The effects of oil price shocks in a new-Keynesian framework with capital accumulation

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CES, PSE, Université Paris I, BETA, Chair Energy and Prosperity

Séminaire de recherches PSL en économie de l’énergie
June 10th 2015
Purpose

- Recall the difference between oil’s output elasticity and oil’s cost share.
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- Analyze the effects of oil shocks in the U.S economy
  - A theoretical study with DSGE model
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- Recall the difference between oil’s output elasticity and oil’s cost share.

- Analyze the effects of oil shocks in the U.S economy
  
  \[ \Rightarrow \text{A theoretical study with DSGE model} \]
  
  \[ \Rightarrow \text{An empirical approach with U.S data (1984:Q1-2007:Q1)} \]

- Analyze the role and evolution of oil dependency.
Outline

Introduction

Model

Estimation

Results

Conclusions
The 1970s’ oil shocks

<table>
<thead>
<tr>
<th></th>
<th>Year</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1978 – 1980</td>
<td>+100%</td>
</tr>
<tr>
<td>Inflation</td>
<td>1973–1974</td>
<td>+4.3 %</td>
</tr>
<tr>
<td></td>
<td>1979–1980</td>
<td>+5.9 %</td>
</tr>
<tr>
<td>Unemployment rate</td>
<td>1973 – 1974</td>
<td>+3.6 points</td>
</tr>
<tr>
<td></td>
<td>1979 – 1982</td>
<td>+3.8 points</td>
</tr>
<tr>
<td>Growth</td>
<td>1973–1975</td>
<td>-6%</td>
</tr>
<tr>
<td></td>
<td>1979–1980</td>
<td>-5.8%</td>
</tr>
<tr>
<td>Real Wages</td>
<td>1973–1975</td>
<td>-2.7%</td>
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<tr>
<td></td>
<td>1979–1980</td>
<td>-1.3%</td>
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Literature: The correlation between oil shocks and the business cycles

- Gisser & Goodwin (1986)
- Dotsey & Reid (1992)
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**Literature: The correlation between oil shocks and the business cycles**

- Gisser & Goodwin (1986)
- Dotsey & Reid (1992)

A correlation **challenged** by:

## The 2000s’ oil shock

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<th>Year</th>
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<tr>
<td></td>
<td>1978 – 1980</td>
<td>+100%</td>
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<tr>
<td></td>
<td>2002 – 2007</td>
<td>+147%</td>
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<tr>
<td><strong>Inflation</strong></td>
<td>1973–1974</td>
<td>+4.3 %</td>
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<tr>
<td></td>
<td>1979–1980</td>
<td>+5.9 %</td>
</tr>
<tr>
<td></td>
<td>2002-2007</td>
<td>+1.3%</td>
</tr>
<tr>
<td><strong>Unemployment rate</strong></td>
<td>1973 – 1974</td>
<td>+3.6 points</td>
</tr>
<tr>
<td></td>
<td>1979 – 1982</td>
<td>+3.8 points</td>
</tr>
<tr>
<td></td>
<td>2002-2007</td>
<td>+1.2 points</td>
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<tr>
<td><strong>Growth</strong></td>
<td>1973–1975</td>
<td>-6%</td>
</tr>
<tr>
<td></td>
<td>1979–1980</td>
<td>-5.8%</td>
</tr>
<tr>
<td></td>
<td>2002-2007</td>
<td>+2.7% (average)</td>
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<tr>
<td><strong>Real Wages</strong></td>
<td>1973–1975</td>
<td>-2.7%</td>
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<tr>
<td></td>
<td>1979–1980</td>
<td>-1.3%</td>
</tr>
<tr>
<td></td>
<td>2002-2005</td>
<td>-0.4%</td>
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## The debate

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<td>Overstated link</td>
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<td>and macroeconomic performance</td>
<td>similar consequences</td>
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<td>share in production;</td>
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<td>changes and</td>
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<td>real wages and;</td>
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<td>monetary policy.</td>
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Research Questions

- Do we really understand how oil shocks spread in the economy?
- Is the U.S economy really invulnerable to oil shocks? If so, what change in the U.S to make the economy immune?
- What kind of policy could be implemented to help to lessen effects of oil shocks?
What have we done?

