Commodity Futures

Example: Light Sweet Crude Oil (WTI) Futures

3 options at expiration date or last trading day.

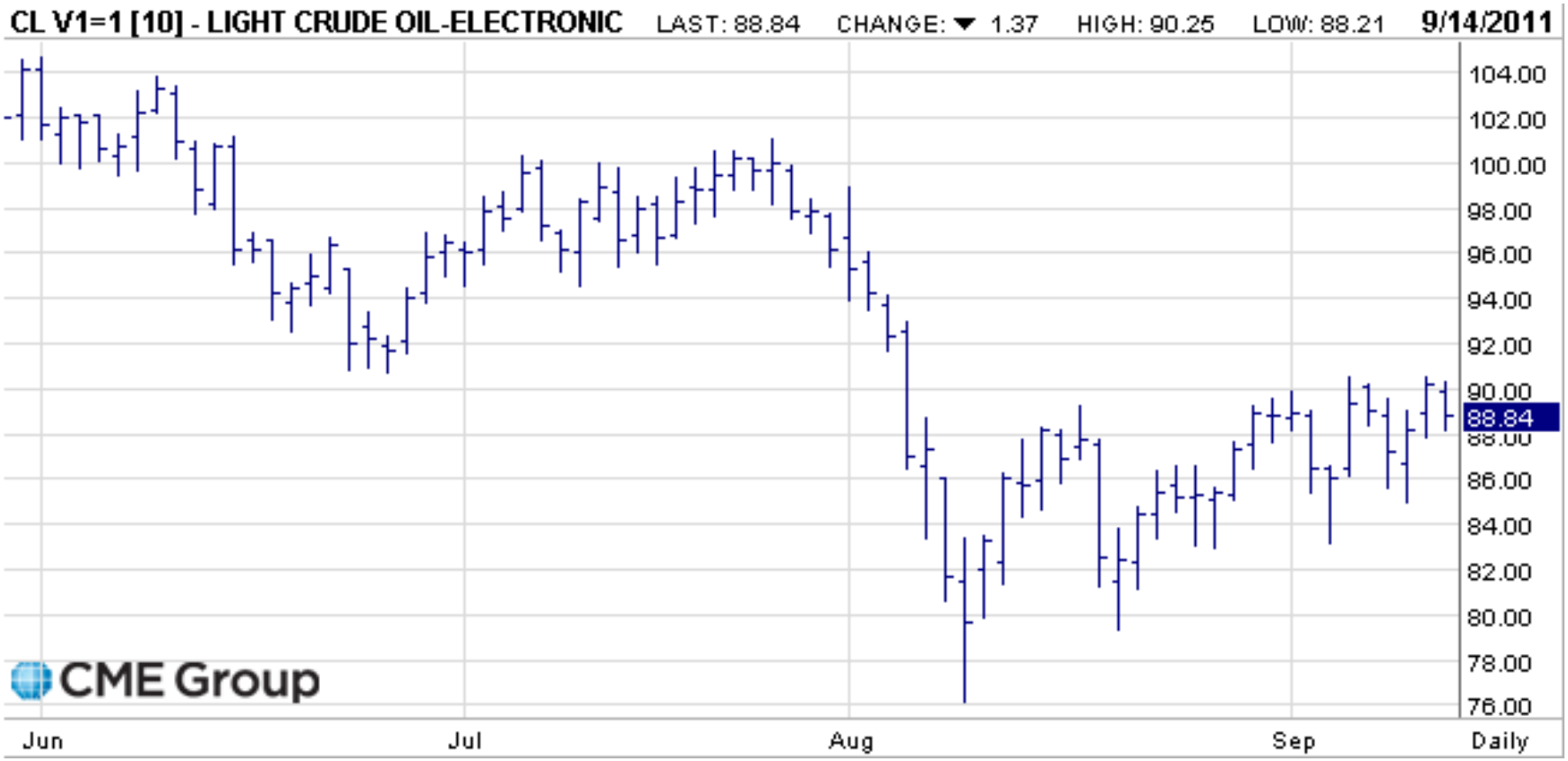
- Contract unit: 1,000 barrels

1. take/send delivery
2. flat the position by performing the opposite trade
3. rollover + rollout still requires flatting out the current position, just purchase in the similar future with a future exp date after flating

