The Strategic Petroleum Reserve and Oil Prices

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### Question: Does the SPR affect crude oil prices?

### Answer: Yes, but not as intended.

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- **Assumption:**
  - Crude Oil Release
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- **Data:**
  - Oil Price ↓
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The SPR and Oil Prices

Introduction

- Introduction

- SVAR

- Robustness Checks
  - Instrument (SPR Purchases)
  - Event Study (SPR Releases)

- Uncertainty Model

- Other Mechanisms

- Policy Implications
Introduction: What is the SPR?

- 730 million barrels of crude oil
- Response to Arab Oil Embargo
- “To reduce the adverse economic impact of a major petroleum supply disruption”
- Controlled by the President

**SPR Storage Locations**
Introduction: How big is the SPR?

- 67% of total domestic crude stocks
- The equivalent of 148 days of net imports
- Cost $100 billion to date

Total Crude Oil Stocks: 1.1 billion barrels
Introduction: When is it used?

SPR Releases

- International supply disruptions
- Domestic supply disruptions
- Non-emergency

SPR Purchases/Releases as a Share of US Oil Production
Introduction: Why would we care?

_Every recession (with one exception) was preceded by an increase in oil prices, and every oil market disruption (with one exception) was followed by an economic recession._

–Hamilton (2011)

If the SPR can decrease oil prices, it would be very valuable
Over half of global crude oil stocks in government-controlled reserves

- 26 IEA and 27 EU member countries must hold strategic reserves
- Russia, China, Japan also have large strategic reserves

Global Strategic Reserves
Introduction: Literature

Answers the question: How should the SPR be managed?

1980s
- US SPR: Teisberg (1981); Chao and Manne (1982)

2000s
- China’s SPR: Wei et al. (2008); Han et al. (2014)

Little empirical work on the effect of the SPR on Oil prices
- Considine (2006)
Introduction: Literature

Why don’t we know the SPR price effect?

- Spurious correlation
- Causal direction unclear
- Mutual dependence on a common cause
- Policy process difficult to model
Killian (2009) monthly global oil market SVAR model:

\[ A_0 Y_t = \alpha + \sum_{i=1}^{24} A_i Y_{t-i} + \varepsilon_t \]

where

\[ Y_t = \begin{bmatrix} \text{Oil Supply}_t \\ \text{Oil Demand}_t \\ \text{Oil Price}_t \end{bmatrix} \]
SVAR: Model

Add SPR Policy variables to weekly US oil market model:

\[ A_0 Y_t = \alpha + \sum_{i=1}^{40} A_i Y_{t-i} + \varepsilon_t \]

where

\[ Y_t = \begin{bmatrix} \text{Oil Supply}_t \\ \text{Oil Demand}_t \\ \text{SPR Purchase}_t \\ \text{SPR Release}_t \\ \text{Oil Price}_t \end{bmatrix} \]
The causal effect of SPR policy on crude oil prices is:

\[
\frac{\partial \text{Price}_{t+h}}{\partial \varepsilon_{t}^{SPR}}, \ h = 1, 2, 3, \ldots
\]
But we only estimate the reduced form:

\[ Y_t = \beta + \sum_{i=1}^{40} B_i Y_{t-i} + e_t \]

where

\[ e_t = A_0^{-1} \varepsilon_t \]

Useful forecasts but no causal interpretation
To identify the causal effect, assume a temporal ordering of variables (exclusion restriction).

This is equivalent to restricting $A_0^{-1}$ in

$$e_t = A_0^{-1} \varepsilon_t$$
SVAR: Identifying Assumptions

Exclusion Restriction

\[ p_t = \alpha_1 q_t + \alpha_1 q_{t-1} + \ldots + \alpha_k p_{t-1} + \ldots \]

\[ q_t = \beta_1 p_t + \beta_1 p_{t-1} + \ldots + \beta_k q_{t-1} + \ldots \]
SVAR: Identifying Assumptions

Exclusion Restriction

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SVAR: Identifying Assumptions

Partition $Y_t$ into slow-moving, policy, and fast-moving variables:

- **Slow-moving**: Oil supply & oil demand
- **Policy Variables**: SPR purchases & SPR releases
- **Fast-moving Variable**: Oil Price
Assumption 1:
Oil supply shocks are exogenous and do not respond contemporaneously to other structural shocks

Motivation
- Production schedule changes costly
- Import transit time > 1 week
- Uncertainty
Assumption 2:

Oil demand immediately responds to oil supply shocks, but not to SPR policy or oil price shocks

Motivation

- Economic production changes costly
- Uncertainty
SVAR: Identifying Assumptions

Assumption 3:

SPR policy can respond immediately to oil supply and demand shocks, but does not respond immediately to oil price shocks

Motivation

- Meeting-filled policy process
Assumption 4: Oil prices can respond immediately to all other structural shocks

Motivation
- Prices move quickly
SVAR: Data

Weekly Data: June 10, 1983 - October 3, 2014

- Oil Supply: Domestic Crude Production and Imports
- Oil Demand: ADS Business Conditions Index
- SPR Policy: Published by DOE
- Oil Price: West Texas Intermediate Spot Price (Real)
SVAR: Results

SPR Impulse Response Functions
### SVAR: Results

#### Average Structural Residuals for Subperiods

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<tr>
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<td>-0.02</td>
<td>0.04</td>
<td>0.03</td>
<td>-0.02</td>
</tr>
<tr>
<td>Purchase</td>
<td>-0.03</td>
<td>-0.03</td>
<td>0.76</td>
<td>0.01</td>
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SVAR Criticisms (Rudebusch, 1998)

- Timing assumptions not credible (simultaneity)
- Policy reaction functions are naive (omitted variables)
- Estimated structural shocks do not always match futures markets shocks
“Natural experiment” or “Narrative” approach

Romer and Romer (1989, 2004); Ramey and Shapiro (1998); Stock and Watson (2010)

Identify the effect of a policy (without exclusion restrictions) with an instrument that is

- Correlated with unexpected policy changes
- Uncorrelated with all other structural shocks
I construct the **SPR purchase schedule** as an instrument, $Z_t$, for actual purchases.

Purchase schedules set months before actual purchases and not publicly announced

- $E(Z_t \varepsilon^i_t) = 0, i \neq Purchase$

DOE reluctant to give purchase schedule exemptions

- $E(Z_t u_{Purchase}^t) \neq 0$
SPR Purchase Schedule (Red) and Actual Deliveries (Blue)
Partition $Y_t$ into the SPR purchase variable ($P_{1\times1}$) and all other variables ($X_{4\times1}$).

$$e_t = \begin{pmatrix} e^X_t \\ e^P_t \\ e^t_X \\ e^t_P \end{pmatrix}, \varepsilon_t = \begin{pmatrix} \varepsilon^x_t \\ \varepsilon^P_t \end{pmatrix}, A_0 = \begin{pmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{pmatrix}$$

Now, $A_0e_t = \varepsilon_t$ becomes:

$$A_{11}e^X_t + A_{12}e^P_t = \varepsilon^X_t$$

$$A_{21}e^X_t + A_{22}e^P_t = \varepsilon^P_t$$
Instrument: Model

Which simplifies to,

$$e^X_t = -A_{11}^{-1} A_{12} e^P_t + A_{11}^{-1} e^X_t$$  \hspace{1cm} (1)

$$e^P_t = -A_{22}^{-1} A_{21} e^X_t + A_{22}^{-1} e^P_t$$  \hspace{1cm} (2)

To estimate $e^P_t$

1. Use $Z_t$ as instrument for $e^P_t$ in (1) and estimate $-A_{11}^{-1} A_{12}$

2. Estimate $\tilde{e}^X_t = A_{11}^{-1} e^X_t$, as $e^X_t + A_{11}^{-1} A_{12} e^P_t$

3. Use $\tilde{e}^X_t$ as an instrument for $e^X_t$ in (2) to estimate $-A_{22}^{-1} A_{21}$

4. Finally, estimate $\tilde{e}^P_t = e^P_t + A_{22}^{-1} A_{21} e^X_t$

5. $\tilde{e}^P_t$ give us $e^P_t$ to scale, $\frac{\partial \text{Oil Price}_t}{\partial e^P_{t+h}}$, $h = 1, 2, ...$
Instrument: Results