To the best of our knowledge, no dynamic general equilibrium model was available that captures the next two stylized facts:

1. The stagflationary impact of sharp oil real price rise.

2. The various impacts of capital accumulation:
   - Hysteresis effect
   - The potential role of capital as a new channel for monetary policy
   - The role of capital energy efficiency in dampening the impact of an oil price rise
What have we done?

The present paper introduces oil into a DSGE model in the same way as Blanchard & Galí (2009) and Blanchard & Riggi (2013), to which it adds capital accumulation.
What have we done?

The present paper introduces oil into a DSGE model in the same way as Blanchard & Galí (2009) and Blanchard & Riggi (2013), to which it adds capital accumulation.

The oil’s output elasticity
What have we done?

The present paper introduces oil into a DSGE model in the same way as Blanchard & Galí (2009) and Blanchard & Riggi (2013), to which it adds capital accumulation.

The oil’s output elasticity $\neq$ oil’s cost share
Why add capital in the model?

1. More realistic.


3. Separate oil from other types of capital.
Decoupling the cost share from output elasticity

$$\max_x Y(x) - p \cdot x$$

leads to:

$$\varepsilon_i := \frac{x_i}{Y(x)} \times \frac{\partial Y}{\partial x_i}(x) = \frac{p_i x_i}{p \cdot x}$$
Decoupling the cost share from output elasticity

\[
\max_x Y(x) - p \cdot x \\
\text{s.t. } f(x) = 0
\]
Decoupling the cost share from output elasticity

\[
\max_x Y(x) - p \cdot x \\
\text{s.t. } f(x) = 0
\]

\[
\varepsilon_i = \frac{x_i(p_i - \lambda \frac{\partial f(x)}{\partial x_i})}{p \cdot x - \lambda x_i \frac{\partial f(x)}{\partial x_i}}.
\]
Decoupling the cost share from output elasticity

\[
\max_x Y(x) - p \cdot x \\
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\]

\[
\lambda \to +\infty \Rightarrow \varepsilon_i \to 1
\]
Decoupling the cost share from output elasticity

\[
\max_x Y(x) - p \cdot x \tag{2}
\]

s.t. \( f(x) = 0 \)

\[
\epsilon_i = \frac{x_i \left( p_i - \lambda \frac{\partial f(x)}{\partial x_i} \right)}{p \cdot x - \lambda x_i \frac{\partial f(x)}{\partial x_i}}.
\]

\[\lambda \to +\infty \Rightarrow \epsilon_i \to 1\]

\(\epsilon\) may take any real value between \(-\infty\) and \(x_i p_i / x \cdot p\) whenever \(0 < \lambda < (p \cdot x) \frac{\partial x_i}{\partial f(x)}\)
Decoupling the cost share from output elasticity

So that a large share $x_i p_i / x \cdot p$ is compatible with a small $\varepsilon$!
Outline

Introduction

Model
  Households
  Firms
  GDP, Monetary Policy and Shocks

Estimation

Results

Conclusions
General Structure

Domestic Economy → Final Good Firms

Households
General Structure

Domestic Economy

- invest
- work
- consume
- l.s taxes

Households

Final Good Firms

- exo p.
- Oil produces
- Labor
- Capital
- exogenous price
- profits
- Foreign exo p.
General Structure
General Structure

Domestic Economy → Final Good Firms

- l.s taxes
- invest
- capital
- work
- consume

Households

Final Goods

Oil

Domestic Economy

- Domestic Economy
- Households
- Final Good Firms

Model

- General Structure
- Domestic Economy
- Households
- Final Good Firms
- Oil

Introduction

- General Structure
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- Oil

Results

- General Structure
- Domestic Economy
- Households
- Final Good Firms
- Oil

Conclusions
General Structure

Domestic Economy
- Final Goods
- Oil
- produces

Households
- invest
- work
- consume
- l.s taxes
- bonds
- capital

Final Good Firms

Intermediate Firms
- Oil
- Labor
- Capital
- exogenous price
- Foreign exo p.
- profits
General Structure

Domestic Economy

- l.s taxes
- bonds
- capital
- work
- consume

Households

Final Good Firms

Intermediate Firms

Final Goods

Oil

Foreign exo p.