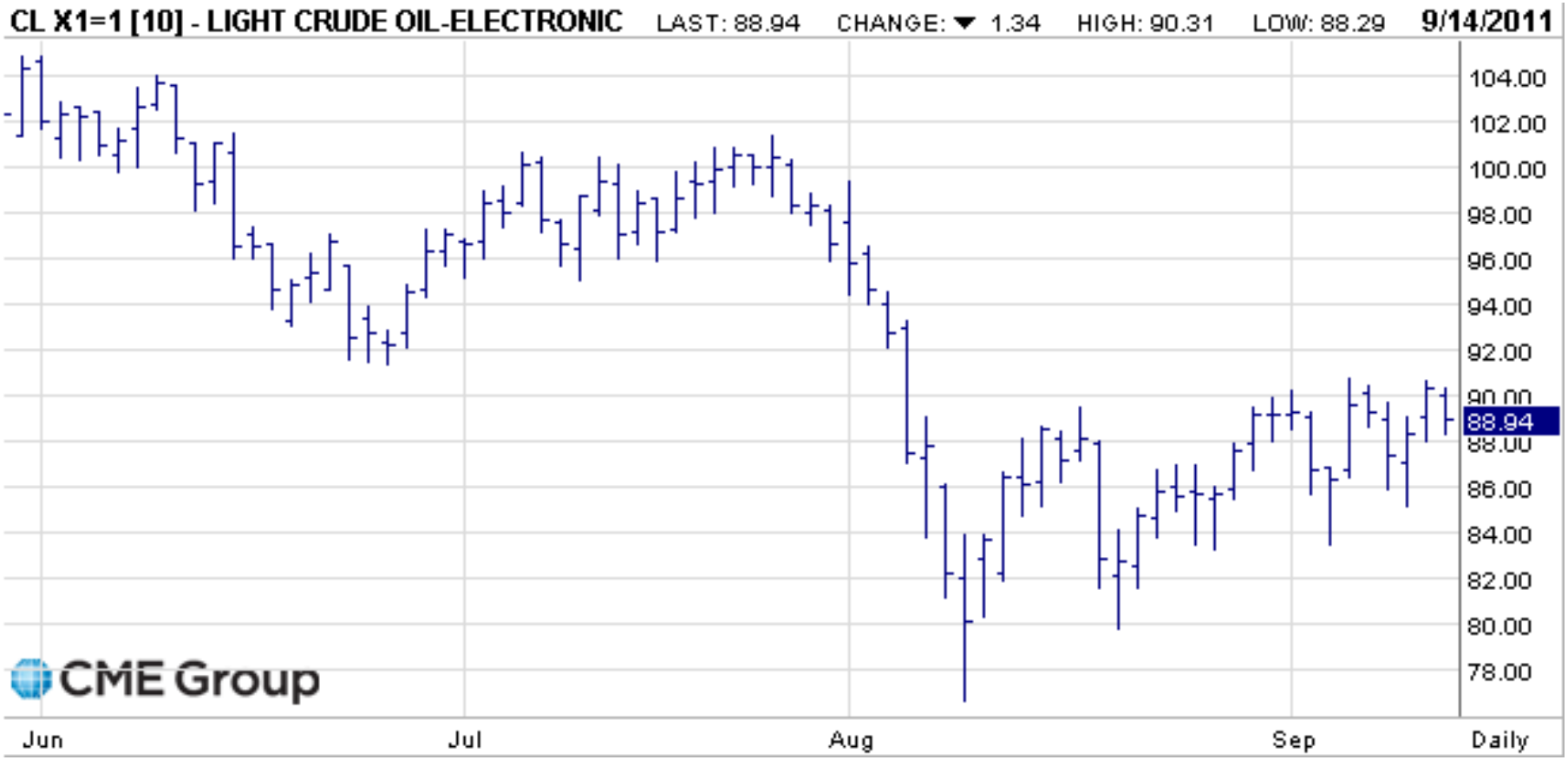
- Quote: dollars & cents per barrel
- Minimum size: $0.01 per barrel ($10)
- Listed contracts: consecutive months for the current year and next 5 years
- Delivery: Physical FOB (expenses for the seller) at any storage facility in Cushing OK with pipeline access to select facilities (TEPPCO), Cushing Storage, Equilon Pipeline Co.). Grade and quality are specified in the contract.
- Delivery on any day of the delivery month.
- Last trading date: last day of the month before the delivery month.

flat or rollover

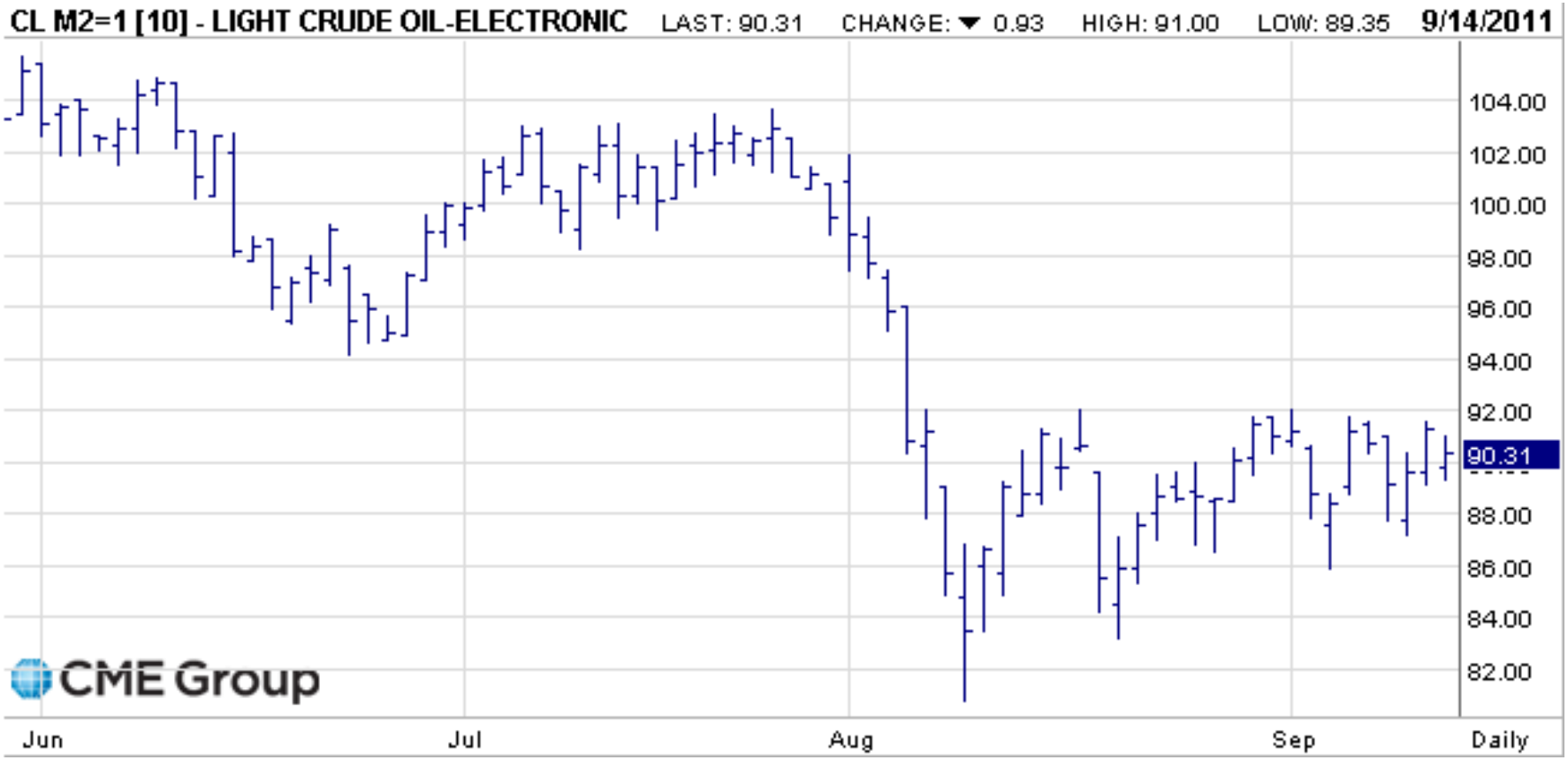
CL V1 (Oct 2011)



CL X1 (Nov 11)


CL X1=1 [10] - LIGHT CRUDE OIL-ELECTRONIC
LAST: 88.94
CHANGE: ▼ 1.34
HIGH: 90.31
LOW: 88.29
9/14/2011
104.00
102.00
100.00
98.00
96.00
94.00
92.00
90.00
88.94
88.00
86.00
84.00
82.00
80.00
78.00
CME Group
Jun
Jul
Aug
Sep
Daily

CL M2 (June 2012)



Term-structure of Futures

- The Term Structure of Futures (on a given contract) is the function which matches time-to-maturity with futures price

- The TS informs about several important characteristics of the product, such as

  -- convenience yield
  -- storage costs
  -- risk (volatility) in the spot market
  -- how events in the future are expected to affect the underlying spot price.

closer date = more open interest

Latest futures price quotes as of Tue, Sep 10th, 2019.

