Trade sanctions & international spatial integration:
What is the impact of sanctioning Iran?

Olivier MASSOL   Emmanuel HACHE   Albert BANAL-ESTAÑOL

FOREWORD

**IFP School**
A French “Grande Ecole” based in Paris
A graduate school of engineering
nested into IFP Energies Nouvelles
A national research & innovation center focused on energy and transportation technologies

**Energy Economics at IFP School**
The Center for Energy Economics and Management
8 faculty members
Focused on the application of quantitative methods to examine important energy issues
SELECTED RECENT RESEARCH PROJECTS

- The economics of resource-based industrialization
- Security of supply in the natural gas industry
- Energy Demand models
- Modeling wholesale markets for energy commodities
- The economics of CCS deployment
- Circular economy: should recycling be imposed for rare earth metals
- Helium: phasing out the U.S. strategic stockpile

CHAIR: THE ECONOMICS OF NATURAL GAS

- Created in April 2016 as a joint initiative led by individual researchers at:
  - Dalhousie
  - IFP School of Economics
  - Mines ParisTech
  - DIW

- An industry-sponsored by EDF, GRTGaz, TOTAL

Motivation & ambition

- clarifying the role of gas in energy economics
  - A domain dominated (in Europe at least) by power-related questions (both in research and teaching)
- promoting research and education on topics related to the natural gas sector to:
  - bridge the gap between academia and industry/regulatory practice
  - analyze the specific features of the gas industry
  - contribute to public policy and regulatory debates

- A small and agile organization that enables projects
THE CHAIR’S ACTIVITIES

- Organize international conferences (1 every 2 years)
- Fund PhD. projects
  - Ongoing doctoral projects
    - Flexibility of the gas supply chain
    - Spatial integration of natural gas markets
    - The econometrics of natural gas demand
    - The drivers of biomethane supply
    - H₂ economics
- Promote research on selected gas issues, e.g.
  - Pipeline economics
  - Storage models
  - The use of rate of return regulation to attract infrastructure investment in LDCs.

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INTRODUCTION

- Politically-motivated trade sanctions usually generate fierce discussions
  - sanctions are decided by a small group of nations to restrict a country’s access to international trade
  - they hardly turn into complete trade blockades (i.e., an embargo)

- What are the sanctions?
  - a series of measures aimed at raising the export cost for the targeted country

- What impacts?
  - For the coerced country (e.g., macroeconomic impacts...)
  - For other countries?
    - If the coerced country is a large exporter,
      **Do the sanctions affect the degree of spatial price integration among importing nations?**

LITTERATURE

- Theoretical models
  The sanctions as a tool to obtain a change in the targeted regime’s behavior (Naghavi and Pignatoro, 2015) or in its propensity to invest in a nuclear program (Miyagiwa and Ohno, 2015).

- Historical surveys
  Lance and Engerman (2003): the historical use of sanctions and their mixed success rate

- Macroeconomics
  For example, Gharehgozli (2017) and Ghorbani Dastgerdi et al. (2018) empirically investigate the impacts on Iran’s real GDP and inflation respectively.

- Trade deflection as a response
  Bown and Crowley (2007); Haidar (2017)
1: BACKGROUND

- Iran
  - A resource-rich nation...
  - ... that can hardly monetize its natural resources

- Iran’s big push on petrochemicals
  During the 2000s, Teheran strongly encouraged the deployment of state-controlled, export-oriented, gas-based industries

<table>
<thead>
<tr>
<th>IRAN</th>
<th>1990</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>petrochemical exports revenues (MM$)</td>
<td>141.0</td>
<td>2,970.0</td>
</tr>
</tbody>
</table>

Source: U.N. Comtrade
THE 2012-2016 SANCTIONS AGAINST IRAN

  - prohibited access to
    - western-controlled shipping services (e.g., ship insurance, banking system),
    - to lines of credit for moving cargo.
    - to fuel supplies for Iranian ships.