Profits

Taylor

Exogenous price

Labor

Capital

Produces

Invest

The diagram illustrates the economic structure of the domestic economy, showing the relationships between households, firms, and industries. Households engage in activities such as working, consuming, and investing. They provide labor and capital to firms, which in turn produce final goods and intermediate goods. The oil industry is also depicted, with oil being produced and consumed.
General Structure
General Structure

Domestic Economy

- l.s taxes
- bonds
- capital
- work
- consume

Households

- invest

Final Goods

- contributes to

Foreign

- Oil
- Labor
- Capital

Intermediate Firms

- profits

Final Good Firms

Oil produces

Government

Taylor

Exogenous price

Exogenous price

Exogenous price
General Structure

Government

Domestic Economy

Final Good Firms

Intermediate Firms

Households

Oil

Labor

Capital

Foreign

Final Goods

Oil

Profits

Taylor

l.s taxes

bonds

invest

capital

work

consume

produces

exogenous price

exo P.
Households

Problem

\[ \max_{C_t, L_t, B_t, K_{t+1}} \mathbb{E}_0 \left[ \sum_{t=0}^{\infty} \beta^t U(C_t(j), L_t(j)) \right], \quad 0 < \beta < 1 \]

s. t

\[ P_{c,t} C_t(j) + P_{k,t} I_t(j) + B_t(j) \leq (1 + i_{t-1}) B_{t-1}(j) + W_t(j) L_t(j) + D_t + r^k_t P_{k,t} K_t(j) + T_t \]
Households

Problem

$$\max_{C_t, L_t, B_t, K_{t+1}} \mathbb{E}_0 \left[ \sum_{t=0}^{\infty} \beta^t U(C_t(j), L_t(j)) \right], \quad 0 < \beta < 1$$

s. t

$$P_{c,t} C_t(j) + P_{k,t} L_t(j) + B_t(j) \leq (1 + i_{t-1}) B_{t-1}(j) + W_t(j) L_t(j) + D_t + r_t^k P_{k,t} K_t(j) + T_t$$

$$U(C_t(j), L_t(j)) = \log(C_t(j)) - \frac{L_t(j)^{1+\phi}}{1+\phi}$$
Households

\[
\text{Problem} \\
\max_{C_t, L_t, B_t, K_{t+1}} \mathbb{E}_0 \left[ \sum_{t=0}^{\infty} \beta^t U(C_t(j), L_t(j)) \right], \quad 0 < \beta < 1
\]

s. t

\[
P_c, t C_t(j) + P_k, t I_t(j) + B_t(j) \leq (1 + i_{t-1})B_{t-1}(j) + W_t(j)L_t(j) + D_t + r_k^t P_{k, t} K_t(j) + T_t
\]

\[
U(C_t(j), L_t(j)) = \log(C_t(j)) - \frac{L_t(j)^{1+\phi}}{1+\phi}
\]

\[
l_t \equiv K_{t+1} - (1 - \delta)K_t
\]
Households

\[ C_t(j) := \Theta x C_{e,t}(j) C_q^{1-x}(j) \]
Households

\[ C_t(j) := \Theta_x C_{e,t}^x(j) C_{q,t}^{1-x}(j) \]

\[ \Theta_x := x^{-x}(1-x)^{-(1-x)} \]
Households

\[ C_{q,t}(j) := \left( \int_0^1 C_{q,t}(i,j)^{1-\frac{1}{\epsilon_p}} \, di \right)^{\frac{\epsilon_p}{\epsilon_p-1}} \]