	Contract	Last	Change	Open	High	Low	Previous	Volume	Open Int	Time
+	CLY00 (Cash)	57.87s	+1.42	0.00	57.87	57.87	56.45	0	0	09/09/19
+	CLV19 (Oct '19)	57.40s	-0.45	58.03	58.76	57.20	57.85	718,610	299,951	09/10/19
+	CLX19 (Nov '19)	57.29s	-0.44	57.91	58.64	57.09	57.73	137,566	236,968	09/10/19
+	CLZ19 (Dec '19)	57.00s	-0.43	57.60	58.32	56.81	57.43	122,062	281,248	09/10/19
+	CLF20 (Jan '20)	56.60s	-0.43	57.13	57.90	56.43	57.03	42,175	152,164	09/10/19
+	CLG20 (Feb '20)	56.18s	-0.42	56.75	57.43	56.06	56.60	27,215	80,526	09/10/19
+	CLH20 (Mar '20)	55.78s	-0.40	56.27	56.99	55.70	56.18	28,126	111,633	09/10/19
+	CLJ20 (Apr '20)	55.38s	-0.40	56.02	56.54	55.26	55.78	12,744	52,647	09/10/19
+	CLK20 (May '20)	55.02s	-0.39	55.62	56.13	54.97	55.41	9,269	46,257	09/10/19
+	CLM20 (Jun '20)	54.68s	-0.38	55.19	55.81	54.54	55.06	40,781	171,474	09/10/19
+	CLN20 (Jul '20)	54.36s	-0.36	55.20	55.44	54.26	54.72	5,183	44,808	09/10/19
+	CLQ20 (Aug '20)	54.08s	-0.35	54.50	55.08	53.98	54.43	3,360	29,203	09/10/19
+	CLU20 (Sep '20)	53.82s	-0.33	54.28	54.83	53.82	54.15	7,130	54,424	09/10/19
+	CLV20 (Oct '20)	53.60s	-0.32	53.90	54.89	53.12	53.92	2,590	35,517	09/10/19
+	CLX20 (Nov '20)	53.42s	-0.29	54.23	54.23	53.42	53.71	2,899	25,295	09/10/19
+	CLZ20 (Dec '20)	53.26s	-0.27	53.60	54.22	53.14	53.53	52,593	175,119	09/10/19
+	CLF21 (Jan '21)	53.07s	-0.24	53.75	53.75	53.07	53.31	1,931	25,057	09/10/19
			-0.22	0.00	53.25	52.89	53.11	890	12,864	09/10/19

