Decomposing Crude Price Differentials – Domestic Shipping Constraints or the Crude Oil Export Ban.

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Energy Policy and Conservation Act (EPCA)

- 1973 Oil Crisis – OPEC proclaimed an embargo on oil that lasted from October 1973 to March of 1974.
- December 1975 – President Ford signed the Energy Policy and Conservation Act (EPCA).
  - Section 103 prohibited the export of crude oil and natural gas.
  - EPCA created a Strategic Petroleum Reserve.
- December of 2015 – Export ban lifted as part of omnibus spending bill.

The recent "shale boom" has been the catalyst for this policy change.

Economic Benefits

As the export ban's lifting was considered, there were a number of studies on the economic implications. Some of these studies claimed large economic benefits if the ban were to be lifted:

- IHS, 2014
  - Increase crude production by **3 million B/D**.
  - Spur **$750 billion** of new investments.
  - Increase GDP by **$135 billion** and per household income by **$391**.
  - Create almost **1 million jobs** at export ban removal's peak.
- Brookings, 2014
  - Increase U.S. GDP by between **$600 billion** and **$1.8 trillion** (NPV through 2039).
  - Create **200,000 to 400,000 jobs** annually between 2015 and 2020.
- ICF International, 2014
  - **$70.2 billion** in new investments by 2020.
  - **500,000 B/D** increase in domestic production.
  - **300,000 new jobs** in 2020.
  - **$38.1 billion** in GDP gains in 2020.

Economic Benefits

All of these economic benefits are based on the following logic:

- Domestic crude priced at discount to foreign crude
- Remove export ban $\Rightarrow$ Higher price for domestic producers $\Rightarrow$ Increased in production $\Rightarrow$ Economic benefits

But consider two facts:

- Gulf Coast crudes (such as LLS) did not see the same level of discounting as mid-continent crudes (such as WTI)
- By the time the export ban was lifted, the price differential between Brent and WTI had already been reduced substantially.

Price Differentials

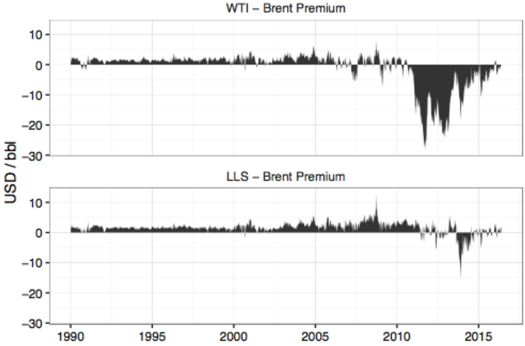


Figure 1: WTI and LLS premia over Brent

Research Question

The WTI–Brent price differential could have been caused by two different constraints:

- The export ban, which constrained domestic producers from shipping their crude abroad and forced them to sell to refineries built to handle a crude oil "diet" with a lower share of the light-tight oil (LTO) from U.S. unconventional drilling.
- Insufficient domestic pipeline capacity that caused internal transportation.

How much did each constraint contribute to the price differential?

Hypothesis

Understanding the impact of the export ban on U.S. crude oil prices and, through these, production, requires understanding *why* the WTI–Brent discount arose.

- The degree to which this discount was due to a constraint on *external* trade (the ban) or *internal* trade (pipeline congestion) is an empirical question.
  - If the constraint was internal, then the opportunity to arbitrage spatial differences in price would have led to new pipeline construction and the elimination of the discount without any new legislation.
  - However, if the discount was due to a mis-match of refining capacity with new U.S. crude supplies, then an earlier lifting of the export ban might have raised domestic wellhead prices for oil producers, increasing their profitability, and prevented refiners from making inefficient investments or inefficient use of their plants.