\[ C_t(j) := \Theta_x C_{e,t}^x(j) C_{q,t}^{1-x}(j) \]

\[ \Theta_x := x^{-x} (1 - x)^{-(1-x)} \]
Optimization

Household’s Optimal Expenditure Allocation
Optimization

Household’s Optimal Expenditure Allocation

\[
\max_{C_q, t(j), C_e, t(j)} \quad P_{c, t} C_t(j)
\]

s. t

\[
P_{c, t} C_t(j) = P_{e, t} C_e, t(j) + P_{q, t} C_q, t(j)
\]

\[
k = \Theta_x C(j)^x_{e, t} C(j)^{1-x}_{q, t}
\]
Optimization

Household's Optimal Expenditure Allocation

\[
\text{max}_{C_q, t(j), C_e, t(j)} P_{c, t} C_t(j)
\]

s. t

\[
P_{c, t} C_t(j) = P_{e, t} C_e, t(j) + P_{q, t} C_q, t(j)
\]

\[
C_t(j) := \Theta_x C(j)^x_{e, t} C(j)^{1-x}_{q, t}
\]

\[
P_{c, t} = P_{e, t}^x P_{q, t}^{1-x}
\]

\[
P_{q, t} C_{q, t}(j) = (1 - x) P_{c, t} C_t(j)
\]

\[
P_{e, t} C_{e, t}(j) = x P_{c, t} C_t(j)
\]
Final Good Producers

Final Good Firm
Final Good Producers

Intermediate Good \( i \in [0, 1] \)

Final Good Firm

\[ Q_t = \left( \int_0^1 Q_t(i) \epsilon_p - \epsilon_p \right) \epsilon_p \epsilon_p - 1 \epsilon_p \]  

The elasticity of substitution among intermediate goods
Final Good Producers

Intermediate Good \( i \in [0, 1] \)

Final Good Firm

\[
Q_t = \left( \int_0^1 Q_t(i) \frac{\epsilon_p - 1}{\epsilon_p} \, di \right) \frac{\epsilon_p}{\epsilon_p - 1}
\]
Final Good Producers

Intermediate Good $i \in [0, 1]$

Final Good Firm

$Q_t = \left( \int_0^1 Q_t(i) \frac{\varepsilon_p - 1}{\varepsilon_p} di \right)^{\frac{\varepsilon_p}{\varepsilon_p - 1}}$

$\varepsilon_p$: the elasticity of substitution among intermediate goods
Final Good Producer Problem

Final Good Firm Profit Optimization

\[
\max_{Q_t(i)} P_{q,t} Q_t - \int_0^1 P_{q,t}(i) Q_t(i) \, di
\]

s. t

\[
Q_t = \left( \int_0^1 Q_t(i) \frac{\epsilon_p - 1}{\epsilon_p} \, di \right)^{\frac{\epsilon_p}{\epsilon_p - 1}}
\]

\[
Q_t(i) = \left( \frac{P_{q,t}(i)}{\bar{P}_{q,t}} \right)^{-\epsilon_p} \bar{Q}_t
\]

\[
P_{q,t} = \left( \int_0^1 P_{q,t}(i)^{1-\epsilon_p} \, di \right)^{\frac{1}{1-\epsilon_p}}
\]
Intermediate Good Firms

Intermediate Firms
Intermediate Good Firms

\[ Q_t(i) = A_t E_t(i)^{\alpha_e} L_t(i)^{\alpha_l} K_t(i)^{\alpha_k} \]

Given: prices and quantities

Choses: \( E_t(i), L_t(i), K_t(i) \)

\( \alpha_e, \alpha_k, \alpha_l \geq 0 \)
Intermediate Good Firms

Intermediate Firms

\[ Q_t(i) = A_t E_t(i)^{\alpha_e} L_t(i)^{\alpha_L} K_t(i)^{\alpha_k} \]

strategy of firm \( i \)