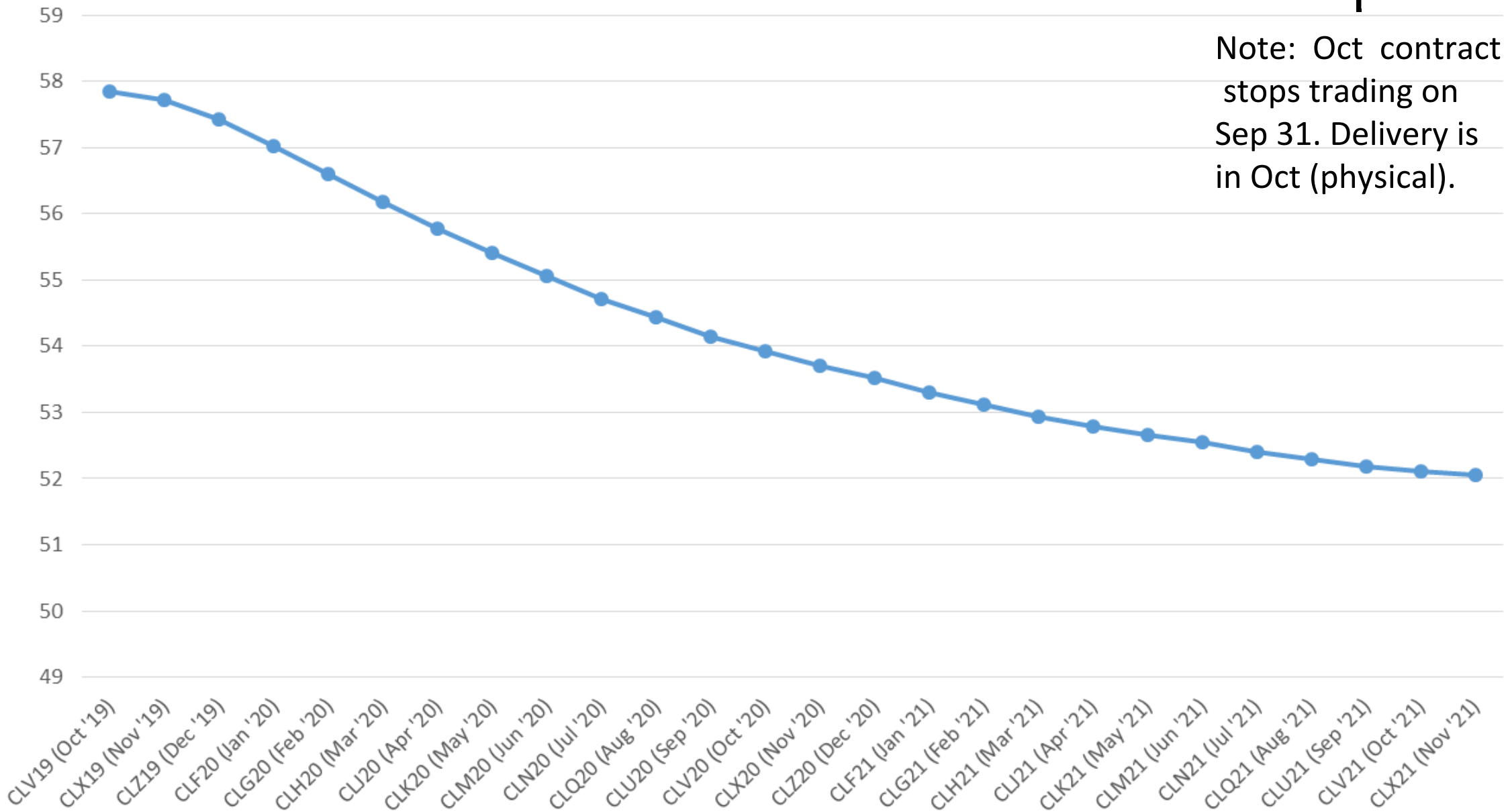
further date = less open interest

Backwardation

Close of Business Sep 10, 2019

CL (CME WTI Contract)

less backward today than before

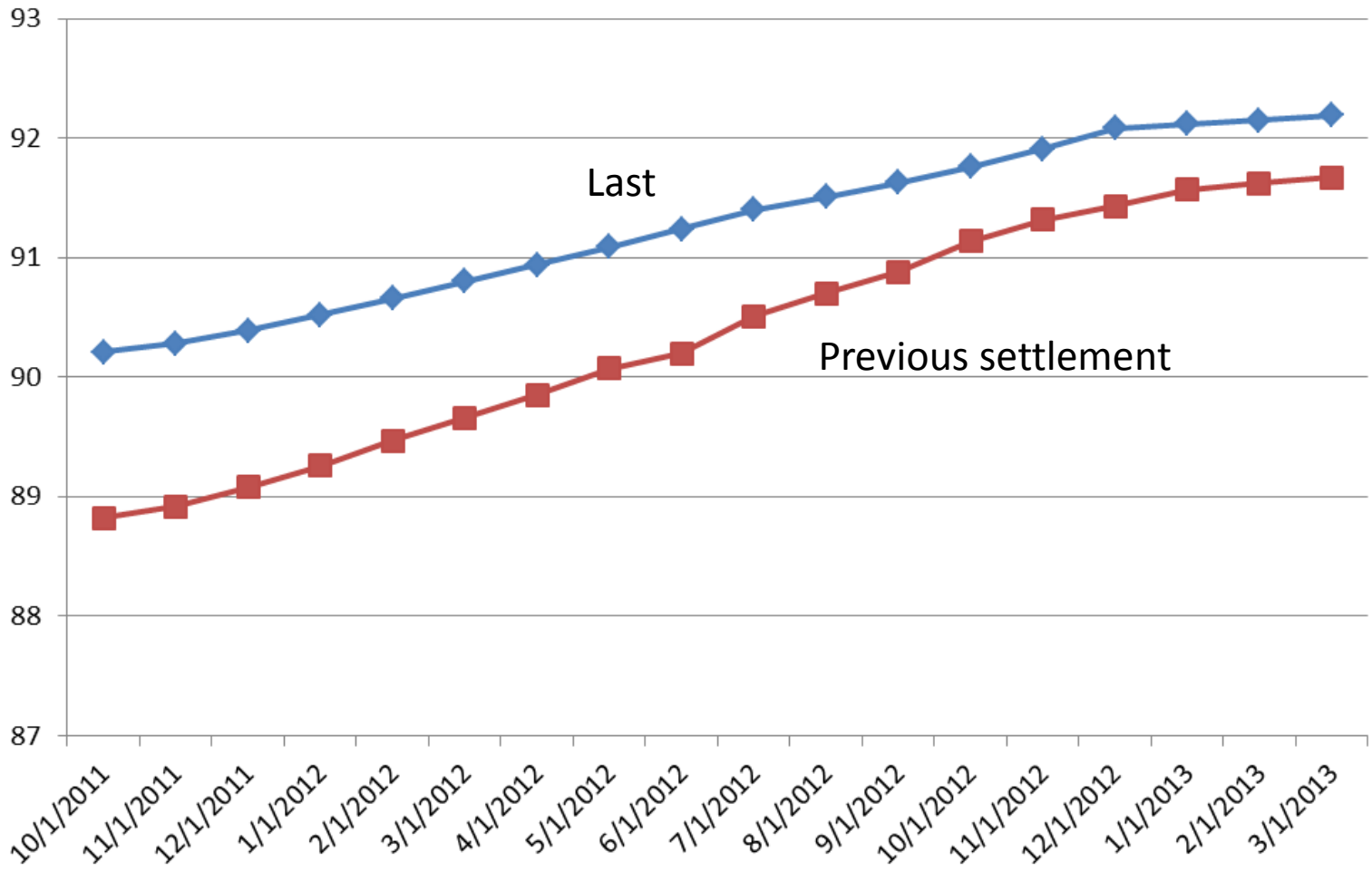


Note: Oct contract stops trading on Sep 31. Delivery is in Oct (physical).

contango

it has been mostly contango for the past 10+ years.

CL Term Structure: Sep 14, 2011



Theoretical Pricing

- No basis between futures and forwards, since commodity is not correlated to funding rate

- Cash & carry costs include transportation and storage and ``convenience'' of having oil to be able to deliver it and replace it later

$$q = (\text{convenience yield}) - (\text{transportation}) - (\text{storage costs})$$

similar as dividends

$$r = \text{term rate}$$

$$S_0 = \text{``spot''}$$

$$F_{0,T} = S_0 e^{(r-q)T}$$

if oil not very needed, $q < 0$ because the storage cost outran the convenience yield

- The shape of the forward curve depends on the supply/demand of oil on the ground and forecasts thereof.

