BUFFER vs. SPECULATION: A REVIEW ON THE ROLE OF CRUDE OIL INVENTORY

Soohyeon Kim, Eunnyeong Heo
Energy, Environmental, and Engineering Economics
Seoul National University

40th IAEE International Conference, Singapore 2017
“A positive speculative demand will shift the demand for above-ground oil inventories, causing ... the level of inventories and the real price of oil to increase on impact.”

-Kilian and Murphy (2010, 2014)
“Crude oil inventories, buffer or speculation?”
To Positive Demand Shock (i.e., excess demand)
To Positive Supply Shock (i.e., oversupply)
## Literature Review

- Ample studies for inventories, but be biased to either buffer or speculation.

### Buffer


### Speculation


- No study has been asking whether oil inventories are buffer or speculative.
To examine the role and behavior of crude oil inventories by detecting whether oil inventories react to oil demand and supply shocks as the buffer to the market or as the facilitation of speculative trading.

Settings

- To positive demand shock (i.e., excess demand)
  - If inventories increase (+): speculative
  - If inventories decrease (-): buffer

- To positive supply shock (i.e., oversupply)
  - If inventories increase (+): buffer
  - If inventories decrease (-): speculative
Empirical Framework

- Structural vector autoregressive (SVAR) model with sign restrictions to allow economic interpretation of idiosyncratic demand and supply shocks

\[ A_0 y_t = A y_{t-1} + B \varepsilon_t, \quad \varepsilon_t \sim N(0, \Sigma_{\varepsilon}) \]

\[ y_t = [\text{production}_t, \text{economic activity}_t, \text{oil inventory}_t, \text{oil price}_t]' \]

\[ \varepsilon_t = [\text{supply shock}_t, \text{demand shock}_t, \text{storage shock}_t, \text{residual shock}_t] \]

- Restrictions for identification
  - Positive supply shock (i.e., oversupply) decreases oil prices
  - Positive demand shock (i.e., excess demand) increases oil price
Empirical Framework

- Bayesian approach
  - Sign restriction algorithm follows Rubio-Ramirez et al. (2010)'s rejection method, assuming a uniform Haar prior
  - For VAR parameters, Normal Inverted-Wishart posterior

- After estimating parameters of SVAR
  1) Impulse response functions (IRFs)
     - To measure how the inventories react over time to demand and supply shocks
  2) Forecast error variance decompositions (FEVDs)
     - To compare the relative contribution of each demand and supply shocks on oil inventories in percentage unit
### Data

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supply</strong></td>
<td>World crude oil production (EIA)</td>
</tr>
<tr>
<td><strong>Demand</strong></td>
<td>World economic activity</td>
</tr>
<tr>
<td></td>
<td>: Weighted average of industrial production in major oil consuming countries (OECD)</td>
</tr>
<tr>
<td><strong>Inventory</strong></td>
<td>1 Global</td>
</tr>
<tr>
<td></td>
<td>: Global commercial crude oil inventory proxy (IEA, EIA, OECD)</td>
</tr>
<tr>
<td></td>
<td>2 U.S.</td>
</tr>
<tr>
<td></td>
<td>: U.S. crude oil inventory excluding SPR (EIA)</td>
</tr>
<tr>
<td><strong>Price</strong></td>
<td>WTI futures real prices (EIA)</td>
</tr>
</tbody>
</table>
2003:M1-2008:M6

Demand shock

Supply shock

IRF

FEVD

30%

SPEC(5.7)  BUFF(-1.4)

24%

SPEC(-1.8)  BUFF(2.6)
2009:M7-2016:M2

**Demand shock**

- SPEC(0.4)
- BUFF(-1.0)

**Supply shock**

- SPEC(-4.4)
- BUFF(4.1)

FEVD:
- 19%
- 23%
“Crude oil inventories have Janus’ two faces”

- Time-varying behavior from speculation to buffer
- Speculation vs. buffer depends on periods and market conditions.
  - [2003-2008] speculative behavior was dominant to demand shock,
  - [2009-2016] supply shock strongly induced speculative and buffer behaviors of inventories.
This study have a contribution in examining both speculative and buffer roles from a neutral perspective.

The impact of oil inventories need to be determined with prudence, considering its varying role with period and market conditions.

Expanding regional scope of inventories to non-OECD can provide richer results.


Imposing sign restrictions on SVAR

- A white noise ($e_t$) in VAR is linear combination ($B$) of structural shocks ($\epsilon_t$) in SVAR
  
  \[ e_t = B\epsilon_t \]

- Sign restrictions ($Q$) are imposed ex-post on the IRFs of $\epsilon_t$
  
  \[ e_t = BQ\epsilon_t, \text{ such that } QQ' = Q'Q = I \]

- Generate IRFs of $\epsilon_t$ by Cholesky decomposition of $\Sigma_e$ and, Draw $Q$ following Rubio-Ramirez et al. (2010)
  
  - Randomly draw matrix $X$ of NID(0, 1), and obtain $Q$ by QR decomposition.
  - More generalized method than using Givens rotation matrix

- If the IRFs of $QX$ (IRFs of $\epsilon_t$) meet the restrictions, save them, unless drop them.
Impulse Response Functions

- How the inventories react over time to demand and supply shocks
- $X$: months after a shock ($x=0$), $Y$: impulse response of inventories
- The IRFs of SVAR are derived from the structural moving average representation

$$y_t = \sum \psi_i \varepsilon_{t-i}$$

- where $\psi_i$ measures the response of $y_{t+i}$ to $\varepsilon_i$. The sequence of $\{\psi_0, \psi_1, \ldots\}$ forms the IRFs.
The 68% confidence bands are plotted for the IRFs, following the convention from Sims and Zha (1999) and Uhlig (2005), the benchmark literature of SVAR approach.

The 68% confidence level is widely used in economic IRFs, especially, of SVAR studies, due to uncertainties arising from identification procedures.
Inventory Data: Global Crude Oil

- A proxy inventory is used to address the lack of open and accurate data.

- Proxy: the U.S. crude oil inventories from EIA are scaled by the ratio of OECD commercial petroleum inventories from EIA over U.S. petroleum inventories from IEA (Kilian and Murphy, 2014).

- Several limitations: the exclusion of non-OECD nations and the omission of hedge funds effect.

- Alternative: global above-ground crude oil inventory compiled by Energy Intelligence Group (EI), but proprietary!
Inventory Data: U.S. Crude Oil

- Because of the high liquidity in the U.S. oil market, the U.S. inventories are highly likely to reveal the distinctive patterns of speculative-buffer responses to oil demand and supply shocks compared to inventories from other countries, which thus best suits for our research purpose.

- In addition, considering the significant role that the U.S. plays in the global oil market, oil producers and traders around the globe pay particular attention to changes in the level of U.S. inventories and hence warrants the use of the variable in our modeling.

- U.S. Strategic Petroleum Reserve (SPR) is not included in our target oil inventory. Since the SPR is emergency storage to mitigate possible supply disruptions in the oil market, it is highly likely to show only its buffer behavior. The SPR level tend to be determined by political decisions, remaining stable mostly, which makes it improper to be analyzed in relation with fluctuant economic variables.