\( \alpha_e, \alpha_k, \alpha_L \geq 0 \)
Intermediate Good Firms

\[ Q_t(i) = A_t E_t(i)^{\alpha_e} L_t(i)^{\alpha_l} K_t(i)^{\alpha_k} \]

Given: \( P_{e,t}, P_{k,t}, W_t \) and \( Q_t(i) \)

Choses: \( E_t(i), L_t(i) \) and \( K_t(i) \)

\( \alpha_e, \alpha_k, \alpha_l \geq 0 \)
Intermediate Good Firms

Given: $P_{e,t}$, $P_{k,t}$, $W_t$ and $Q_t(i)$

Choses: $E_t(i)$, $L_t(i)$ and $K_t(i)$

Given: prices and quantities

Choses: $P_{q,t}(i)$

Intermediate Firms

$Q_t(i) = A_t E_t(i)^{\alpha_e} L_t(i)^{\alpha_L} K_t(i)^{\alpha_k}$

strategy of firm $i$

$\alpha_e$, $\alpha_k$, $\alpha_L \geq 0$
Price Optimization

Price Maximization (at each date $t$) (Calvo Price Setting)

\[ P_{q,t}(i) = P_{q,t-1}(i) \]

\[ P_{q,t}(i) = P_{o,q,t}(i) \]

\[ P_{q,t} = \left( \theta_p P_{q,t-1}^{1-\epsilon_p} + (1 - \theta_p) P_{o,q,t}^{1-\epsilon_p} \right) \]
GDP

\[ P_{c,t}Y_t = P_{q,t}Q_t - P_{e,t}E_t \]
$\text{GDP}$

\[ P_{c,t} Y_t = P_{q,t} Q_t - P_{e,t} E_t \]

\[ \alpha_e = \frac{M_p \times \text{Oil's Cost share}}{1 + \text{Oil's Cost share}} \]
Blanchard & Galí (2009) and Blanchard and Riggi (2013) define implicit GDP deflator \((P_y,t)\) by:

\[
P_{q,t} := P_{y,t}^{1-\alpha_e} P_{e,t}^{\alpha_e}
\]

which yields to:

\[
P_{y,t} = P_{q,t}^{\beta} P_{e,t}^{1-\beta}, \quad \beta > 1
\]
Blanchard & Galí (2009) and Blanchard and Riggi (2013) define implicit GDP deflator \((P_{y,t})\) by:

\[ P_{q,t} := P_{y,t}^{1-\alpha_e} P_{e,t}^{\alpha_e} \]

which yields to:

\[ P_{y,t} = P_{q,t}^{\beta} P_{e,t}^{1-\beta}, \quad \beta > 1 \]

We assume however that:

\[ P_{y,t} = P_{c,t} \]
Government
Government
Government

\[ \frac{1+i_t}{1+i} = \left( \frac{n_{q,t}}{n} \right)^{\phi} \left( \frac{Y_t}{Y} \right)^{\phi_y} \varepsilon_{i,t} \]
Government

\[ \frac{1+i_t}{1+i} = \left( \frac{\Pi_{q,t}}{\Pi} \right)^{\phi_{\pi}} \left( \frac{Y_t}{\bar{Y}} \right)^{\phi_y} \varepsilon_{i,t} \]

\[ \Pi_{q,t} := \frac{P_{q,t}}{P_{q,t-1}} \]

\[ \ln(\varepsilon_{i,t}) = \rho_i \ln(\varepsilon_{i,t-1}) + e_{i,t} \]
Government

\[
\frac{1 + i_t}{1 + i} = \left( \frac{\Pi_{q,t}}{\Pi} \right)^{\phi_{\pi}} \left( \frac{Y_t}{Y} \right)^{\phi_y} \varepsilon_{i,t}
\]

\[
\Pi_{q,t} := \frac{P_{q,t}}{P_{q,t-1}}
\]

\[
(1 + i_{t-1})B_{t-1} + G_t = B_t + T_t
\]