Contango and Backwardation

- Contango: slope of the futures curve is increasing
- Backwardation: slope of the futures curve is decreasing

future price is higher because assume the common situation where I have to buy the spot now and store for some time to deliver and storage takes cost

Intuition: Contango holds when storage costs dominate the term structure (i.e. there is no shortage of crude in the spot market)

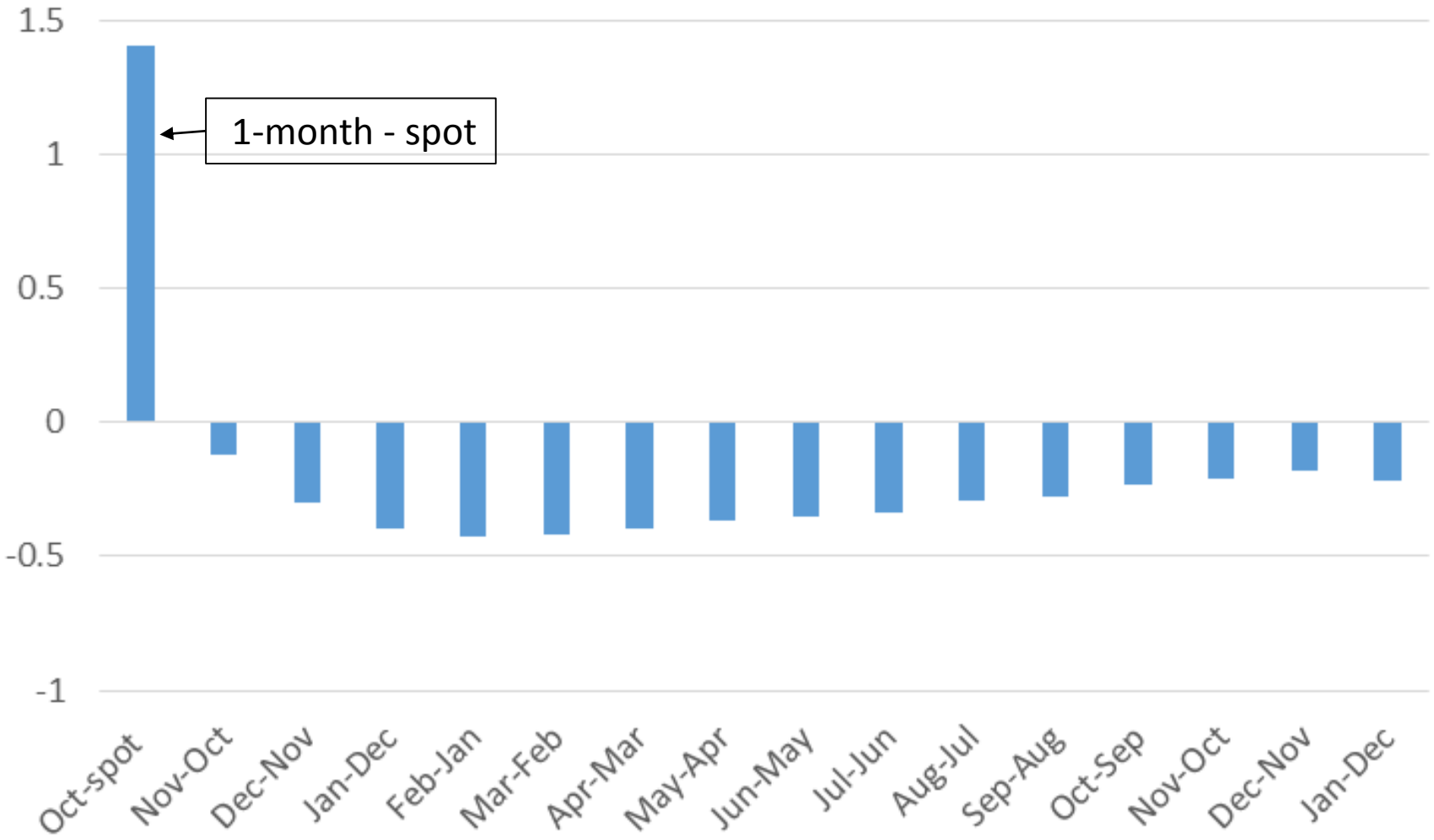
Backwardation is associated with high demand in the spot market, so that having oil now is more desirable than receiving it later. Low demand for storage.

future price is lower because in the future time the demand might drop to the normal

In a nutshell: backwardation arises when production cannot meet demand and contango when production can meet demand.

In oil crises, futures term structures are backwarded.

Differences (in $/ barrel) between successive month contracts (Spot= 56.45)