Price Differentials

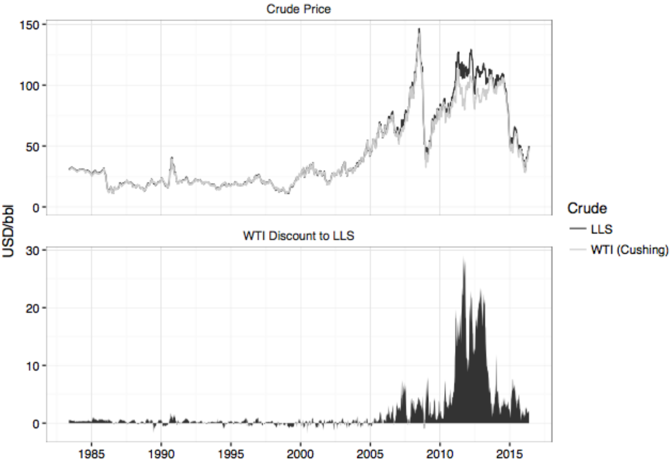


Figure 2: LLS vs WTI

Price Differentials

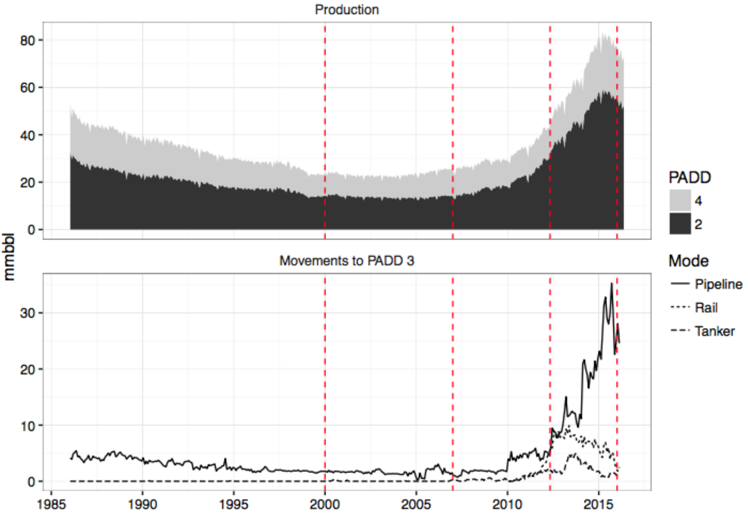


Figure 4: Oil production in and tranpsortation from PADDs 2 and 4

Price Differentials

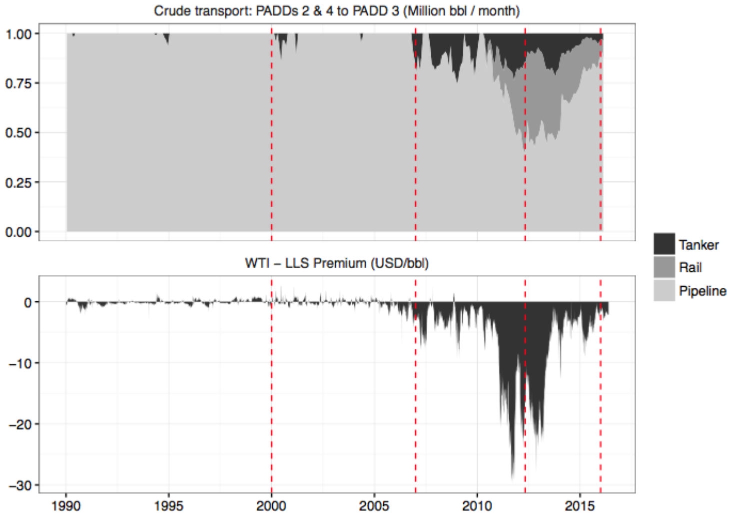


Figure 3: Mode of crude oil transport and WTI–LLS discount

Empirical Specification

Structural Break Test

$$PD_{c,t} = P_{c,t} - P_{brent,t} \forall c \in \{wticushing, wtimidland, hls, wts, lls\} \quad (1)$$

$$PD_{c,t} = \sum_{e=0}^{E-1} \mathbb{1}\left[T_e < t \leq T_{e+1}\right]\left(\alpha_{c,e} + \beta_{c,e} t\right) + \epsilon_{c,t}. \quad (2)$$

Empirical Specification

Structural Break Test

Table: Structural Break Time Periods

Time Period	Event	Description
January 1990 to December 2006	Pre-Shale Boom Era	EIA's drilling productivity report begins tracking shale play production in 2007.
January 2007 to April 2012	Shale Boom and Pre-Pipeline Upgrades	In April of 2012, the Seaway Pipeline was reversed. Throughout the next several years, other significant reversals and upgrades were also completed.
May 2012 to December 2015	Shale Boom and Pipeline Upgrades Occurring	The export ban was listed in December of 2015.

Empirical Specification

Pipeline vs. Refining Constraint

$$PD_{c,t} = \alpha_0 + \gamma_c^{shipping} \frac{Tanker_t + Rail_t}{Tanker_t + Rail_t + Pipeline_t} + \gamma_c^{api} api_t + \epsilon_{c,t}. \quad (3)$$

Where $\frac{Tanker_t + Rail_t}{Tanker_t + Rail_t + Pipeline_t}$ represents pipeline congestion and api_t is the average API input into U.S. refineries.

Results

Structural Break Test

Table 3: Decomposition of differentials using level and trend only

	WTI Cushing	WTI Midland	WTS*	LLS*	HLS
α_0	1.202***	1.103***	1.207***	1.014***	1.286***
	(7.18)	(8.10)	(5.68)	(8.53)	(12.01)
α_1	65.54**	71.98**	48.20*	13.01**	3.332
	(3.06)	(3.09)	(2.16)	(2.74)	(0.93)
α_2	-129.9***	-150.6***	-123.9***	-17.80	9.381
	(-9.03)	(-11.55)	(-7.05)	(-1.31)	(0.94)
β_0	0.0430	0.0390	0.0342	0.0174	0.0163
	(1.49)	(1.56)	(1.51)	(0.91)	(0.95)
β_1	-3.533**	-3.883**	-2.440*	-0.620*	-0.0294
	(-3.20)	(-3.22)	(-2.14)	(-2.58)	(-0.17)
β_2	5.012***	5.741***	4.932***	0.608	-0.419
	(8.49)	(10.92)	(6.98)	(1.09)	(-1.02)
N	312	312	312	312	312

