The Dynamics of Storage Costs

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Overview
We document that the monthly storage cost of oil averages 0.50% of the spot price and varies over time. We decompose the basis, defined as the ratio of the spread between the futures and spot prices over the spot price, into the storage cost (scc) and the adjusted convenience yield (acyc) channels. The scc dominates the mean of the basis and accounts for nearly half of its variations. We show that the scc predicts future inventory growth and is the main conduit through which the predictive power of the basis for oil spot returns arises.

Motivation
- Inventories play a central role in commodity theories, such as the theory of storage (Kaldor, 1939; Working, 1949).
- We know very little about the average cost of storing crude oil and its time series dynamics! No direct test in the literature.
- Main challenge of existing research: Data availability!
- We use a novel dataset of the Louisiana Offshore Oil Port (LOOP) sour crude oil storage futures (SFC) to construct a new storage cost measure.
- We seek to provide answers to several important questions, such as:
  1. What is the cost of storing oil for 1-month?
  2. Is the storage cost really constant as assumed by the literature?
  3. What are the key economic implications of the storage cost for (i) the futures–spot price spread (i.e. the basis)? (ii) the predictability of inventory growth? (iii) the predictability of spot returns?

Methodology
Cost-of-carry formula:

\[
F \times 1 + \frac{r_{F,S}}{12} = S + \frac{X_{S,F} - CY_{F,S}}{S}
\]

Re-arranging, we obtain the basis:

\[
basis = scc = acyc - \text{Carrying Costs}
\]

Dissecting the basis
- **Mean of the basis:**
  \[
  E(basis) = E(acyc) - E(carrying)
  \]
  \[
  100\% \cdot \frac{E(acyc) - E(carrying)}{E(basis)}
  \]
- **Variance of the basis:**
  \[
  \text{Var}(basis) = \text{Var}(acyc) - 2 \times \text{Cov}(basis, acyc) + \text{Var}(carrying)
  \]
  \[
  100\% \cdot \frac{\text{Var}(basis)}{\text{Var}(acity)}
  \]

Computation of core variables:
- **Basis**
  \[
  basis = \frac{F(t) - S(t)}{S(t)}
  \]
- **Storage Cost Channel**
  \[
  scc = \frac{X_{S,F} - CY_{F,S}}{S}
  \]
- **Adjusted Convenience Yield Channel**
  \[
  acyc = scc + basis
  \]

Data
- **Storage Futures Contracts (SFC) from Refinitiv Tick History**
  - Monthly expiration cycle
  - Same maturity as the crude oil futures
- **Gulf Coast Sour Crude Oil Futures** from Refinitiv Tick History
  - Sampling on the last trading day to obtain spot price
  - Sample period: January 2016 – December 2019

Time-Series Dynamics of the scc

- The scc displays considerable time-series variation. Challenge to standard assumption by the literature!

Basis Decomposition

<table>
<thead>
<tr>
<th>Panel A: Unconditional</th>
<th>Panel B: Backwardation</th>
<th>Panel C: Contango</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>scc</strong></td>
<td><strong>acyc</strong></td>
<td><strong>scc</strong></td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>281.05%</td>
<td>181.05%</td>
</tr>
<tr>
<td><strong>Variance</strong></td>
<td>45.35%</td>
<td>54.65%</td>
</tr>
</tbody>
</table>

- The scc contributes about half of the variation in the basis. Challenge to the assumption that storage costs display very little variations in the time-series dimension (Ga et al., 2020; Edgerington et al., 2021).
- The scc becomes dominant during contango periods, when the incentive to store is stronger.

Predictability of Inventory Growth

The theory of storage (Fama and French, 1987) implies that:

\[
E(scc(t+1)) = F(scc(t)) + \alpha \cdot scc(t) + \beta \cdot scc(t-1) + \gamma \cdot CY_{F,S} + \epsilon_{scc(t+1)}
\]

We estimate predictive regressions (also including controls):

\[
R_{F,S} = \alpha + \beta \cdot \text{basis} + \gamma \cdot CY_{F,S} + \epsilon_{F,S}
\]

**Panel A: Unconditional**
- \( \alpha = 2.241 \) (2.982)
- \( \beta = 4.475 \) (3.544)
- \( \gamma = 5.900 \) (3.544)

**Panel B: Backwardation**
- \( \alpha = -3.951 \) (-3.334)
- \( \beta = -3.288 \) (-3.288)
- \( \gamma = -0.499 \) (-0.499)

**Panel C: Contango**
- \( \alpha = 0.800 \) (0.900)
- \( \beta = -2.806 \) (-2.806)
- \( \gamma = 0.382 \) (0.382)

- The scc has significant predictive ability for future inventory growth. The effect is stronger during contango periods.

Spot Return Predictability

The theory of storage (Fama and French, 1987) implies that:

\[
E(scc(t+1)) = F(scc(t))
\]

We can easily show that:

\[
E(scc(t+1) = F(scc(t) + \text{basis})
\]

We estimate predictive regressions (also including controls):

\[
R_{F,S} = \alpha + \beta \cdot \text{basis} + \gamma \cdot scc(t) + \epsilon_{F,S}
\]

**Panel A: Unconditional**
- \( \alpha = 4.475 \) (3.544)
- \( \beta = -2.196 \) (-1.854)
- \( \gamma = 5.900 \) (3.544)

**Panel B: Backwardation**
- \( \alpha = -3.951 \) (-3.334)
- \( \beta = -1.420 \) (-1.292)
- \( \gamma = -0.499 \) (-0.499)

**Panel C: Contango**
- \( \alpha = 0.800 \) (0.900)
- \( \beta = -2.806 \) (-2.806)
- \( \gamma = 0.382 \) (0.382)

- The scc, rather than the acyc, is the main conduit through which the predictive power of the basis arises!
- The scc also predicts the returns of companies in the mid-stream segment of the oil industry.

- Challenge to the conventional wisdom in the literature that the predictive power of the commodity futures basis is driven by the the convenience yield!

Conclusions
- Using a novel dataset on LOOP sour crude oil storage futures, we construct a new measure of storage costs and explore its properties.
- The level of the storage cost is economically large and varies over time and over different market states.
- We decompose the basis into a storage cost channel (scc) and a convenience yield channel (acyc):
  - The scc dominates the level of the basis.
  - It explains about 45% of variations in the basis.
- We document the information content of the scc for:
  - Future inventory growth
  - Future spot return

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