The macroeconomics of oil

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Work in progress with Jordi Gali. Pieces, and hypotheses, for discussion.
St. Louis Fed: Series: OILPRICE, Spot Oil Price: West Texas Intermediate

Spot Oil Price: West Texas Intermediate (OILPRICE)
Source: Dow Jones & Company

Shaded areas indicate recessions as determined by the NBER.
2006 Federal Reserve Bank of St. Louis: research.stlouisfed.org

Nr. 2
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Organizing ideas

- On the supply side: Increase in cost for energy-using sectors.
  Required real wage adjustment.
  The inflation-unemployment trade-off and optimal monetary policy.
  The 1970s versus the 2000s.

- On the demand side. Distribution effects, between firms, between countries: Focus on the transfer from oil importers to oil exporters.
  Effect on world saving, and the world interest rate.
  Effect on current account balances (global imbalances)
1. The required real wage adjustment

Some simple accounting: Consider the energy-using sector.

\[ Q = Q(V, E), \quad V = V(AN, K) \]

where \( Q \) is gross output, (gross of energy input, but net of other inputs)
Then (if constant markups)

\[ \Delta p_Q = \alpha_V \Delta p_V + \alpha_E \Delta p_E \]

where the \( \alpha \)s are shares of factors in gross output, and:

\[ \Delta p_V = \alpha_N (\Delta w - \Delta a) + \alpha_K \Delta p_K \]

where the \( \alpha \)s are the shares of factors in value added.
Implications for the real wage (in terms of output):

$$(\Delta w - \Delta p_Q) = \Delta a - \frac{\alpha_E}{\alpha_V \alpha_N} (\Delta p_E - \Delta p_Q) - \frac{\alpha_K}{\alpha_N}(\Delta p_K - \Delta p_Q)$$

If we assume that the return to capital, defined as $P_K/P_Q$ has to be constant, then:

$$(\Delta w - \Delta p_Q) = \Delta a - \frac{\alpha_E}{\alpha_V \alpha_N} (\Delta p_E - \Delta p_Q)$$

Shares depend on definition of “energy sector”. For the US, if define as oil and gas, petroleum and coal, $\alpha_E \approx 2.5\%$ stable since 1978; $\alpha_N \approx 66\%$. If consumption has the same energy composition as gross output, then required rate of change in the consumption real wage.
Constructing each of the two terms on the right-hand side:

- Figure 2. US, since 1978. Using actual shares and energy price deflator for energy intermediate inputs, and $\Delta a$ as TFP growth from BLS divided by actual labor share.

- Figure 3. Same, using Basu-Fernald corrected TFP measure.

- Figure 4. US, since 1950. Constant $\alpha_E/(\alpha_V \alpha_N) = 4\%$, $P_E$ as the PPI for energy.

- Figure 5. US, since 1950. Smoothed TFP: 5-year average.
Required real wage adjustment

-0.08
-0.06
-0.04
-0.02
0
0.02
0.04
0.06
0.08


Percent

from energy prices
from tfp growth
Required real wage adjustment 2

-0.06
-0.04
-0.02
0
0.02
0.04
0.06
0.08

from energy prices from tfp growth (Basu-Fernald)
Required real wage adjustment

-0.08
-0.06
-0.04
-0.02
0
0.02
0.04
0.06
0.08
0.1
0.12
Percent
from tfp growth from energy prices

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Required real wage adjustment

-0.03
-0.02
-0.01
0
0.01
0.02
0.03
0.04
0.05
0.06


Percent

from tfp growth (5-year average) from energy prices

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Conclusions and open questions.

- Effect is small because $\alpha_E$ is small... (Rotemberg-Woodford)
  
  70% increase in $P_E/P_Q$ from 2000 to 2006. 
  $70\% \times (2.5\%/0.7) = 2.5\%$ decrease in real wage relative to path over 6 years.
  
  (What if use a larger definition of energy? KLEM data base: $\alpha_E = 4\%$. But corresponding $P_E$ moves less.)

- Underlying TFP growth smoother, but not constant.
- Disruptions in oil supply; Rationing (Gilbert-Mork). Relevant?
- The 1970s versus the 2000s (at least for the US)
• Other differences between the two components?

Degree of substitutability between labor and oil: Relevant for size of price increase, not relation wage-energy price:

\[ Q = Q(\min(N, E), K) \]

Adverse shift in energy supply curve. If \( P_K/P_Q = ct \), for \( N = \bar{N} \), \( E = \bar{E} \), \( \Delta p_E - p_Q >> 0 \)

\[ Q = Q(N + E, K) \]

Adverse shift in energy supply curve. If \( P_K/P_Q = ct \), for \( N = \bar{N} \), \( \Delta p_E - p_Q = 0 \) and \( E \) decreases.

In both cases, relation change in wage, change in price of energy is the same as above.

• Oil price changes more visible than changes in underlying TFP growth. Easier to adjust real wages?
2. Optimal monetary policy

A simple model. Ignore nominal rigidities to start.

