Price Adjustment and Competition in US Strategic Petroleum Reserve Drawdowns

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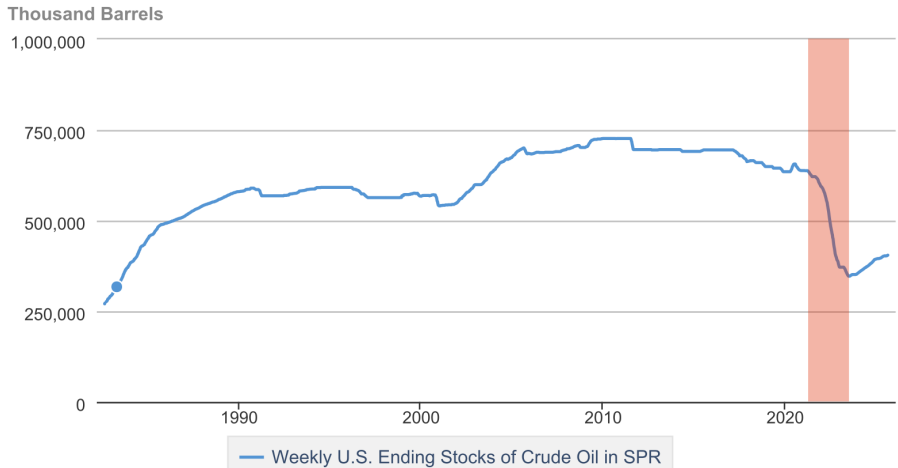
Weekly U.S. Ending Stocks of Crude Oil in SPR



eia Data source: U.S. Energy Information Administration

How DOE sells oil from the SPR

- SPR releases are structured as parallel, pay-as-bid multiunit auctions
- Lots are differentiated by quality, location, and **delivery window**
  - In 2022: on average, five weeks between auction date and earliest delivery
- Bids are expressed as a **basis** relative to a floating oil price index
  - Upon delivery a winning bidder pays his bid **plus** the current index price

Why basis auctions?

1. Transforms a common values auction into a private values auction
    - Improves revenue (by mitigating winner's curse, reducing info rents)
    - Reduces dependence of allocations on beliefs about oil prices

2. Reduces winners' incentives for ex post default if prices fall

Empirical analysis

1. Statistical tests for common values in 2022 bidding data
   - Reduced form test of common values (Nyborg et al 2002; Bjønnes 2001)
   - Reduced form test of IPV (Hickman, Hubbard, Richert 2021)

   $\Rightarrow$ **Conclude that results are consistent with pure private values**

2. Calibration exercise
   - Based on a uniform price auction model from Vives (2011)

   $\Rightarrow$ **Plausible 2022 revenue benefits in excess of $100M**

Research context

- Long term contracts are ubiquitous
  - Not least in energy markets (coal supply, pipeline capacity, wholesale electricity)
- Many long term contracts feature explicit **price adjustment** mechanisms
  - Limits incentive to breach/renegotiate or shirk as opportunity costs evolve
  - Prevents arms races for information
  - Early contributions: Goldberg (1985), Goldberg and Erickson (1987), Joskow (1988)
- With price adjustment, contracting resembles a **contingent payment auction**
  - Limits info rents (Hansen 1985, Riley 1988) and adverse selection (Skrzypacz 2013)

Setup

- I oil refiners each having unit demand
- W is an index price for crude oil (e.g., WTI Houston)
- Absent the SPR sale, i can purchase on the open market at $W + Z + u_i$
  - u_i is an idiosyncratic *opportunity cost* privately known to i (his *cost basis*)
  - Z is another common cost shifter (e.g., tracking error in the index price)
- i observes private signals (w_i, z_i) of (W, Z)

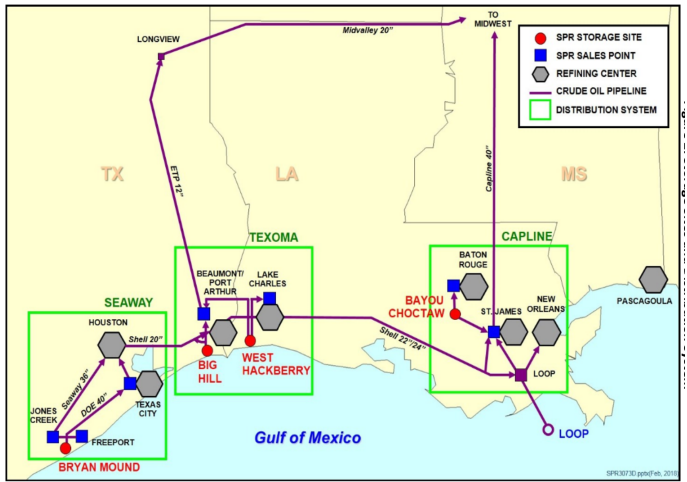
Summary of results

- **If $Z = 0$ almost surely:**

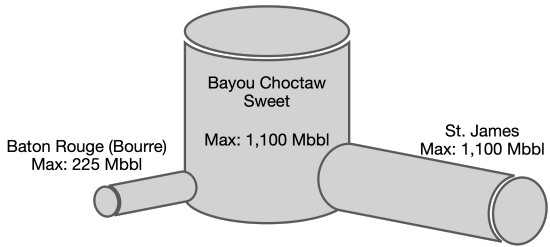
Fixed Price Auction	Basis Auction
• Winner pays b upon delivery	• Winner pays b plus w upon delivery
1. Has a common component	1. Does not have a common component
2. Max realization of $s_i = w_i/N + u_i$ wins	2. Max realization of u_i wins
3. Strong incentive for ex post default	3. No incentive for ex post default

- **Otherwise:** Basis auction can still have a common component.

