ONLINE APPENDIX
Decomposing Crude Price Differentials: Domestic Shipping Constraints or the Crude Oil Export Ban?*

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January 16, 2019

1 Estimating long-run relationships

An absolute version of the Law of One Price (LOOP) means that the price of crude oil in one market must move one-for-one in another. If LOOP holds, then the difference in crude prices, $P_{c,t} - P_{brent,t}$, must be stationary and cannot have a unit root. Otherwise, the two markets are not well-arbitraged. In econometric terms, it must be that[1]

$$P_{c,t} - P_{brent,t} = \mu + \epsilon_t. \tag{1}$$

The mean price differential, μ, represents differences in crude oil quality and any steady-state transportation costs. The shock, ϵ_t, is mean-zero and may exhibit autocorrelation and heteroskedasticity.

Before proceeding, we check the unit root properties of the weekly average of each crude oil price using a Dickey-Fuller test. The null hypothesis of a unit root during 1990–2006 and the full sample cannot be rejected at the 10% level.[2] The t-statistic for this test is included in Table 2 of summary statistics. Then for each weekly domestic crude oil price, $P_{c,t}$, we use Dynamic OLS (Stock and Watson,

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[*] Online appendix for "Decomposing Crude Price Differentials: Domestic Shipping Constraints or the Crude Oil Export Ban?" forthcoming in *The Energy Journal*. Access article at `https://www.iaee.org/en/publications/scope.aspx`

[1] We considered estimating our model using the logarithm of oil prices; however, the absolute version of LOOP was rejected in all cases. Given our strong priors that an absolute version of LOOP should hold, particularly for Brent and WTI, we chose to estimate our model in levels. This is also the functional form used by Bausell et al. (2001).

[2] There has been a robust debate about the stationarity properties of oil prices after Perron (1989) showed that one can reject a unit root if trends and structural breaks are allowed. Noguera (2013) and Ghoshray (2014) confirm this. The unit root properties of oil prices, however, are not the central focus of this paper. Thus, whether oil prices truly have unit roots is moot in this context.

1993; Saikkonen, 1991) to estimate the following cointegrating relationship for the pre-shale period 1990–2006 when the market was in its long-run equilibrium:

$$P_{c,t} = \mu + \delta P_{brent,t} + \sum_{j=-l}^{l} \pi_j P_{brent,t-j} + \epsilon_t. \tag{2}$$

A cross-correlogram suggests that the appropriate number of leads and lags of Brent crude differences is $l = 2$, and we calculate our standard errors using a HAC matrix computed using a Bartlett kernel and Andrews (1991) automatic bandwidth selection.[3]

To verify that our estimates are not spurious, we conduct an Engle-Granger test for a spurious relationship between $P_{c,t}$ and $P_{brent,t}$ by applying a Dickey-Fuller test applied to the estimated residuals equation (2). The 1%, 5%, and 10% critical values for 200 observations are -3.954, -3.368, and -3.067, respectively (Enders, 2008). We reject the null of no cointegration at the 1% level for our six series. This confirms that at minimum, a relative form of LOOP holds for all six crudes. To further distinguish whether the stronger, absolute version of LOOP holds, we use a *t*-test to test the null hypothesis that $\delta = 1$ versus $\delta \neq 1$. If the test is rejected at the 0.01 level, we use $\hat{\delta}$ to compute price differentials. Otherwise, we simply use $\delta = 1$ to compute these.

Table 1 shows estimates for equation (2). In addition to confirming that LOOP holds for each series, we fail to reject the null hypothesis that $\delta = 1$ for WTI Midland, WTI Cushing and HLS. For these three, we compute price differentials as

$$PD_{c,t} = P_{c,t} - P_{brent,t}. \tag{3}$$

Equation (3) shows that the price differential, $PD_{c,t}$, is an estimate of $\mu + \epsilon_t$.

