Oil Price Shocks
Precautionary Demand in Crude Oil Market

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Motivation

Nine of ten recessions in the United States were preceded by a sharp rise in the price of oil.
A large number of studies tried to establish theoretical links to prove that oil prices were responsible for the recessions, periods of inflation and reduced economic growth.

Traditional literature on energy economics gives central role to exogenous political events in modeling the oil market: Oil supply disruptions.

However, more recent studies (Barsky and Kilian (2004), Kilian (2009), Blanchard and Gali (2007), Campolni (2007)) take a different stand and provides arguments in favor of reverse causality from macroeconomic variables to oil prices: Aggregate demand or foreign TFP shock.

These studies helped to understand differences between oil prices shocks and their macroeconomic implications in 70s and 2000s.
Closer look to the history: 70s vs 90s

World Oil Consumption

- OECD
- NON OECD

Thousands of Barrels per Day


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Existing literature is almost silent about this fact.

Only Kilian (2010), using structural VAR model of the global crude oil market points out the role for precautionary demand in crude oil market.

Besides, he claims that it is less the physical supply disruptions than the increased precautionary demand for oil triggered by increased uncertainty about future oil supply shortfall is driving price of oil.

What is the intuition?
Different shocks can cause different macroeconomic dynamics.

While, an unexpected oil supply disruption causes a small and temporary effect on real oil price and real economic activity, unanticipated oil market-specific demand increases have an immediate, large and persistent effect on those variables.

Hence, it is important to understand the nature of the shocks before formulating policy responses.

There is highly positive correlation between commodity prices and real interest rates.
Based on these findings, I propose to build a theoretical model to explore macroeconomic consequences of precautionary demand motives in crude oil market.

First step is to simulate the effects of demand shocks in oil market on macroeconomic variables, such as GDP and inflation.

We build on the analysis of oil price and monetary policy undertaken by Leduc and Sill (2004) and Carlstom and Fuerst (2006).

These papers employ DSGE models, where monopolistically competitive firm use exogenously priced oil in their production process.

Our novelty is to introduce cash market and storage market (Pindyck (2001), Kilian and Alquist (2008)) for oil, where firms can buy oil futures to offset energy uncertainty.
Second step is to analyze the role for alternative monetary policies in amplifying or dampening the economy’s response to oil price shocks.

Under new specification for the source of these shocks, we may expect to have different policy proposals compared with the existing literature.
Sticky-price business-cycle model with representative household, representative final good producer and a continuum of intermediate goods producers.

Oil is used as an input by monopolistically competitive intermediate goods producers.

Firms buy physical oil in cash market and futures in financial market.

Inventory dealers store the oil and sell forward contracts or futures.

Following Pindyck (2001) futures and spot prices interact in the market for storage through the convenience yield of the commodity.
$$\max_{C_t, L_t, B_t} E_0 \sum_{t=0}^{\infty} \beta^t \left[ \log C_t - \frac{L_t^{1+\phi}}{1+\phi} \right]$$

subject to

$$P_tC_t + B_t = R_{t-1}B_{t-1} + w_tP_tL_t + r_t^kP_t\bar{K} + \pi_t^f$$
where

\[ Q_t = \left[ \int_0^1 Q_t(i) \frac{\epsilon - 1}{\epsilon} \, di \right] \frac{\epsilon}{\epsilon - 1} \]
Continuum of firms

Calvo price setting: $1 - \theta$ fraction does profit maximization, $\theta$ can do only stick the old price, $P_t(i) = P_{t-1}(i)$.

Production

$$Q_t(i) = A_t K_t^{\alpha_k} L_t^{\alpha_l} O_t^{\alpha_o}$$

$$\pi_f^t(i) = P_t(i) Q_t(i) - w_t P_t L_t(i) - r_t K_t P_t L_t(i) - P_o O_o$$

Financial Market Operation

$$\max X_t E_0 \sum_{t=0}^{\infty} \left( \frac{1}{1 + r} \right) \left[ \frac{P_t^{o}}{P_t^{o+1}} X_t - \frac{F_t X_t}{P_t^{o+1}} \right]$$

- $F_t$: futures price at $t$ for $t + 1$
- $X_t$: # of futures contracts
\[
\max_{I_{t+1}} E_0 \sum_{t=0}^{\infty} \left( \frac{1}{1 + r} \right)^t \left[ \left( \frac{F_{t-1}}{P_t} - p_t^0 \right) I_t + p_t^0 I_t - p_t^0 I_{t+1} + g_t(I_{t+1}, \sigma_{\epsilon_t}) \right]
\]

\[
E_t \left[ \frac{1}{1 + r \frac{F_t}{P_{t+1}}} \right] = p_t^0 - g_1(I_{t+1}, \sigma_{\epsilon_t})
\]

- \( g_1(I_t, \sigma_{\epsilon}^2) > 0 \)
- \( g_{11}(I_t, \sigma_{\epsilon}^2) < 0 \)
- \( g_{12}(I_t, \sigma_{\epsilon}^2) > 0 \)
- \( \lim_{I_t \to 0} g_1(I_t, \sigma_{\epsilon}^2) = \infty \)
Oil exporting country is an endowment economy.

In each period, it receives a random oil endowment $\tilde{\omega}_t$.

\[ \tilde{\omega}_{t+1} \sim N(\omega, \sigma_{t+1}^2) \]

where

\[ \sigma_{t+1}^2 = \lambda \sigma_t^2 + \epsilon_t \]

It acts as a price-taker in spot market for oil and uses revenues to buy consumption goods from final good producers.

\[ P_t C_t^F = P_t^o \tilde{\omega}_t \]
Qualitative Results

- The Effect of Uncertainty on Spot Price

\[
Q' (\tilde{\omega}_t - \Delta l_t) = E_t [Q' (\tilde{\omega}_{t+1} - \Delta l_{t+1})] + g_1 (l_t, \sigma_{\epsilon_t})
\]

- Add monetary Policy

\[
R_t = \phi_\pi (\pi_t - \pi^*) + \phi_y \hat{y}_t
\]

- Run experiments for alternative policies
- Solve for the optimal monetary policy
Preliminary Results-1

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Preliminary Results-2

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Conclusion

- Uncertainty about future oil supply overshoots spot price of oil today.
- The effect is transmitted to the spot price through the level of inventory.
- Monetary policy can intervene to discourage the storage by increasing interest rates.
- Optimal monetary policy?