\[
\ln(\varepsilon_{i,t}) = \rho_i \ln(\varepsilon_{i,t-1}) + e_{i,t}
\]
\[ \ln(G_r,t) = (1 - \rho_g)(\ln(\omega Q)) + \rho_g \ln(G_r,t-1) + \rho_{alk} e_{alk,t} + \rho_{ae} e_{ae,t} + e_g,t \]

\[ \frac{1+i_t}{1+i} = \left( \frac{\Pi_{q,t}}{\Pi} \right)^{\phi_\pi} \left( \frac{Y_t}{\bar{Y}} \right)^{\phi_y} \varepsilon_{i,t} \]

\[ \Pi_{q,t} := \frac{P_{q,t}}{P_{q,t-1}} \]

\[ (1 + i_{t-1})B_{t-1} + G_t = B_t + T_t \]

\[ \ln(\varepsilon_{i,t}) = \rho_i \ln(\varepsilon_{i,t-1}) + e_{i,t} \]
Shocks

\[ S_{e,t} := \frac{P_{e,t}}{P_{q,t}} \]

\[ \log(S_{e,t}) = \rho_s \log(S_{e,t-1}) + e_{se,t} \]
Shocks

Oil Price:

\[ S_{e,t} := \frac{P_{e,t}}{P_{q,t}} \]

\[ \log(S_{e,t}) = \rho_{s,e} \log(S_{e,t-1}) + e_{se,t} \]

Capital Price:

\[ S_{k,t} := \frac{P_{k,t}}{P_{q,t}} \]

\[ \log(S_{k,t}) = \rho_{s,k} \log(S_{k,t-1}) + e_{sk,t} \]
Shocks

\[ \ln(A_{LK,t}) = \rho_a \ln(A_{LK,t-1}) + e_{alk,t} \]
Shocks

\[ \ln(A_{LK,t}) = \rho_a \ln(A_{LK,t-1}) + e_{alk,t} \]

\[ \varepsilon_{p,t} = \rho_p \varepsilon_{p,t-1} + e_{p,t} - \nu_p e_{p,t-1} \]
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Outline

**Introduction**

**Model**

**Estimation**

  Setting

  Estimation Results

**Results**

**Conclusions**
Data
1984:Q1–2007:Q1

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<thead>
<tr>
<th>Observed Variable</th>
<th>Transformation</th>
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<tbody>
<tr>
<td>labobs</td>
<td>$\ln\left(\frac{\text{Averagehours} \times \text{CE16OVIndex}}{\text{LNSIndex}}\right) \times 100 - \text{mean}\left(\ln\left(\frac{\text{Averagehours} \times \text{CE16OVIndex}}{\text{LNSIndex}}\right) \times 100\right)$</td>
</tr>
<tr>
<td>infobs</td>
<td>$\ln\left(\frac{\text{GDPDEF}}{\text{GDPDEF}(-1)}\right) \times 100 - \text{mean}\left(\ln\left(\frac{\text{GDPDEF}}{\text{GDPDEF}(-1)}\right) \times 100\right)$</td>
</tr>
<tr>
<td>iobs</td>
<td>$\left(\ln\left(1 + \frac{\text{FEDFUND}}{400}\right) - \text{mean}\left(\ln\left(1 + \frac{\text{FEDFUND}}{400}\right)\right)\right) \times 100$</td>
</tr>
<tr>
<td>eobs</td>
<td>$\ln\left(\frac{\text{TotalSAOil}}{\text{LNSIndex}}\right) \times 100 - \text{mean}\left(\ln\left(\frac{\text{TotalSAOil}}{\text{LNSIndex}}\right) \times 100\right)$</td>
</tr>
<tr>
<td>invobs</td>
<td>$\text{detrend}\left(\ln\left(\frac{\text{PFI}}{\text{GDPDEF} \times \text{LNSIndex}}\right) \times 100\right)$</td>
</tr>
<tr>
<td>yobs</td>
<td>$\text{detrend}\left(\ln\left(\frac{\text{GDPC09}}{\text{LNSIndex}}\right) \times 100\right)$</td>
</tr>
</tbody>
</table>
## Calibrated Parameters