Production is given by:

\[ Q = E^\alpha N^{1-\alpha} \]

where \( E \) is a given (an adverse shock is a decrease in \( E \)). So:

\[ MPN = (1 - \alpha) \frac{Q}{N} = \frac{W}{PQ} \]

Utility is given by:

\[ \log(C) - \frac{1}{1 + \phi} N^{1+\phi} \]

so

\[ MRS = CN^\phi = \frac{W}{PQ} \]
Equilibrium implies:

\[ MPN = \frac{W}{P_Q} = MRS \]

Or in terms of log deviations from an initial equilibrium:

\[ \Delta q - \Delta n = \Delta w - \Delta p_Q = \phi \Delta n + \Delta c \]

where lower case letters are logs of corresponding variables.

Assume \( \Delta c = \beta \Delta q \).

- If \( \beta = 1 \), then
  \[ \Delta n = 0, \; \Delta q = \alpha \Delta e < 0, \; \text{and} \; \Delta w - \Delta p_Q = \alpha \Delta e \; \text{if} \; \Delta e < 0 \]

- If \( \beta < 1 \), then:
  \[ \Delta n = \frac{(1 - \beta) \alpha}{(1 + \phi) - (1 - \beta)(1 - \alpha)} \Delta e < 0 \; \text{if} \; \Delta e < 0 \]
Basic point: A decrease in $e$ (equivalently an increase in $p_E$):

- Requires a decrease in the real wage
- Leads to a decrease in equilibrium output
- May lead to a decrease in equilibrium employment, depending on the strength of the income effect ($\beta$).

Now introduce nominal rigidities. Implications for monetary policy?
Care about inflation for two reasons:

- Directly (uncertainty about rate itself, and implications for distribution of relative prices/wages.
- Indirectly, so as to achieve the natural level of output (the natural rate of unemployment). ("Divine coincidence")

Focus on the second one. Then, a set of standard results (Erceg et al):

- Nominal price rigidity: Stabilize price inflation. Will maintain output at its natural level.
- Nominal wage rigidity: Stabilize wage inflation.
- Nominal price and wage rigidity. Stabilize a weighted average of the two.
Looking more closely:

What price inflation?

- First pass: The output (not value-added) price of the energy-using sector.

- Gas stations (part of the retail trade sector)? Use oil as input, gas plus services as output.

  Should the price of gas be included in the price index?

- No: Weigh according to degree of stickiness (Calvo coefficient). (Mankiw-Reis). Gas prices (at the pump) not sticky.

- So roughly: target “core” output price. Same as core CPI? Not quite, especially in open economy).
Best to stabilize output at the natural rate? Probably not.

- Real wage rigidities. (Blanchard-Gali). Suppose in model above that $W/P_Q = \text{constant}$. Then:

$$\Delta n = \Delta e << 0$$

Then, optimal to maintain output above natural level (and the reverse with respect to a decrease in $P_E/P_Q$).

- Markups (Rotemberg-Woodford). The potential for collusion, and thus for higher markups, is higher when the incentives to defect are low. This is the case if higher oil prices lead to (temporarily) lower profits.

$$P_Q = (1 + \mu) \frac{W}{(1 - \alpha)Q/N} \Rightarrow \frac{W}{P_Q} = \frac{(1 - \alpha)Q/N}{1 + \mu}$$

- Both require a temporary increase in (core) price inflation.

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Conclusions and questions.

- Optimal price index and relation to core CPI?

- Weight on wage versus price inflation. Central with respect to supply shocks.

- Temporary changes in target core inflation. How large, how long?

- Are real wage rigidities endogenous? Probably, but CB credibility not enough to eliminate them.
3. The evidence so far, and the 2000s vs the 1970s

In looking at data, what should we expect?

- Decrease in real consumption wage (adjusted for productivity)
- (Approximate) constancy of real value added wage
- Increase in unemployment and inflation
- Trade-off chosen by CB:
  - For US CB: focus on core inflation. For Euro area CB, first round, no second round.
US numbers

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<tr>
<th></th>
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<th>2003</th>
<th>2004</th>
<th>2005</th>
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<td>5.1</td>
<td>4.8</td>
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</tr>
</tbody>
</table>

(Source: OECD. Wages and productivity in the business sector)

\[\Delta\pi_{CPI} > \Delta\pi_{GDP}\]
\[\Delta w - \Delta a - \Delta\pi_{CPI} < 0\]
\[\Delta w - \Delta a - \Delta\pi_{GDP} < 0\]
\[\Delta u < 0\]
Euro zone numbers

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\[ \Delta \pi_{CPI} > \Delta \pi_{GDP} \]
\[ \Delta w - \Delta a - \Delta \pi_{CPI} < 0 \]
\[ \Delta w - \Delta a - \Delta \pi_{GDP} < 0 \]
\[ \Delta u < 0 \]
Much better than predicted (feared). Why?

- US. Back to earlier figure: Strong productivity growth. So two shocks: Price of oil, and unexpectedly strong productivity growth.

