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:

$$F_{t,t+1} = S_t + \underbrace{\underbrace{SFC_{t,t\to t+1}(1+r_{t,t\to t+1})^{1/12}}_{\text{Storage Costs}} + E_t\left(\underbrace{X_{t,t\to t+1}}_{\text{Other Costs}} - \underbrace{CY_{t,t\to t+1}}_{\text{Convenience Yield}}\right)}_{\text{Carrying Costs}}$$

Re-arranging, we obtain the basis:

$$\underbrace{\frac{F_{t,t+1}-S_t}{S_t}}_{basis_t} = \underbrace{\frac{SFC_{t,t\to t+1}(1+r_{t,t\to t+1})^{1/12}}{S_t}}_{scc_t} - \underbrace{E_t\left(\frac{CY_{t,t\to t+1}-X_{t,t\to t+1}}{S_t}\right)}_{acyc_t}$$

$$basis_t = scc_t - acyc_t$$

Dissecting the basis

✓ **Mean** of the basis:

$$E(basis_t) = E(scc_t) - E(acyc_t)$$

$$100\% = \frac{E(scc_t)}{E(basis_t)} - \frac{E(acyc_t)}{E(basis_t)}$$

✓ **Variance** of the basis:

$$Var(basis_t) = Var(scc_t - acyc_t)$$

$$100\% = \underbrace{\frac{Var(scc_t) - 2\times Cov(scc_t, acyc_t)}{Var(basis_t)}}_{\text{Var Cont}_{scc}} + \underbrace{\frac{Var(acyc_t)}{Var(basis_t)}}_{\text{Var Cont}_{acyc}}$$

Computation of core variables:

✓ **Basis** $basis_t = \frac{F_{t,t+1}-S_t}{S_t}$

✓ **Storage Cost Channel** $scc_t = \frac{SFC_{t,t\to t+1}(1+r_{t,t\to t+1})^{1/12}}{S_t}$

✓ **Adjusted Convenience Yield Channel** $acyc_t = scc_t - basis_t$

Data

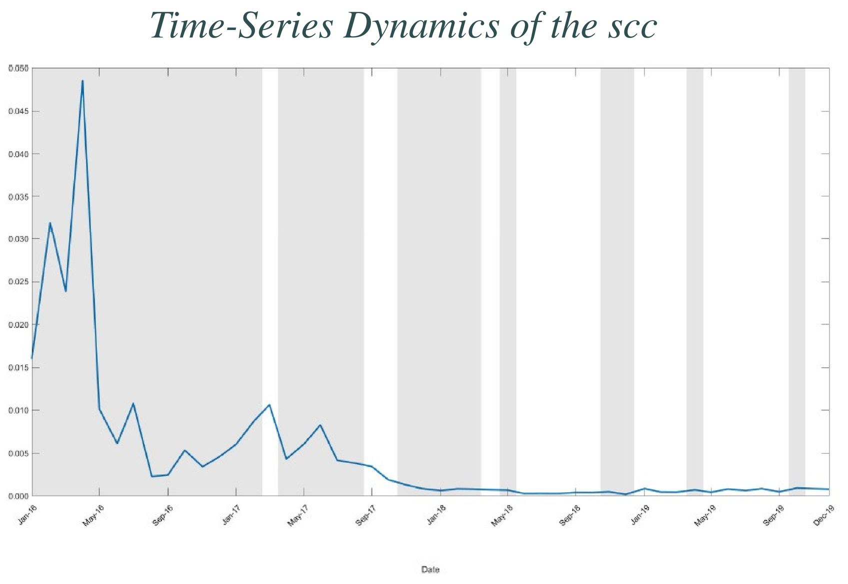
✓ **Storage Futures Contracts (SFC)** from Refinitv Tick History

– Monthly expiration cycle
– Same maturity as the crude oil futures

✓ **Gulf Coast Sour Crude Oil Futures** from Refinitv 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

Panel A: Unconditional		
	scc	acyc
Mean	281.05%	181.05%
Variance	45.35%	54.65%

Panel B: Backwardation		
	scc	acyc
Mean	-9.70%	-109.70%
Variance	-3.45%	103.45%

Panel C: Contango		
	scc	acyc
Mean	62.36%	-37.64%
Variance	76.34%	23.66%

✓ 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 (Gu et al., 2020; Ederington et al., 2021).

✓ The scc becomes dominant during contango periods, when the incentive to store is stronger.

Predictability of Inventory Growth

$$\%\Delta Inv_{t+1} = \alpha + \beta \times \%\Delta scc_t + \gamma \times Controls_t + e_{t+1}$$

$\%\Delta scc_t$	0.020	0.021	0.020				
	(2.802)	(2.728)	(2.157)				
$\%\Delta scc_t \times I_{\text{contango},t}$				0.042	0.042		
				(4.379)	(4.286)		
$\%\Delta scc_t \times I_{\text{backwardation},t}$				0.009	0.007		
				(1.877)	(1.376)		
$\%\Delta scc_t \times I_{\text{spare capacity}<q_{50},t}$						0.045	0.048
						(3.641)	(3.541)
$\%\Delta scc_t \times I_{\text{spare capacity}>q_{50},t}$						0.007	0.006
						(1.440)	(0.929)
$\%\Delta acyc_t$			-0.001		-0.001		-0.001
			(-3.951)		(-3.288)		(-3.527)
$\%\Delta imports_t$			0.015		0.011		-0.011
			(0.499)		(0.379)		(-0.377)
$\%\Delta refinery_t$			-0.179		-0.204		-0.180
			(-1.864)		(-2.334)		(-2.060)
$\%\Delta production_t$			0.331		0.283		0.180
			(2.751)		(2.358)		(1.373)
$\%\Delta I_t$		-0.060	0.042	-0.138	-0.033	-0.016	0.066
		(-0.491)	(0.290)	(-1.001)	(-0.215)	(-0.143)	(0.539)
Adj R^2	0.071	0.053	0.130	0.091	0.176	0.106	0.187

✓ 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: $E_t(S_{t+1}) = F_{t,t+1}$. It can easily be shown that:

$$E_t\left(\underbrace{\frac{S_{t+1}-S_t}{S_t}}_{R_{t+1}}\right) = \frac{F_{t,t+1}-S_t}{S_t} = basis_t$$

We estimate predictive regressions (also including controls):

$$R_{t+1} = \alpha + \beta \times basis_t + \epsilon_{t+1} \quad \text{(Recall that } basis_t = scc_t - acyc_t\text{)}$$
$$R_{t+1} = \alpha + \gamma \times scc_t + \delta \times acyc_t + \epsilon_{t+1}$$

$basis$	2.241						
	(2.382)						
scc		4.475		3.800	3.034		2.647
		(3.014)		(3.334)	(2.958)		(2.805)
$acyc$			-2.196	-1.420		-2.605	-2.335
			(-1.654)	(-1.292)		(-1.585)	(-1.445)
$relbasis$					-0.009	1.710	1.814
					(-0.014)	(1.102)	(1.207)
mom					-0.079	-0.105	-0.067
					(-1.458)	(-2.295)	(-1.354)
$basmom$					-0.050	-0.002	-0.013
					(-0.152)	(-0.006)	(-0.038)
Adj R^2	0.150	0.139	0.068	0.154	0.122	0.132	0.153

✓ 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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