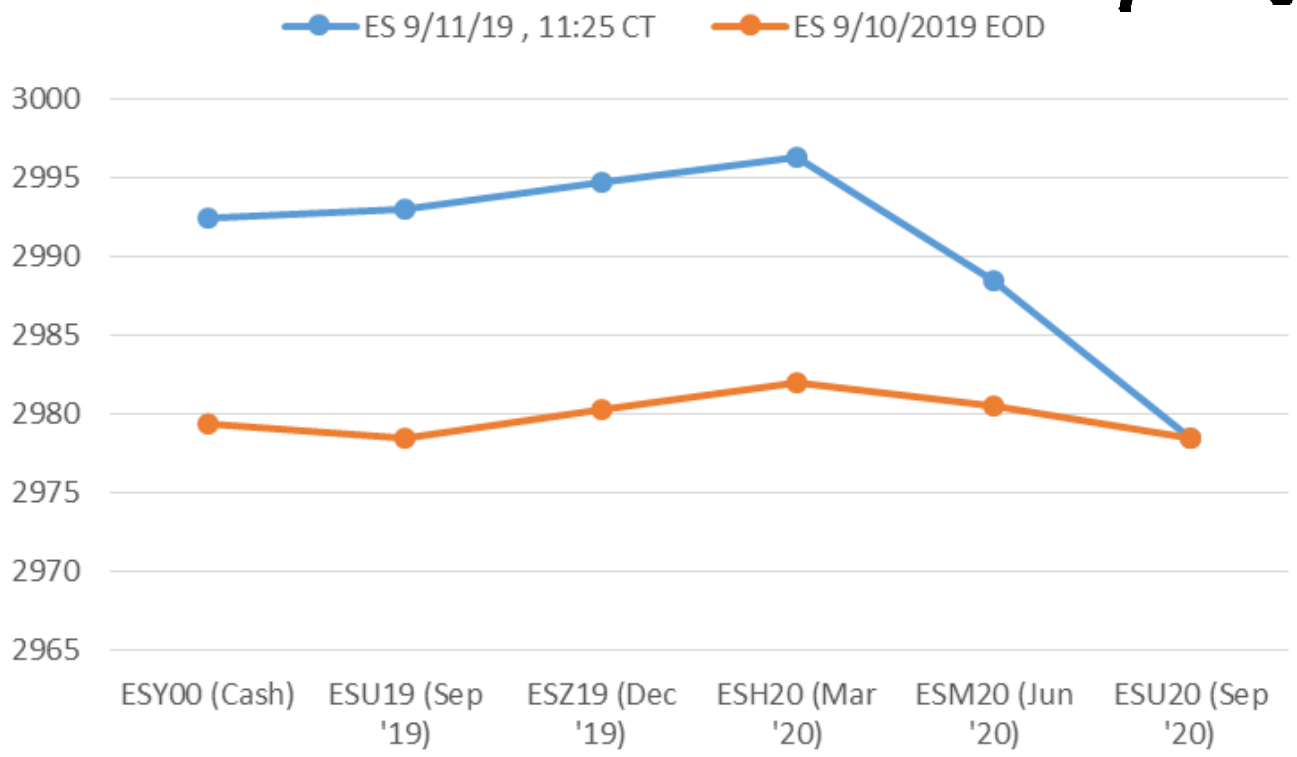
more data at EIA

WTI CL Term-structure

CLY00 (Cash)	57.87				Implied r-q	Implied Term r-q	
CLV19 (Oct '19)	57.4	1.4		1.4	(annualized)	(annualized)	Term
CLX19 (Nov '19)	57.29	-0.12	Nov-Oct	-0.12	-1.08%	-1.08%	Nov-Oct
CLZ19 (Dec '19)	57	-0.3	Dec-Nov	-0.3	-2.72%	-1.90%	Dec-Oct
CLF20 (Jan '20)	56.6	-0.4	Jan-Dec	-0.4	-3.64%	-2.48%	Jan-Oct
CLG20 (Feb '20)	56.18	-0.43	Feb-Jan	-0.43	-3.94%	-2.85%	Feb-Oct
CLH20 (Mar '20)	55.78	-0.42	Mar-Feb	-0.42	-3.88%	-3.05%	Mar-Oct
CLJ20 (Apr '20)	55.38	-0.4	Apr-Mar	-0.4	-3.72%	-3.16%	Apr-Oct
CLK20 (May '20)	55.02	-0.37	May-Apr	-0.37	-3.47%	-3.21%	May-Oct
CLM20 (Jun '20)	54.68	-0.35	Jun-May	-0.35	-3.30%	-3.22%	Jun--Oct
CLN20 (Jul '20)	54.36	-0.34	Jul-Jun	-0.34	-3.23%	-3.22%	Jul--Oct
CLQ20 (Aug '20)	54.08	-0.29	Aug-Jul	-0.29	-2.77%	-3.18%	Aug--Oct
CLU20 (Sep '20)	53.82	-0.28	Sep-Aug	-0.28	-2.69%	-3.13%	Sep-Oct
CLV20 (Oct '20)	53.6	-0.23	Oct-Sep	-0.23	-2.22%	-3.06%	Oct--Oct
CLX20 (Nov '20)	53.42	-0.21	Nov-Oct	-0.21	-2.03%	-2.98%	Nov -Oct
CLZ20 (Dec '20)	53.26	-0.18	Dec-Nov	-0.18	-1.75%	-2.89%	Dec-Oct
CLF21 (Jan '21)	53.07	-0.22	Jan-Dec	-0.22	-2.15%	-2.84%	Jan-Oct

E-mini S&P term structure

$$\frac{1}{T}\log\left(\frac{F_T}{S}\right) = r - q$$



Dividend yield (SPY, Yahoo finance)
= 1.85%

1-year Treasury rate
= 1.81%

Nominal r-d =
=1.81-1.85= -0.04%

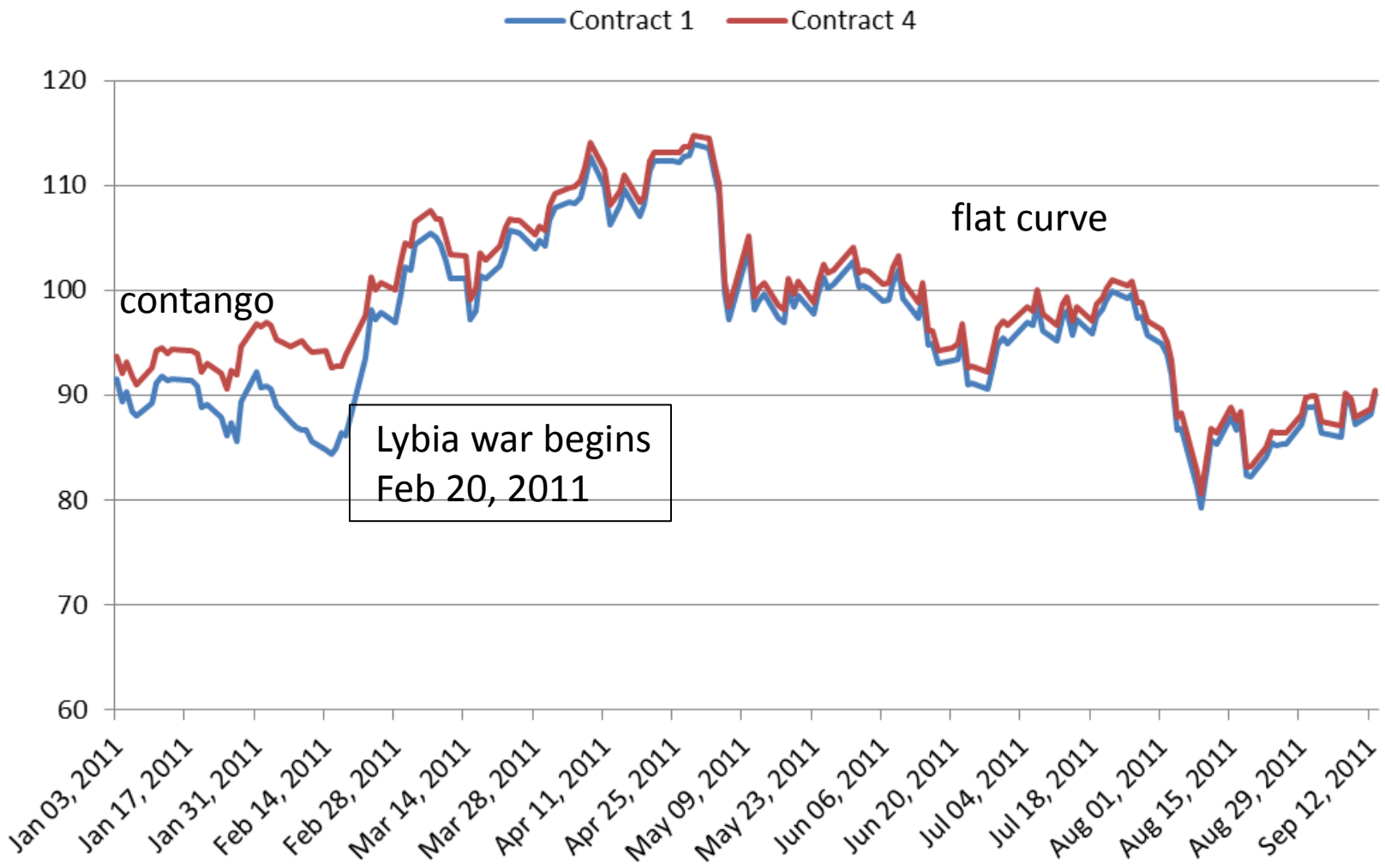
eMINI s&p	9/11/2019	11:25 cst		
Contract	Last	Previous	% Change	implied r-q (ANNUALIZED)
ESY00 (Cash)	2992.46	2979.39	0.44%	
ESU19 (Sep '19)	2993	2978.5	0.49%	0.00%
ESZ19 (Dec '19)	2994.75	2980.25	0.49%	0.02%
ESH20 (Mar '20)	2996.25	2982	0.48%	0.07%

