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)

**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 Imaclim-R framework
The IMACLIM-R model

Economic System

Annual Consistent Static Macroeconomic ‘Snapshot’

- Relative prices
- Savings
- Investment allocation

Technical Constraints

Moving the Envelope of Technical Possibilities:
Reduced Forms of Technology-rich Models

- New Equipment stocks
- New Technical Coefficients

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

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

World and MDE oil production (bbl/d)
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 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))

1. Oil and Gas production sector
   - Employment (+0.4%)
     - Wages (+0.4%)
       - Demand for non-energy goods (+2.2%)
   - Lower energy prices
     - Purchasing power of households (-5% for the energy bill)
       - Increased margins (+0.2%)
         - Increased GDP (+1.4%)
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

- 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 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

- 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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The IMACLIM-R model - dynamic

- **Static Equilibrium** (t) under constraints
- **Dynamic sub-modules** (reduced forms of BU models)
- **Static Equilibrium** (t+1) under updated constraints

- Economic signals (prices, quantities, Investments)
- Technical and structural parameters (i-o coefficients, population, productivity)

- **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

12 regions
12 sectors (5 energy, 3 transports, construction, industry, agriculture, composite)

Households
Utility function
- prices
- wages
- income
- Final demand + Investment

Production sectors
Under technology and capacity constraints

Public Administration
Redistribution & Infrastructures

Mobility: time budget, households equipments and infrastructures
Energy consuming services: stock of m², electric appliances

World goods, services and capital markets

Exports
Imports

Endogenous trade

Under or over use of capacities
Rate of utilisation of the labor force

Transfers
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