For the other three crudes, WTS, LLS, and FO USGC, we reject the null hypothesis that $\delta = 0$ in favor of the alternative ($\delta \neq 1$). This means that only a relative version of LOOP holds for these three crudes, so we compute price differentials as

$$PD_{c,t} = P_{c,t} - \hat{\delta}_c P_{brent,t}. \tag{4}$$

While we statically reject $\delta_c = 1$ for these crudes, the coefficient is still very close to 1.[4] Since $\hat{\delta}_c$ is a superconsistent estimator of the true δ_c, sampling error from estimating δ will not affect the consistency or distribution of our estimator when we use $PD_{c,t}$ as the dependent variable in subsequent regressions.

2 Additional Tables and Figures

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[3] This was implemented using the `cointreg` command in Stata's `lrcov` package.

[4] We cannot definitively explain why $\delta \neq 1$ for these crudes, but we do note that these crudes are heavier and/or more sour than the others. Table 3 shows the crude oil characteristics Bloomberg cites. EIA documentation of the FO USGC crude price explains that the price is a blend of several offshore crudes. A number of these have been tracked by Bloomberg periodically, and the documentation for them shows that they are heavier and more sour than WTI or LLS.

Table 1: LOOP regressions for 1990m1–2006m12

	Mid-continent			Gulf Coast		
	WTI Cushing	WTI Midland	WTS	LLS	HLS	FO USGC
δ	1.005***	1.009***	0.919***	1.022***	0.992***	0.939***
	(0.00929)	(0.00830)	(0.00727)	(0.00694)	(0.00651)	(0.0108)
μ	1.463***	1.214***	1.448***	1.159***	1.400***	0.398
	(0.266)	(0.237)	(0.208)	(0.198)	(0.186)	(0.308)
N	199	199	199	199	199	199
$z_{\delta-1}$	0.488	1.032	-11.12	3.158	-1.207	-5.661
	[0.626]	[0.302]	[9.72e-29]	[0.00159]	[0.228]	[1.51e-08]
D-Fuller	-6.346	-6.639	-6.820	-6.958	-7.112	-9.298

Standard errors in parentheses; p-valuse in brackets.

Dynamic OLS with HAC estimator using Bartlett kernel and Andrews (1991) bandwidth selection.

$z_{\delta-1}$ is a t-test for absolute version of LOOP, and δ chosen based on rejection of Absolote LOOP at the 0.01 level

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2: Summary statistics

	Mean	SD	Min	Max	N	D-Fuller	Pr($DFuller$)	First obs.	Last obs.
Brent	47.80	34.88	9.80	133.90	312	-1.29	0.63	1990m1	2015m12
Mid-continent crudes									
WTI Cushing	46.78	31.07	11.31	133.93	312	-1.40	0.58	1990m1	2015m12
WTI Midland	46.16	30.37	11.06	134.11	312	-1.45	0.56	1990m1	2015m12
WTS	44.24	30.16	10.07	131.15	312	-1.48	0.54	1990m1	2015m12
Coastal crudes									
LLS	49.34	34.63	11.27	137.99	312	-1.31	0.63	1990m1	2015m12
HLS	48.79	34.64	11.00	136.92	312	-1.32	0.62	1990m1	2015m12
FO USGC	45.61	33.34	9.48	130.06	312	-1.20	0.67	1990m1	2015m12
Explanatory variables									
Avg API: PADD 3	30.95	1.15	28.96	33.69	312	.	.	1990m1	2015m12
Rail/Tanker share from PADDs 2 & 4 to PADD 3	0.09	0.16	0.00	0.60	312	.	.	1990m1	2015m12

Dickey-Fuller test is for null hypothesis of a unit root.

Table 3: Crude quality

Crude	API gravity (degrees)	Sulfur content
WTI Cushing	39	0.34%
WTI Midland	39	0.34%
WTS	34	1.9%
LLS	35.7	0.44%
HLS	33.7	0.39%
Brent	> 35	¡ 1%

