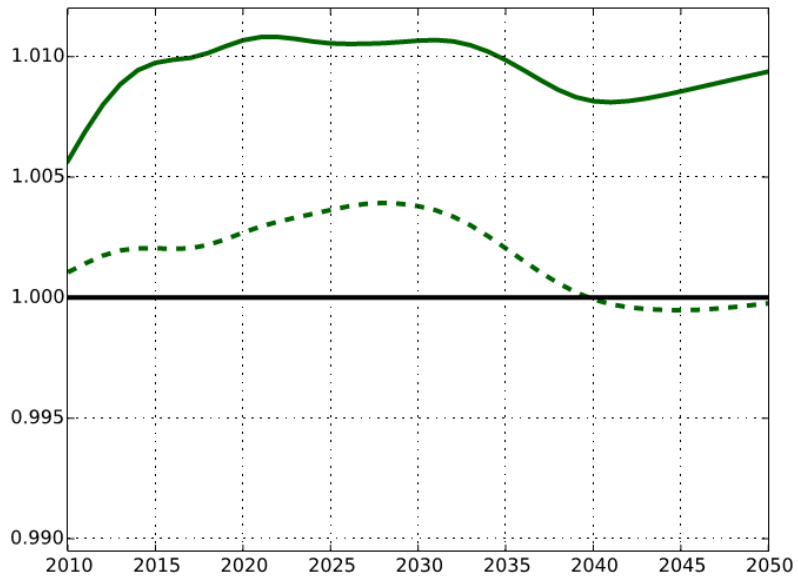
- Demand for liquid fuels (residential, industry, transport)
 - Utility and profit maximization under constraints
 - Short-term : inertia in the renewal of equipments and LBD
 - Long-term : consumption styles (preferences), technical potentials (technology availability, asymptotes), location patterns

The gas module

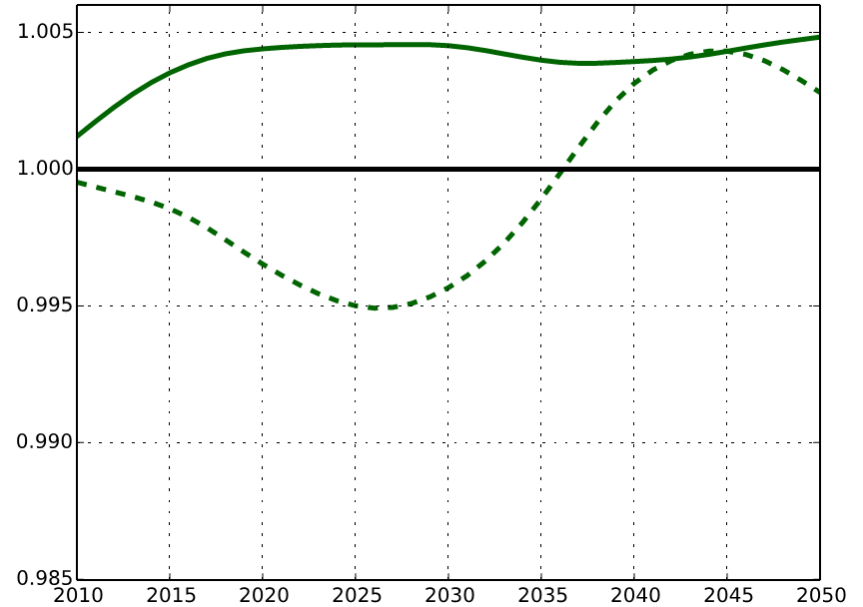
- Supply curve for conventional gas
- A single breakeven price for shale gas
- International market shares depends on :
 - Profitability (breakeven price, utilization rate)
 - Available reserves (R/P ratio rule)
- Production prices driven by
 - Local production costs
 - A profit margin elastic to the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



Terms of trade



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



Energy intensive industries' production costs relatively to world prices