E-Mini S&P Futures Term Structure (9/11/2019, downloaded 11:50 AM CT)

Contract	Last	Change	Previous	Volume	Open Int	Time
ESY00 (Cash)	2992	13.07	2979.39	-	-	11:37 CT
ESU19 (Sep '19)	2993	14.5	2978.5	876,331	2513360	11:37 CT
ESZ19 (Dec '19)	2995	14.5	2980.25	71,641	209453	11:36 CT
ESH20 (Mar '20)	2996	14.25	2982	180	8724	11:25 CT
ESM20 (Jun '20)	2989	8	2980.5	2	1911	10:25 CT
ESU20 (Sep '20)	2979	0	2978.5	1	6	9/10/2019

when you build the curves, you need to think of the liquidity.

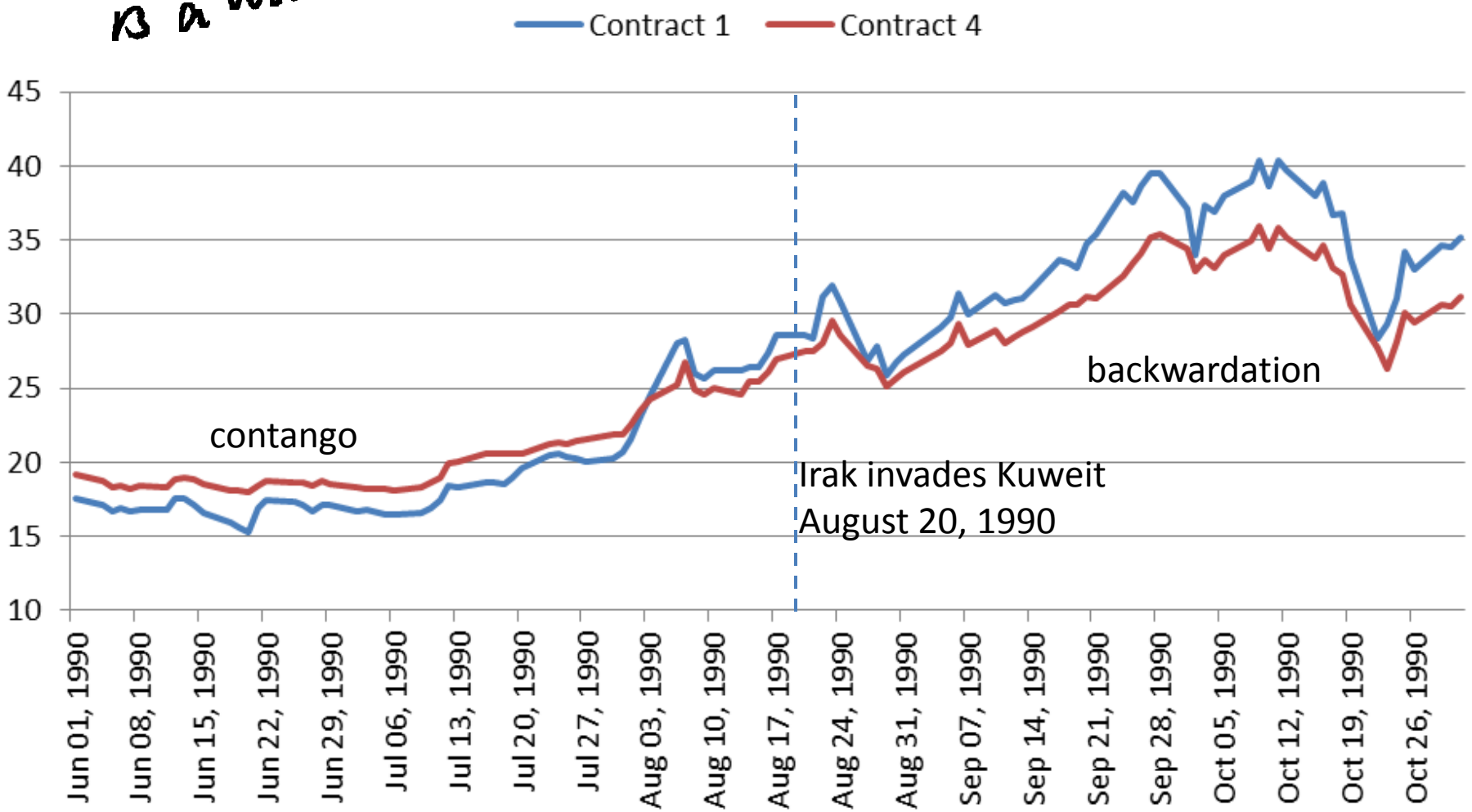
1st and 4th Month CL contracts in 2011



(source: Energy Information Administration)