Pipeline vs. Refining Constraint

Table 4: Decomposition of differentials using rail plus tanker share and API

	WTI Cushing	WTI Midland	WTS*	LLS*	HLS
$\gamma^{shipping}$	-31.19***	-37.93***	-20.87***	-9.301***	-2.797
	(-7.83)	(-11.70)	(-4.75)	(-4.57)	(-1.23)
γ^{api}	-0.361	-0.703*	-0.765	-0.381*	-0.412*
	(-1.36)	(-2.21)	(-1.93)	(-2.59)	(-2.53)
α_0	13.11	23.72*	26.00*	13.16**	14.41**
	(1.57)	(2.37)	(2.06)	(2.83)	(2.80)
N	312	312	312	312	312
R^2					
χ_2	29.7	30.7	29.5	20.3	26.1
$\Pr(\chi_2)$	0.00000036	0.00000022	0.00000038	0.000039	0.0000021
$F_{X=0}$	32.6	80.2	11.5	10.5	3.21
$\Pr(F_{X=0})$	1.4e-13	9.0e-29	0.000015	0.000040	0.042

t statistics in parentheses

Andrews HAC variance-covariance matrix computed with Bartlett kernel.

Automatic bandwidth selection used. t is measured in years.

χ_2 is Cumby and Huizinga (1992) statistic for autocorrelation of order 2

Starred dependent variables computed using initial LOOP regressions in Table 1

F_β statistics are joint test for structural breaks in β. $F_{X=0}$ test for joint significance of X variables.

Results

Decomposition

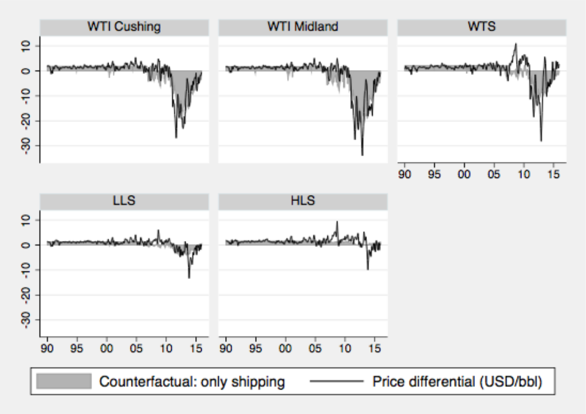
We are interested in two possible counterfactual worlds:

- only internal pipeline constraints
- only refining constraints

$$\widehat{PD}_{c,t}^{\text{shipping}} = \hat{\alpha}_0 + \hat{\gamma}_c^{shipping} \frac{Tanker_t + Rail_t}{Tanker_t + Rail_t + Pipeline_t} + \hat{\gamma}_c^{api} \overline{api} \quad (4)$$

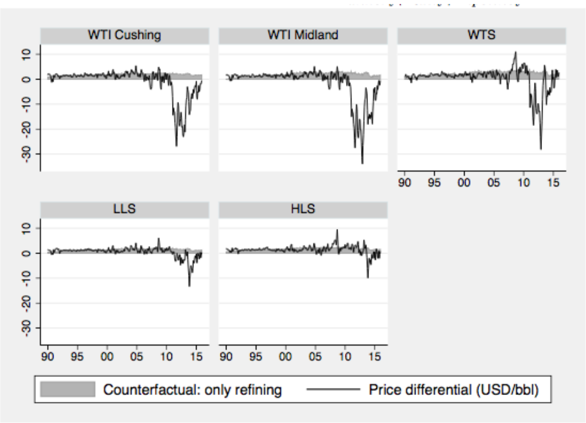
$$\widehat{PD}_{c,t}^{\text{refining}} = \hat{\alpha}_0 + \hat{\gamma}_c^{shipping} \overline{\frac{Tanker_t + Rail_t}{Tanker + Rail + Pipeline}} + \hat{\gamma}_c^{api} api_t. \quad (5)$$

Pipeline vs. Refining Constraint



(a) Shipping constraints only: $\frac{Tanker_t + Rail_t}{Tanker_t + Rail_t + Pipeline_t}$

Pipeline vs. Refining Constraint



(b) Refining constraints only: api_t

Figure 7: Predicted differentials using only one explanatory variable

Pipeline vs. Refining Constraint

Table 5: Percent of variation in price differential explained

	Both variables	Shipping Only	Refining Only
wticushing	0.73	0.72	0.02
wtimidland	0.76	0.75	0.01
wts	0.47	0.44	0.00
lls	0.49	0.45	0.00
hls	0.11	0.04	0.05

Explanatory power computed is R^2 from (6). Excluded variables are set to their means during the period 1990m1–2006m12.

Conclusions

- Results suggest that pipeline congestion from the mid-continent to gulf coast were the primary culprit for price differentials between domestic and international crude.
- This suggests that had the export ban not existed during the shale boom, a price differential likely would have still arisen.