QUESTION: were these sanctions bypassed?
- Organize a trade deflection toward non-sanctioning countries (Haidar, 2017)
- Engage in smuggling activities

BACKGROUND

- The National Petrochemical Company (NPC) is now the world's second largest producer of methanol.
  4 arguments explain the appeal of methanol processing
  1 - This is a profitable option (Massol and Banal-Estañol, 2014)
  2 - Compared to LNG, MeOH processing is less capital intensive and involves simpler processing technologies.
  3 – Its logistics is less vulnerable to foreign sanctions than those of natural gas.
  4 – The main markets are located in Asia.

- Absent any sanctions, the NPC is reputed to operate as a “swing supplier” (IHS, 2017)
  - It has limited downstream integration
  - It acts primarily as a merchant seller that shifts methanol to the destination markets in Asia that offer the highest netback price.
**BACKGROUND**

**Methanol**
- A basic petrochemical mainly produced from natural gas,
  - Can be converted into formaldehyde (a raw material used in particle board, plywood, paints, foams, rubbers, adhesive, coatings, resin plastic, explosives, pharmaceuticals, and pesticides), acetic acid, olefins (ethylene, propylene) or gasoline additives. In China, methanol is also consumed as a motor fuel (Su et al., 2013).
- A globally traded commodity, **traded at destination markets** (in USD/ton)
- A homogenous good (i.e., no regional variations in quality standards).

**World capacity for methanol by shareholder—2017**

**World consumption of methanol by region—1987 to 2017**

12/13/2019

2: **MODEL**
IRAN AS A SWING SUPPLIER

We consider $M > 2$ export markets where

- the excess demand in market $i$ and in period $t$ is $q_{it} = D(P_{it})$.
- $s^k_{it}$ is the quantity shipped to market $i$ by producer $k$.

Assuming perfect competition, the producer’s behavior is

$$\max_{s^k_{it}} \Pi_k(s^k_{it}) = \sum_{t=1}^{T} P_{it} s^k_{it} - C_k \left( \sum_{t=1}^{T} s^k_{it} \right) - \sum_{t=1}^{T} \tau_{it} s^k_{it}$$

s.t.

$$\sum_{t=1}^{T} s^k_{it} \leq K_k \quad (\gamma_k)$$

A SWING SUPPLIER

- We derive the F.O.C. of optimality for two markets $i$ & $j$.
- If producer $k$ serves these two markets:

$$\begin{align*}
P_i - MC_i - \tau^i - \gamma_i &= 0 \\ P_j - MC_j - \tau^j - \gamma_j &= 0
\end{align*}$$

and thus

$$P_i - P_j = \tau^i - \tau^j$$

The behavior of the swing supplier contributes to the economic integration of the two markets.

The local prices are said to verify

Marshall’s Law Of One Price (LOOP)
3: AN EMPIRICAL APPROACH

METHODOLOGY: A PBM APPROACH

A Parity Bounds Model (PBM):
- Arbitrageurs assumed to be profit-maximizing
- Spreads examined with “switching regime” specification, estimating probability of observing each of a series of trade regimes

Sexton et al. (1991) considers three regimes:

(I) “arbitrage”: \( P_{it} - P_{jt} - T_i - T_j = 0 \)

(II) “outside the parity bounds”: \( P_{it} - P_{jt} - T_i - T_j > 0 \)

(III) “inside the parity bounds”: \( P_{it} - P_{jt} - T_i - T_j < 0 \)
**METHODOLOGY: A STANDARD PBM**

If one models the arbitrage cost as: \( T_i = \alpha + Z_i \beta + \epsilon_i \) with \( \epsilon_i \sim N(0, \sigma_\epsilon^2) \)

The PBM to be estimated is:

- **Regime I:** \( P_s - P_{m} = \alpha + Z_i \beta + \epsilon_i \),
- **Regime II:** \( P_s - P_{m} = \alpha + Z_i \beta + \epsilon_i + \eta_i \),
- **Regime III:** \( P_s - P_{m} = \alpha + Z_i \beta + \epsilon_i - \eta_i \),

where \( \eta_i \sim N^*(0, \sigma_\eta^2) \)

The ambition is to estimate \( \{ \lambda_i, \lambda_{T}, 1 - \lambda_i - \lambda_{T} \} \) the probabilities to observe these regimes and \( (\alpha, \beta, \sigma_\epsilon, \sigma_\eta) \) the parameters.