CL1 and CL4 around the Kuweit war (1990)

backwardation when there is a war



Rolling futures

- Rolling futures means moving from one contract to another as time passes to generate a constant-maturity position across time.
- Application: this allows traders to maintain exposure to the underlying commodity beyond the first expiration.
- Example: the USO (United States Oil Trust) is an ETF (exchange-traded fund) which invests in a rolled futures strategy in CL1 / CL2.

$$I_t = USO,\ F_t^1 = CL1,\ F_t^2 = CL2$$

$$a_t = \text{fraction of the funds invested notionally in } CL1$$

$$\frac{\Delta I_t}{I_t} = \frac{I_{t+1} - I_t}{I_t} = a_t \frac{\Delta F_t^1}{F_t^1} + (1 - a_t) \frac{\Delta F_t^2}{F_t^2} + r\Delta t$$

Rolling futures gives rise to a ``drift'' relative to spot

Long + contango.

$$\frac{\Delta I_t}{I_t} = a_t \frac{\Delta F_t^1}{F_t^1} + (1-a_t)\frac{\Delta F_t^2}{F_t^2} + r\Delta t$$

Cash not doing as well as commodity

$$F_t^i = S_t e^{(r-q_i)(T-t_i)} \qquad \therefore \qquad \frac{\Delta F_t^i}{F_t^i} = \frac{\Delta S_t}{S_t} - (r-q_i)\Delta t$$

$$\frac{\Delta I_t}{I_t} = a_t\left(\frac{\Delta S_t}{S_t} - (r-q_1)\Delta t\right) + (1-a_t)\left(\frac{\Delta S_t}{S_t} - (r-q_2)\Delta t\right) + r\Delta t$$

$$= \frac{\Delta S_t}{S_t} - r\Delta t + \left(a_t q_1 + (1-a_t)q_2\right)\Delta t + r\Delta t$$

ETF

$$= \frac{\Delta S_t}{S_t} + \left(a_t q_1 + (1-a_t)q_2\right)\Delta t$$

commodity.

Slope, drift and the performance of rolled strategies

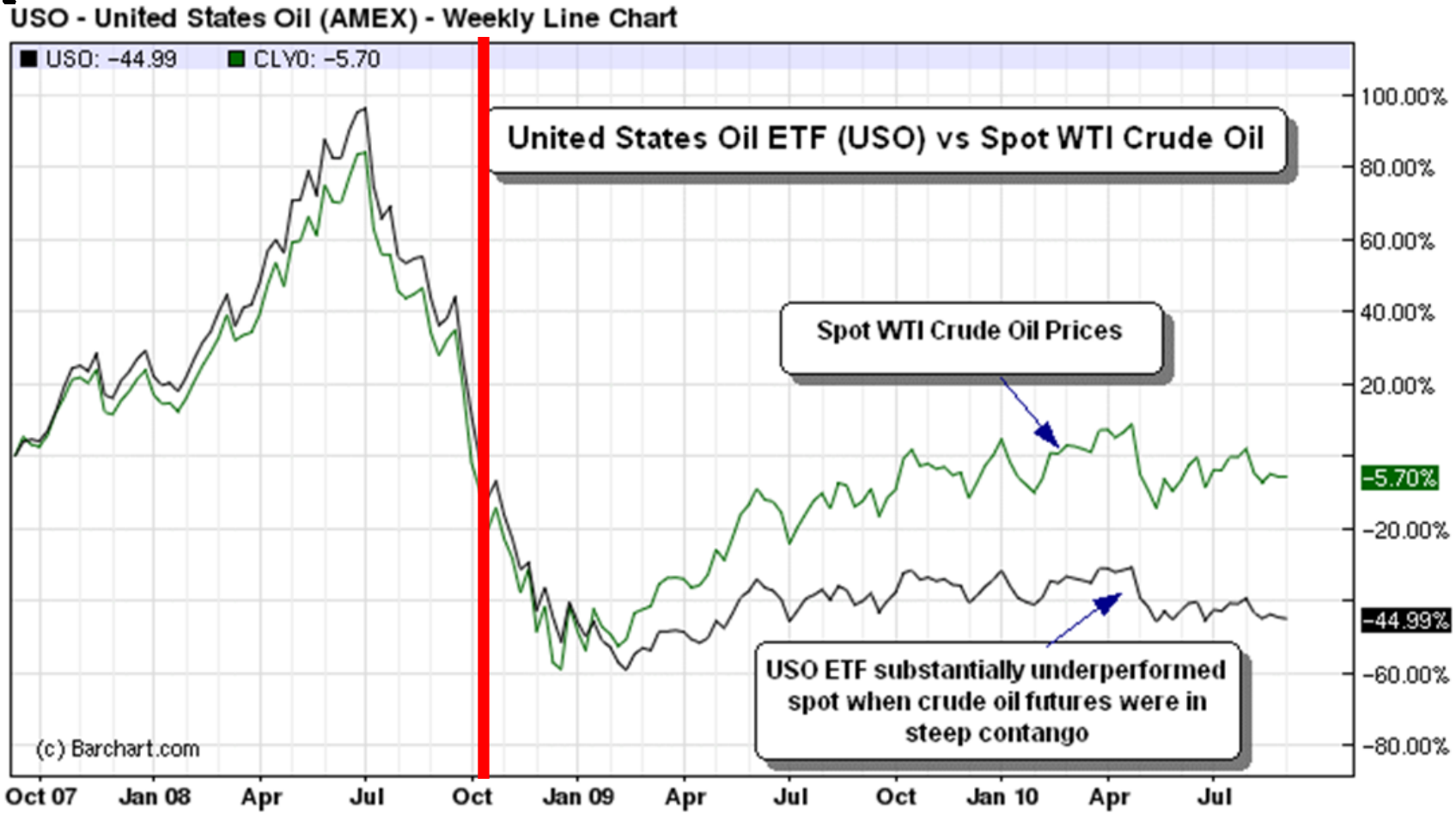
- If $q < 0$ – i.e., low convenience yield, high storage costs, contango situation the rolled future strategy under-performs the commodity

- If $q>0$ -- i.e. high convenience yield, storage costs are low compared to the demand for crude, the rolled strategy outperforms crude

- Conclusion: rolled futures funds like USO should underperform the commodity in times when there is contango (upward sloping futures curve)

arbitrage is limited by rede

USO Fund vs Spot WTI



Implied r-q from ratio between CL4 and CL1