SPR system map

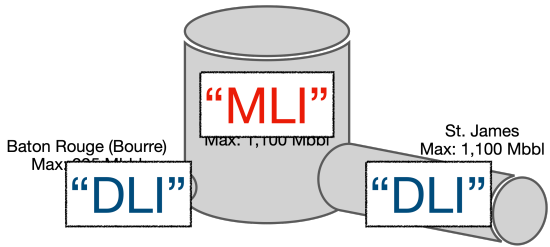


Point-of-sale constraints



- A bid specifies both a crude oil "stream" (site-type) and a point-of-sale
- Bids cleared from high-to-low by stream up to point-of-sale constraints

Point-of-sale constraints



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Summary statistics (sample means)

	Sweet Crude			Sour Crude		
	Per DLI (Pipeline)	Per DLI (Vessel)	Per MLI	Per DLI (Pipeline)	Per DLI (Vessel)	Per MLI
Number of bidders	6.10	4.89	10.91	4.05	3.69	8.00
Number of bids	19.65	5.67	40.36	13.82	6.31	27.57
Number of winning bidders	3.30	1.11	6.00	2.36	1.23	4.36
Number of winning bids	8.55	1.25	16.45	7.71	3.20	13.86
Total quantity demanded	9906.75	2961.11	23962.27	7559.77	3880.38	16272.14
Total quantity sold	3825.00	643.75	7422.73	3927.14	1654.00	7072.14
Maximum winning PAF	0.42	-2.21	1.19	1.28	0.90	1.85
Average winning PAF	-0.76	-2.23	-0.93	0.23	0.06	-0.08
Minimum winning PAF	-2.03	-2.24	-2.89	-0.56	-0.58	-1.44
Nominal reserve PAF (5% BRP)	-5.12	-5.06	-5.13	-5.18	-5.21	-5.15

Notes: 2022 SPR drawdown bidding data. Includes all bids. (1) PAF refers to price adjustment factor; (2) Bid quantities are expressed in thousands of barrels (Mbbl).

Overview

- **Goal:** test for common values in the SPR bidding data
  - Absence of an empirically significant Z is consistent with model
  - Reduced form approach

- **Caveat:** $\not\Rightarrow$ DOE's basis auction *eliminated* common value uncertainty

Nyborg-Bjønnes Test: Motivation

Nyborg Rydqvist Sundaresan (2002, JPE)

- $\uparrow$ uncertainty worsens winner's curse / "champion's plague"
- $\uparrow$ uncertainty $\Rightarrow$ lower, steeper bid schedules
- Bjønnes (2001): N can disentangle contribution of risk aversion

- How to measure uncertainty?
  1. Days elapsed from auction until delivery
  2. An oil price volatility index (CBOE OVX)

Nyborg-Bjønnes Test: Results

	Dependent variable:					
	Mean PAF		Std. PAF	Mean PAF		Std. PAF
	(1)	(2)	(3)	(4)	(5)	(6)
Days Until Delivery	0.030	0.036	−0.007			
	(0.022)	(0.025)	(0.005)			
Volatility Index (OVX)				0.023	0.042	0.014*
				(0.040)	(0.028)	(0.008)
Sweet Crude	−2.037	−2.372**	0.139	−2.149*	−2.310***	0.084
	(1.330)	(1.127)	(0.406)	(1.237)	(0.826)	(0.359)
Vessel DLI	−2.815***	−2.720***	0.042	−2.809***	−2.701***	0.009
	(0.787)	(0.587)	(0.179)	(0.739)	(0.484)	(0.170)
Unit of Observation	Bidder-Tranche	Tranche	Bidder-Tranche	Bidder-Tranche	Tranche	Bidder-Tranche
Observations	268	54	268	268	54	268
Adjusted R^2	0.058	0.206	0.055	0.067	0.253	0.066

*p<0.1; **p<0.05; ***p<0.01

Notes: (1) Covariates omitted for space: N, tranche size, intercept. All regression instrument for N using storage site location. First stage F statistic: 8.11; (2) Means and standard deviations of price adjustment factors (PAFs) are weighted by bid quantity; (3) Volatility Index (OVX) is the closing price of the CBOE Crude Oil Volatility Index on the auction date; (4) Observations are weighted by uncertainty (Days Until Delivery in (1)-(3), Volatility Index (OVX) in (4)-(6); (5) Table reports unclustered heteroskedasticity-robust standard errors.