Crude characteristics taken from Bloomberg

Table 4: Price differential decomposition, instrumental variables

	Mid-continent			Gulf Coast		
	WTI Cushing	WTI Midland	WTS*	LLS*	HLS	FO USGC*
γ^{ship}	-31.78***	-38.98***	-21.53***	-9.789***	-4.589*	1.133
	(3.897)	(3.106)	(4.470)	(2.071)	(2.330)	(2.445)
γ^{api}	-0.413	-0.784*	-0.798^{+}	-0.379**	-0.324*	-0.301
	(0.291)	(0.327)	(0.415)	(0.145)	(0.158)	(0.252)
$\nu^{Ike/Gustav}$	4.524***	4.738***	9.146***	5.032***	7.348***	23.56***
	(0.474)	(0.525)	(0.686)	(0.207)	(0.227)	(0.430)
$\nu^{Katrina/Rita}$	0.902*	0.560	-0.550	1.289***	-0.273	1.003^{+}
	(0.456)	(0.500)	(0.733)	(0.243)	(0.266)	(0.559)
α_0	14.73	26.29*	27.07*	13.06**	11.38*	9.657
	(9.192)	(10.29)	(13.19)	(4.567)	(4.986)	(7.981)
N	326	326	326	326	326	326
$\chi^2(6)$	31.59	32.82	29.85	28.43	37.43	23.22
	[0.0000196]	[0.0000113]	[0.0000420]	[0.0000781]	[0.00000145]	[0.000725]
R^2	0.720	0.751	0.474	0.501	0.216	0.154
R^2_{ship}	0.715	0.738	0.444	0.461	0.169	0.138
R^2_{api}	0.00737	0.00598	0.00415	0.0168	0.0739	0.150
Overid: $\chi^2(2)$	2.038	3.016	0.694	3.488	1.699	2.031
	[0.361]	[0.221]	[0.707]	[0.175]	[0.428]	[0.362]
Endog $F_{2,319}$	1.173	3.625	1.067	12.27	6.500	2.129
	[0.311]	[0.0277]	[0.345]	[0.00000735]	[0.00171]	[0.121]
Shea's partial R^2_{ship}	0.938	0.938	0.938	0.938	0.938	0.938
Shea's partial R^2_{ref}	0.879	0.879	0.879	0.879	0.879	0.879

Standard errors in parentheses; p-values in brackets.

Significance tests against normal distribution: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

IV with HAC estimator using Bartlett kernel and Andrews (1991) bandwidth selection.

$\chi^2(6)$ is Cumby and Huizinga (1992) statistic for autocorrelation of order 6

Starred dependent variables computed using initial LOOP regressions in Table 1

Overid $\chi^2(2)$ is Wooldridge (1995) test of overidentifying restrictions.

Endog $F_{2,319}$ is regression-based test for exogeneity of the instrumented variables.

3 Robustness: serial correlation

Our estimates of equations (1) and (2) both suffer from serial correlation of the residuals, as evidenced by the Cumby and Huizinga (1992) statistics in the bottom of Tables 2 and 3. While the Andrews (1991) HAC estimator corrects standard errors for this issue, we also try parametrically correcting for serial correlation by adding two lags of $PD_{c,t}$ and re-estimating our model (still with the HAC standard errors). Results are given in Tables 5 and 6. Because adjustment of price differentials is now dynamic, the relevant quantities of interest are the long-run multipliers, not the simple coefficients. Given a generic coefficient, γ, the associated long-run multiplier is

$$\gamma^{LRM} = \frac{\gamma}{1 - \rho_1 - \rho_2}.$$

The long-run multipliers are very close to the coefficients estimated in static regressions (Tables 2 and 3), so we are comfortable that our results are robust to serial correlation.

4 Robustness: other crudes

As mentioned, we repeat our analysis for all of the geography-specific crude oil prices reported by the EIA at the monthly level (plus the six main prices we focus on). The majority of these are state or PADD-specific average crude oil wellhead prices. Summary statistics are given in Table 7. Table 8 gives results from our stage one pre-shale model, equation (1). We compute price differentials from these quantities exactly as before and estimate models (1) and (2) both without lags (Tables 9 and 10) and with lags (Tables 12 and 13). We find qualitatively similar results as before. Crudes along the US Gulf Coast (AL, LA, and MS) do exhibit structural breaks, but rejection of the null of no breaks is weaker than for inland crudes, and the trend in the post-pipeline regime is not statistically different from zero. Statistical support for breaks in PADD 5 crudes is much weaker, and a number of the trend terms have the opposite signs from mid-continent crudes. This is as expected. PADD 5 is not well connected to the rest of the country via crude pipelines, so mid-continent transmission constraints should have small effects.