<table>
<thead>
<tr>
<th>$\beta$</th>
<th>$\delta$</th>
<th>$\epsilon_p$</th>
<th>$\omega$</th>
<th>$x$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.99</td>
<td>0.025</td>
<td>8</td>
<td>0.18</td>
<td>0.023</td>
</tr>
</tbody>
</table>

**Table**: Calibrated Parameters
Identification Analysis

Lack of consensus over the value of oil’s output elasticity.
Identification Analysis

Lack of consensus over the value of oil’s output elasticity.
⇒ we perform an identification analysis
Identification Analysis

Lack of consensus over the value of oil’s output elasticity.

⇒ we perform an identification analysis

Result:
Lack of consensus over the value of oil’s output elasticity.

⇒ we perform an identification analysis

Result:

If the chosen prior for the output elasticity parameter is high, the price Calvo parameter loses identification strength.
Table: Prior and Posterior Distribution of Structural Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Prior distribution</th>
<th>Posterior distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mode</td>
</tr>
<tr>
<td>( \theta ) estimated</td>
<td>( \alpha_k ) IGamma(0.1,2)</td>
<td>0.3728</td>
</tr>
<tr>
<td>Capital elasticity</td>
<td>( \alpha_\ell ) IGamma(0.4,2)</td>
<td>0.6424</td>
</tr>
<tr>
<td>Labor elasticity</td>
<td>( \alpha_e ) IGamma(0.6,2)</td>
<td>0.1234</td>
</tr>
<tr>
<td>Oil elasticity</td>
<td>( \phi ) IGamma(1.17,0.5)</td>
<td>0.6209</td>
</tr>
<tr>
<td>Inverse Frisch elasticity</td>
<td>( \phi_\pi ) Normal(1.2,0.1)</td>
<td>1.2235</td>
</tr>
<tr>
<td>Taylor rule response to inflation</td>
<td>( \phi_y ) Normal(0.5,0.1)</td>
<td>0.8020</td>
</tr>
<tr>
<td>Calvo price parameter</td>
<td>( \theta ) Beta(0.5,0.1)</td>
<td>0.9812</td>
</tr>
</tbody>
</table>

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<td></td>
<td></td>
<td>Mode</td>
</tr>
<tr>
<td>( \theta ) calibrated</td>
<td>( \alpha_k ) IGamma(0.2,2)</td>
<td>0.3918</td>
</tr>
<tr>
<td>Capital elasticity</td>
<td>( \alpha_\ell ) IGamma(0.4,2)</td>
<td>0.5947</td>
</tr>
<tr>
<td>Labor elasticity</td>
<td>( \alpha_e ) IGamma(0.5,2)</td>
<td>0.1132</td>
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<tr>
<td>Oil elasticity</td>
<td>( \phi ) IGamma(1.17,0.5)</td>
<td>1.2562</td>
</tr>
<tr>
<td>Inverse Frisch elasticity</td>
<td>( \phi_\pi ) Normal(1.2,0.1)</td>
<td>1.5236</td>
</tr>
<tr>
<td>Taylor rule response to inflation</td>
<td>( \phi_y ) Normal(0.5,0.1)</td>
<td>0.0265</td>
</tr>
</tbody>
</table>
Outline

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Estimation

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The Ecological Transition Effect. Case: $\theta$ Estimated
The Ecological Transition Effect. Case: $\theta$ Calibrated
The Evolution of $\hat{\alpha}_e$ from 1999:Q1 to 2006:Q3 in Bi-annual Frequency
The reduction of oil’s dependence
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  \[\Rightarrow\] The 1979’s oil productivity increase explains **in part** the difference of oil shocks between 2000s’ and the one in 1970s’.
### Conclusions

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  ⇒ Reducing the output elasticity of oil is a promising policy recommendation.

- Oil dependency significantly **decreased in 1979**.
  