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**THE DENSITY FUNCTIONS**

We let \( \pi_i = P_{s} - P_{m} - \alpha - Z_i \beta \)

<table>
<thead>
<tr>
<th>Regime</th>
<th>Density Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>( f^I(\pi_i) = \frac{1}{\sigma_\epsilon} \phi \left( \frac{\pi_i}{\sigma_\epsilon} \right) )</td>
</tr>
<tr>
<td>II</td>
<td>( f^{II}(\pi_i) = \left[ \frac{2}{\sqrt{\sigma_\epsilon^2 + \sigma_\eta^2}} \right] \phi \left( \frac{\pi_i}{\sqrt{\sigma_\epsilon^2 + \sigma_\eta^2}} \right) \left[ 1 - \Phi \left( \frac{-\sigma_\epsilon \pi_i}{\sigma_\epsilon \sqrt{\sigma_\epsilon^2 + \sigma_\eta^2}} \right) \right] )</td>
</tr>
<tr>
<td>III</td>
<td>( f^{III}(\pi_i) = \left[ \frac{2}{\sqrt{\sigma_\epsilon^2 + \sigma_\eta^2}} \right] \phi \left( \frac{\pi_i}{\sqrt{\sigma_\epsilon^2 + \sigma_\eta^2}} \right) \left[ 1 - \Phi \left( \frac{\sigma_\epsilon \pi_i}{\sigma_\epsilon \sqrt{\sigma_\epsilon^2 + \sigma_\eta^2}} \right) \right] )</td>
</tr>
</tbody>
</table>

Note: Here, \( \phi \) denotes the standard normal density function, and \( \Phi \) is the standard normal cumulative distribution function. The density function of Regime I is that of a normal variable. The ones of regimes II and III are the density of the sum of a normal random variable and a truncated normal random variable derived in Weinsein (1964).
**ESTIMATION**

- The joint density function for \( \pi \) over all trading regimes is

\[
f_t(\pi) = \lambda_t f^{I'}(\pi) + \lambda_t f^{II'}(\pi) + (1 - \lambda_t) f^{III'}(\pi)
\]

**Estimation**

Max

\[
\text{Log}(L) = \sum_{t=1}^{N} \log(f_t(\pi))
\]

s.t.

- Probabilities are in [0,1]
- std. dev. >0

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**THE EXTENDED PBM**

**Negassa and Myers (2007):** the probability of being in regime \( r \) at time \( t \) is allowed to change under the sanctions:

\[
\lambda_r (1 - D_r) + \delta_r D_r
\]

The joint density function for the observation at time \( t \) is

\[
f_t(\pi) = \left[ \lambda_r (1 - D_r) + \delta_r D_r \right] f^{I'}(\pi) + \left[ \lambda_r (1 - D_r) + \delta_r D_r \right] f^{II'}(\pi) + \left[ (1 - \lambda_r) (1 - D_r) + (1 - \delta_r) D_r \right] f^{III'}(\pi)
\]
4: APPLICATION

DATA

- Monthly transaction price data for MeOH delivered in China, India, South-Korea and South-Eastern Asia (Source: Argus).
  Altogether, these countries accounted for 66% of global consumption (IHS, 2017).

Table 2. Average prices at destination (in $/ton).

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>India</th>
<th>SE Asa</th>
<th>S. Korea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire sample period</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean price</td>
<td>324.46</td>
<td>299.78</td>
<td>339.07</td>
<td>339.12</td>
</tr>
<tr>
<td>Subperiod I: before the sanctions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean price</td>
<td>309.49</td>
<td>280.13</td>
<td>303.53</td>
<td>307.88</td>
</tr>
<tr>
<td>Subperiod II: under the sanctions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean price</td>
<td>345.29</td>
<td>321.28</td>
<td>376.50</td>
<td>369.19</td>
</tr>
<tr>
<td>Variation</td>
<td>+11.6%</td>
<td>+14.7%</td>
<td>+24.0%</td>
<td>+19.9%</td>
</tr>
<tr>
<td>Subperiod III: after the sanctions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean price</td>
<td>314.19</td>
<td>294.30</td>
<td>331.10</td>
<td>335.97</td>
</tr>
<tr>
<td>Variation</td>
<td>-9.0%</td>
<td>-8.4%</td>
<td>-12.1%</td>
<td>-9.0%</td>
</tr>
</tbody>
</table>
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**THE SPATIAL PRICE SPREADS**