In PADDs 1, 2, and 4, the coefficient on γ^{ship} is negative and significant for all states except South Dakota, which has minimal crude production. The shipping constraint coefficient (γ^{ship}) for Gulf Coast and PADD 5 crudes has much smaller magnitudes. In contrast, the coefficient on API gravity, γ^{api}, has limited statistical significance for all regressions, and is not significant at all for most. In total, these results support our conclusion that crude-oil discounts were mainly related to shipping constraints, not export (refining) constraints.

Table 5: Price differential break tests, AR(2)

	Mid-continent			Gulf Coast		
	WTI Cushing	WTI Midland	WTS*	LLS*	HLS	FO USGC*
Level						
α_0	0.264*	0.239**	0.288**	0.336***	0.524***	0.138
	(0.104)	(0.0840)	(0.105)	(0.0933)	(0.110)	(0.119)
α_1	14.86**	16.72**	12.59*	3.887*	1.149	-1.897
	(5.388)	(5.777)	(5.243)	(1.611)	(1.493)	(5.728)
α_2	-26.98*	-31.04*	-27.31*	-8.958^{+}	-0.254	4.857
	(11.27)	(13.97)	(12.63)	(5.054)	(5.410)	(14.59)
Trend						
β_0	0.00377	0.00429	0.00358	0.00147	-0.00116	-0.000275
	(0.00971)	(0.00802)	(0.0103)	(0.00859)	(0.00981)	(0.0188)
β_1	-0.805**	-0.906**	-0.646*	-0.188*	-0.0175	0.144
	(0.282)	(0.304)	(0.272)	(0.0820)	(0.0749)	(0.292)
β_2	1.052*	1.195*	1.094*	0.331	-0.0168	-0.198
	(0.441)	(0.549)	(0.504)	(0.203)	(0.222)	(0.594)
Lags						
ρ_1	1.015***	1.125***	1.097***	0.760***	0.719***	0.663***
	(0.0823)	(0.0837)	(0.101)	(0.130)	(0.117)	(0.105)
ρ_2	-0.219*	-0.329***	-0.320**	-0.0743	-0.153	-0.149
	(0.0992)	(0.0946)	(0.105)	(0.0960)	(0.0961)	(0.0924)
Hurricanes						
$\nu^{Ike/Gustav}$	2.100***	2.084***	2.443***	3.394***	4.706***	13.08***
	(0.404)	(0.406)	(0.525)	(0.325)	(0.360)	(1.806)
$\nu^{Katrina/Rita}$	1.353***	1.082***	0.761	1.433**	0.459	2.096***
	(0.149)	(0.245)	(0.489)	(0.520)	(0.513)	(0.350)
N	310	310	310	310	310	310
$\chi^2(6)$	1.549	2.269	3.092	2.574	2.013	3.007
	[0.956]	[0.893]	[0.797]	[0.860]	[0.918]	[0.808]
$F_{\beta_0=\beta_1}$	8.120	8.900	5.684	5.251	0.0470	0.245
	[0.00468]	[0.00309]	[0.0177]	[0.0226]	[0.829]	[0.621]
$F_{\beta_1=\beta_2}$	9.545	9.071	8.695	5.419	0.0000107	0.243
	[0.00219]	[0.00282]	[0.00344]	[0.0206]	[0.997]	[0.623]
$F_{\beta_0=\beta_1=\beta_2}$	5.151	5.418	4.825	3.768	0.0266	0.160
	[0.00632]	[0.00488]	[0.00866]	[0.0242]	[0.974]	[0.853]

Standard errors in parentheses; p-values in brackets.

Significance tests against normal distribution: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

OLS with HAC estimator using Bartlett kernel and Andrews (1991) bandwidth selection.