HHR (2021) Test: Motivation

Hickman Hubbard Richert (2021)

- Under the null of IPV in the absence of UH, there should be no residual correlation in bids after (flexibly) controlling for N and other observables
- Evidence of good power against APV, CIPV, IPV-UH in single unit auctions
- Extended to multiunit (uniform price) auction in Richert (2024)

- **Implementation:** regress bid intercepts on means of rival's bid intercepts
  - Numerical simulations to investigate power

HHR (2021) Test: Results

	(1)	(2)
Mean Rival PAF	0.019	−0.056
	(0.087)	(0.090)
Sweet Crude	0.180	−0.565
	(0.715)	(0.467)
Vessel DLI	−1.876***	−1.660***
	(0.682)	(0.439)
Constant	−2.001**	−1.553***
	(0.779)	(0.520)
Polynomial in N	Cubic	Cubic
Restricted Sample	Yes	No
Observations	144	217
R^2	0.087	0.088
F Statistic	2.170** (df = 6; 137)	3.383*** (df = 6; 210)

*p<0.1; **p<0.05; ***p<0.01

Notes: (1) Restricted sample excludes auctions with any bids stipulating high minimum quantities; (2) Table reports unclustered heteroskedasticity-robust standard errors.

Summing up

1. Fail to find evidence of private information with Nyborg/Bjønnes Test

2. Fail to reject IPV with HHR Test
   - Null result but arguably informative given stringency of test

- **No smoking gun.** But results are consistent with $Z \approx 0$

Overview

- Question: what was the revenue impact of using basis auctions in 2022?

- Two problems:
  1. If model is correct, data reveals nothing about counterfactual private information
  2. Theory gives little guidance on pay-as-bid auctions with mixed information structures

- Strategy:
  1. Calibrate the Vives (2010, 2011) uniform price auction model to the data
  2. Use model to predict revenue impacts for different levels of private information

Calibration: Key Results

1. With a fixed price auction, correlation in bidder valuations exceeds 0.70

2. Average revenue gain exceeds $100M for a wide range of info structures
   - Whenever counterfactual adverse selection is present but not too severe

Conclusion

- I investigate the role of price adjustment in SPR release auctions
- Simple theory model illustrates why DOE might prefer price adjustment
- Evidence from statistical tests is consistent with absence of CV uncertainty
- Choice of format potentially has large revenue impacts (and other effects)

Thank you!

Questions/comments: matthew.okeefe@vanderbilt.edu

Mean Delivery Index Price (DIP) vs. Base Reference Price (BRP)

		Sweet Crude			Sour Crude		
Date of Sale	Delivery Window	BRP	DIP	% Δ	BRP	DIP	% Δ
2022-03-08	24-84 days	95.15	106.99	12.44	92.60	103.76	12.06
2022-04-12	33-79 days	111.00	116.57	5.02	106.28	108.34	1.93
2022-06-01	20-75 days	113.39	110.51	-2.54	108.81	94.54	-13.11
2022-06-28	49-94 days	121.42	89.15	-26.58	114.21	85.47	-25.16
2022-08-02	45-80 days	103.68	87.39	-15.71	97.61	82.77	-15.20
2022-09-27	35-64 days	89.45	87.56	-2.12			
2022-10-25	37-67 days	89.91	77.07	-14.28	83.86	71.39	-14.87

Notes: (1) Delivery index price is calculated from daily closing prices of Bloomberg tickers USCRMEHC (Crude Oil WTI Houston) and USCRMARS (Crude Oil Mars), see main test for discussion; (2) Base reference prices are obtained from auction-specific Notices of Sale; (3) Delivery windows vary by MLI and DLI, the maximum range is recorded.

Correlations between Bids and Uncertainty (Full)

	Dependent variable:					
	Mean PAF		Std. PAF	Mean PAF		Std. PAF
	(1)	(2)	(3)	(4)	(5)	(6)
Days Until Delivery	0.030	0.036	−0.007			
	(0.022)	(0.025)	(0.005)			
Volatility Index (OVX)				0.023	0.042	0.014*
				(0.040)	(0.028)	(0.008)
N	0.523	0.680	−0.087	0.589	0.668	−0.061
	(0.553)	(0.504)	(0.151)	(0.514)	(0.421)	(0.127)
Sweet Crude	−2.037	−2.372**	0.139	−2.149*	−2.310***	0.084
	(1.330)	(1.127)	(0.406)	(1.237)	(0.826)	(0.359)
Vessel DLI	−2.815***	−2.720***	0.042	−2.809***	−2.701***	0.009
	(0.787)	(0.587)	(0.179)	(0.739)	(0.484)	(0.170)
Tranche Size (MMbbl)	−0.594*	−0.711**	0.109	−0.641**	−0.729***	0.091
	(0.329)	(0.303)	(0.086)	(0.308)	(0.256)	(0.076)
Constant	−3.431*	−3.997*	0.834**	−3.046	−4.020*	−0.345
	(1.938)	(2.216)	(0.362)	(2.405)	(2.056)	(0.388)
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