Impulse Response Function (Purchase Instrument)
Cochrane and Piazzesi (2002); Bernanke and Kuttner (2005)

Directly estimate structural policy shock ($\varepsilon_{t}^{release}$) from daily futures market data

*If you are right, you are done*

$$\frac{\partial \text{Oil Price}_{t+h}}{\partial \varepsilon_{t}^{\text{SPR}}}, \quad h = 1, 2, 3, ...$$
Event Study

Assumptions:

- The change in crude futures price \((P_t - P_{t-1})\) captures the unexpected component of the SPR announcement
- The change in crude futures price is driven only by SPR announcement
Event Study Examples
Event Study: Results

Impulse Response Function (Release Event Study)
Problematic assumption:

- The change in crude futures price is driven only by SPR announcement

To make this assumption more plausible, use an alternate financial instrument

- WTI-Canadian crude oil futures spread
Event Study: Results

Impulse Response Function (Release Event Study)
Question: Does the SPR affect crude oil prices?

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Uncertainty interacted SVAR (Towbin and Weber, 2013)

Add uncertainty ($V_t$) and uncertainty-SPR policy interaction terms to the price equation

$$Y_t = B_0 + \sum_{i=1}^{40} (B_i Y_{t-i} + C_i Y_{t-i} V_t) + DV_t + e_t$$

where,

$$V_t = \text{WTI Spot Price Volatility (90-day)}$$
Uncertainty Model: Data

Oil Market Uncertainty Index

Volatility Index

Date


-2 0 2 4 6
Uncertainty Model

Use the $V^{high} = 90$th percentile volatility to estimate,

$$Y_t^{high} = \hat{F}^{high} + \sum_{i=1}^{40} \hat{G}_i^{high} Y_{t-i} + \hat{e}_t$$

where,

$$\hat{F}^{high} = \hat{B}_0 + \hat{D}V^{high}$$

$$\hat{G}_i^{high} = \hat{B}_i + \hat{C}_i V^{high}$$
Use the $V_{low} = 10$th percentile volatility to estimate,

$$
Y_{t \, low} = \hat{F}_{low} + \sum_{i=1}^{40} \hat{G}_{i \, low} Y_{t-i} + \hat{e}_t
$$

where,

$$
\hat{F}_{low} = \hat{B}_0 + \hat{D} V_{low}
$$

$$
\hat{G}_{i \, low} = \hat{B}_i + \hat{C}_i V_{low}
$$
Uncertainty Model: Results

SPR Purchase Impulse Response Functions

Low Volatility

High Volatility
Uncertainty Model: Results

SPR Release Impulse Response Functions

Low Volatility

High Volatility
Other mechanisms have been proposed in the literature (Considine, 2006):

- OPEC reduces production in response to SPR releases
- Gulf Coast commercial stocks absorb SPR releases
To find the effect of SPR policy on OPEC production and Gulf Coast crude oil stocks:

First, convert weekly structural shocks to monthly shocks,

\[ \hat{\varepsilon}_m^t = \frac{1}{4} \sum_{i=1}^{4} \hat{\varepsilon}_{it} \]

Then, regress OPEC production and regional stocks on monthly shocks,

\[
OPEC_t = \alpha + \sum_{i=0}^{9} \hat{\varepsilon}_m^t + u_t \\
\]

\[
Stocks_t = \alpha + \sum_{i=0}^{9} \hat{\varepsilon}_m^t + u_t 
\]
The SPR and Oil Prices

Introduction
SVAR
Robustness Checks
Instrument Event Study
Uncertainty Model
Other Mechanisms
Policy Implications

SPR-OPEC Impulse Response Functions
SPR-Gulf Coast Crude Stocks Impulse Response Functions
Policy Implications:

- Do not purchase oil for the SPR when oil market uncertainty is high
- If you want to lower oil prices, try another policy
Policy Implications:

- Coordinate strategic reserve purchases across countries
Thank You