China SE Asia is found to be not stationary

**INSIGHTS FROM A SIMPLE PBM**

- **Step 1:** Estimation of a simple PBM with unchanged probabilities

- **Step 2:** We use the estimates to evaluate (Kiefer, 1980):

\[
\text{Proba}' = \frac{\hat{\lambda}_t f_t'(\pi_t)}{\hat{\lambda}_t f_t'(\pi_t) + \hat{\lambda}_o f_o'(\pi_t) + [1 - \hat{\lambda}_t - \hat{\lambda}_o] f_m'(\pi_t)}
\]

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26
IS THE CHANGE IN PROBABILITIES SUPPORTED BY THE DATA?

We thus estimate the Extended PBM

Table 5. Likelihood ratio tests

<table>
<thead>
<tr>
<th></th>
<th>Log-likelihood Restricted Model</th>
<th>Log-likelihood Unrestricted Model</th>
<th>χ² (2) statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>China – India</td>
<td>-474.802</td>
<td>-473.988</td>
<td>1.628</td>
<td>0.443</td>
</tr>
<tr>
<td>SE Asia – India</td>
<td>-492.797</td>
<td>-477.619</td>
<td>30.356 ***</td>
<td>0.000</td>
</tr>
<tr>
<td>S. Korea – China</td>
<td>-426.280</td>
<td>-416.020</td>
<td>20.520 ***</td>
<td>0.000</td>
</tr>
<tr>
<td>S. Korea – India</td>
<td>-468.940</td>
<td>-460.909</td>
<td>16.063 ***</td>
<td>0.000</td>
</tr>
<tr>
<td>S. Korea – SE Asia</td>
<td>-411.784</td>
<td>-408.880</td>
<td>5.808 *</td>
<td>0.055</td>
</tr>
</tbody>
</table>

Note: Asterisks indicate rejection of the null hypothesis at the 0.1*, 0.05** and 0.01*** significance levels, respectively.

Table 6. Estimation results for the price differential between China and India

<table>
<thead>
<tr>
<th></th>
<th>China – India</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean parameters</td>
<td></td>
</tr>
<tr>
<td>α</td>
<td>44.126 ***</td>
</tr>
<tr>
<td>β</td>
<td>0.565 ***</td>
</tr>
<tr>
<td>Standard deviations</td>
<td></td>
</tr>
<tr>
<td>σ_τ</td>
<td>8.701 ***</td>
</tr>
<tr>
<td>σ_μ</td>
<td>28.999 ***</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Probabilities (in %)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>λ_τ</td>
<td>70.762 ***</td>
</tr>
<tr>
<td>λ_μ</td>
<td>0.000</td>
</tr>
<tr>
<td>1 - λ_τ - λ_μ</td>
<td>29.238 ***</td>
</tr>
</tbody>
</table>

Log-likelihood = -474.802

Note: Estimates for the monthly dummies are not reported for brevity. Numbers in parentheses are standard errors. Significance tests are based on asymptotic standard errors that have been computed using the Hessian matrix of the log-likelihood function. Asterisks indicate significance at 0.1**, 0.05*** and 0.01**** levels, respectively.
**CONCLUSIONS**

- **Absent any sanctions**, a high degree of market integration is achieved among Asian markets.

- **Under the sanctions**, we observe signs of **balkanization**
  - they form two distinct market areas respectively (China & India) and (Korea & Southeast Asia).
  - the degree of market integration achieved within each of these two areas remain very high.

- **Overall**, our findings are consistent with market commentaries arguing that the sanctions only imperfectly prevented the exportation of Iranian methanol to China and India
  - These two countries are reputed to have offered alternative insurance and transportation schemes to Iran.
Thank you!