- Euro zone. Much weaker productivity growth. Low real wage rigidity? More likely, a steady decrease in the bargaining power of workers. (Shift versus slope)
The 2000s versus the 1970s

- More inflation, more unemployment.
  In all cases, increase in inflation, then increase in unemployment.
  Decrease in consumption real wage, but also in real wage in terms of GDP (except France, 1972-1977)

- Different shocks?
  Productivity growth.
  In the 1970s, major decrease in underlying TFP growth in Europe, smaller in the United States. In the 2000s, increase in underlying TFP growth in the US, not in Europe.

  Decline in world equilibrium real interest rate (related to oil price increase? more below)
US numbers. 1972-1977

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\[ \pi_W - \pi_{GDP} - g_a \]

\[ \pi_W - \pi_{CPI} - g_a \]

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### US numbers. 1978-1983

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\[ \pi_W - \pi_{GDP} - g_a \]

|                  | 0.3  | 0.8  | 1.1  | -2.1 | 0.8  | -2.7 | -0.3    |

\[ \pi_W - \pi_{CPI} - g_a \]

|                  | -0.3 | -1.9 | -2.9 | -3.0 | 0.7  | -2.0 | -1.5    |
### France numbers. 1972-1977

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\pi_W - \pi_{GDP} - g_a \quad -1.0 \quad 0.1 \quad 2.9 \quad 2.1 \quad -1.4 \quad -0.8 \quad 0.3
\]

\[
\pi_W - \pi_{CPI} - g_a \quad -0.1 \quad 1.1 \quad 1.3 \quad 3.3 \quad 0.0 \quad -1.0 \quad 0.7
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Nr. 30
• Real wage rigidities? Formal indexation clauses in the 1970s (Modigliani). First pass: Not obvious in the data ($\Delta w - \Delta p_Q$ on $u$).

• Different monetary policies?
  Different preferences, or misperceptions (Bernanke-Gertler-Watson, Orphanides, Collard-Delas).
  Challenge: More inflation, more unemployment in response to the shock?
  \[
  \pi = E\pi(+1) + a(y - y^*)
  \]
  Need tighter policy now, with higher expected inflation in the future.
  Timing may help, with a richer dynamic specification. Inflation first, then unemployment.
4. The transfer problem

On the demand side, two main issues. Investment: leave aside here. And implications of wealth transfers across countries.

Increase in the value of net oil exports, 2002-2005: $370b to $800b, so $430b (1.5% of world GDP).

- Increase in net exports: $430b. (Major exporters: Saudi Arabia 13%, Russia 12%, Iran 5% Venezuela 4%, Kuwait 3%)

- Increase in net imports. U.S. $120b, Other advanced, $200b, China $50b, Other developing $50b.

So, think in terms of two major transfers:

- US/Europe towards oil exporters; largest
- China/Asia towards oil exporters
Oil importers, and oil exporters

- Oil importers. Perceived as largely permanent.
  At given interest rate, saving roughly unchanged.

- Oil exporters 1. Revenues largely/fully government controlled: “Stabilization funds,” from Kuwait to Russia, to Norway.
  Large proportion of oil revenues saved. More on Norway.

- Oil exporters 2: Many of them pegged to the dollar.
  - Likely to have real appreciation through inflation.
  - And/or forced to have more contractionary fiscal policy, larger current account surplus.

Evidence so far: Spend between 00- (Norway) to 50+ cents (Venezuela, Iran) on the dollar.
(Saving the oil revenues. The case of Norway)

- 80% of profits from oil companies go to the state.
- Creation in 1990 of an oil fund, now called “Pension fund”. Equal to 150% of GDP (300b$). Invested only in foreign assets.
- Fiscal spending rule allows for a non-oil structural deficit equal to up to 4% of the size of the fund.

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<th>(%)</th>
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<tr>
<td>Gross national saving/GDP</td>
<td>24.8</td>
<td>37.1</td>
</tr>
<tr>
<td>Household saving/GDP</td>
<td>5.2</td>
<td>6.3</td>
</tr>
</tbody>
</table>
World interest rate and global imbalances

- Increase in world saving.
  How large? Not very large:
  Assume half of additional oil revenues saved by oil exporters, none dis-saved by oil importers
  0.5 times $ 430b, or $215b. Equal to an increase in the US saving rate of .7% of world GDP, or 2% of US GDP.
  So some, but small, decrease in world real interest rate (relevant for the supply side).

- Larger global imbalances. But, again, not much larger, and no negative connotation).
Parting thoughts

• Small effects of oil price changes, on the supply and demand side. (Geopolitical implications more important. Transfers of wealth to Russia, Iran, Venezuela)

• Compounded in the 1970s by other shocks, and policy mistakes

• Same issues (on the supply side) however (more) relevant for movements in TFP growth.

• Which inflation rate to target, and how flexibly?
Some references


Blanchard O. and J Gali, “Real wage rigidities and the New-Keynesian model”, NBER WP 11806


World Economic Outlook, April 2006, Chapter II, “Oil prices and global imbalances”