  ⇒ The 1979’s oil productivity increase explains **in part** the difference of oil shocks between 2000s’ and the one in 1970s’.

- **However**, there is no empirical evidence that this has been the case in the 2000s’.
Conclusions

Our estimations show:

- **Increasing** aggregate returns to scale.
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- **Increasing** aggregate returns to scale.

- Much higher estimates of oil’s output elasticity than with conventional computation based on the cost share (12% and 11% in comparison with 3.5%).

  Oil’s output elasticity **is larger than** the oil’s cost share value.

  ⇒ Oil’s cost share and oil’s output elasticity **are not** necessarily equal.
Thank you for your attention!
Household’s Optimization

\[ 1 = \beta E_t (1 + i_t) \frac{C_t}{C_{t+1}} \frac{P_{c,t}}{P_{c,t+1}} \]

---

**First Order Conditions**

\[ 1 = \beta E_t \left[ \left(1 + i_t\right) \frac{C_t}{C_{t+1}} \frac{P_{c,t}}{P_{c,t+1}} \right] \]

---

**Euler**

\[ 1 = \beta E_t \left[ \left(1 + i_t\right) \frac{C_t}{C_{t+1}} \frac{P_{c,t}}{P_{c,t+1}} \right] \]

**Fisher**

\[ 1 = \beta E_t \left[ \frac{C_t}{C_{t+1}} \frac{P_{c,t}}{P_{c,t+1}} \frac{P_{k,t+1}}{P_{k,t}} \left( \rho^{k,t+1} + 1 - \delta \right) \right] \]

---

**Fisher**

\[ \frac{W_t}{P_{c,t}} = C_t L_t^\phi \]
Cost Minimization

\[ MC_t = \frac{W_t}{\alpha_L \frac{Q_t(i)}{L_t(i)}} = \frac{r_t^k P_{k,t}}{\alpha_k \frac{Q_t(i)}{K_t(i)}} = \frac{P_{e,t}}{\alpha_e \frac{Q_t(i)}{E_t(i)}} \]

\[ \text{cost}(Q_t(i)) = \alpha F_t Q(i)^{\frac{1}{\alpha}} \]
Calvo Price Setting

Calvo Price Setting Problem

\[
\max_{P_{q,t}(i)} \mathbb{E}_t \left[ \sum_{k=0}^{\infty} \theta^k d_{t,t+k} \left[ P_{q,t}(i) Q_{t,t+k}(i) - \text{cost}(Q_{t,t+k}(i)) \right] \right]
\]

s.t

\[
Q_{t,t+k}(i) = \left( \frac{P_{q,t}(i)}{P_{q,t+k}} \right)^{-\epsilon} Q_{t+k}, \quad \forall k \geq 0
\]
Calvo Price Setting

Calvo Price Setting Solution

\[ \mathbb{E}_t \left[ \sum_{k=0}^{\infty} \theta^k \omega_{t+k} \left( P_{q,t}^o - \mathcal{M}^p M_{c_{t+k}}^o \right) \right] = 0 \]

- \( d_{t,t+k}(j) := \beta^k \frac{\lambda_{t+k}(j)}{\lambda_t(j)} \)
- \( M_{C_{t+k}}^o := M_{C_{t+k}} \)
- \( Q_{t+k}|_t := \left( \frac{P_{q,t}^o}{P_{q,t+k}} \right)^{-\varepsilon_p} Q_{t+k} \)
Definition of Equilibrium

Equilibrium

In all markets, agents maximize their problems and the government budget constraint is fulfilled.
Definition of Equilibrium

agents maximize its problems

all markets clear

Equilibrium

Govern ment budget const. fulfilled
No Ponzi Scheme

Transversality condition (no Ponzi Scheme)

\[ \lim_{k \to \infty} \mathbb{E}_t \left( \frac{B_{t+k}}{t+k-1} \prod_{s=0}^{t+k-1} (1 + i_{s-1}) \right) \geq 0, \quad \forall t. \]