$\chi^2(6)$ is Cumby and Huizinga (1992) statistic for autocorrelation of order 6

Starred dependent variables computed using initial LOOP regressions in Table 1

Table 6: Price differential decomposition, AR(2)

	Mid-continent			Gulf Coast		
	WTI Cushing	WTI Midland	WTS*	LLS*	HLS	FO USGC*
γ^{ship}	-5.669**	-7.947***	-4.392**	-2.695***	-1.445*	0.428
	(1.945)	(2.042)	(1.378)	(0.661)	(0.588)	(1.611)
γ^{api}	-0.0163	-0.112	-0.137^{+}	-0.0572	-0.0659	-0.150
	(0.0764)	(0.0768)	(0.0800)	(0.0412)	(0.0433)	(0.123)
ρ_1	1.041***	1.128***	1.109***	0.779***	0.787***	0.667***
	(0.0868)	(0.0911)	(0.104)	(0.105)	(0.107)	(0.101)
ρ_2	-0.229*	-0.338***	-0.320**	-0.0567	-0.0951	-0.145
	(0.0938)	(0.0862)	(0.0982)	(0.0864)	(0.0954)	(0.0915)
$\nu^{Ike/Gustav}$	1.858***	1.873***	2.527***	3.447***	4.683***	13.38***
	(0.280)	(0.280)	(0.459)	(0.259)	(0.318)	(1.564)
$\nu^{Katrina/Rita}$	1.301***	0.907**	0.496	1.345^{+}	0.464	1.879***
	(0.184)	(0.300)	(0.646)	(0.785)	(0.615)	(0.361)
α_0	0.833	3.873	4.714^{+}	2.138	2.457^{+}	4.880
	(2.468)	(2.463)	(2.563)	(1.324)	(1.382)	(3.908)
N	310	310	310	310	310	310
$\chi^2(6)$	1.714	1.532	2.756	3.350	4.482	2.780
	[0.944]	[0.957]	[0.839]	[0.764]	[0.612]	[0.836]
$\widetilde{\gamma}^{ship}_{LRM}$	-30.09	-37.74	-20.88	-9.711	-4.688	0.897
	(5.230)	(5.643)	(5.597)	(2.254)	(2.143)	(3.369)
$\widetilde{\gamma}^{api}_{LRM}$	-0.0866	-0.534	-0.652	-0.206	-0.214	-0.314
	(0.389)	(0.317)	(0.343)	(0.137)	(0.139)	(0.258)

Standard errors in parentheses; *p*-values in brackets.

Significance tests against normal distribution: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

OLS with HAC estimator using Bartlett kernel and Andrews (1991) bandwidth selection.

$\chi^2(6)$ is Cumby and Huizinga (1992) statistic for autocorrelation of order 6

Starred dependent variables computed using initial LOOP regressions in Table 1

Long-run multipliers and their standard errors are below.

Table 7: All variables: summary statistics

	Mean	SD	Min	Max	N	D-Fuller	Pr($DFuller$)	First obs.	Last obs.
Brent	47.80	34.88	9.80	133.90	312	-1.29	0.63	1990m1	2015m12
Mid-continent crudes									
WTI Cushing	46.78	31.07	11.31	133.93	312	-1.40	0.58	1990m1	2015m12
WTI Midland	46.16	30.37	11.06	134.11	312	-1.45	0.56	1990m1	2015m12
WTS	44.24	30.16	10.07	131.15	312	-1.48	0.54	1990m1	2015m12
Coastal crudes									
LLS	49.34	34.63	11.27	137.99	312	-1.31	0.63	1990m1	2015m12
HLS	48.79	34.64	11.00	136.92	312	-1.32	0.62	1990m1	2015m12
FO USGC	45.61	33.34	9.48	130.06	312	-1.20	0.67	1990m1	2015m12
EIA FPP: Stream									
CA Midway-Sunset	45.65	33.50	7.05	120.20	267	-1.40	0.58	1993m10	2015m12
WTI (EIA)	48.71	30.97	9.69	132.21	267	-1.43	0.57	1993m10	2015m12
WTS (EIA)	46.85	30.59	8.60	129.56	267	-1.49	0.54	1993m10	2015m12
EIA FPP: PADD 1									
PADD 1	43.44	29.57	10.49	130.20	312	-1.38	0.59	1990m1	2015m12
PA	59.53	26.24	18.40	130.11	188	-1.50	0.53	2000m5	2015m12
EIA FPP: PADD 2									
PADD 2	43.03	29.16	9.29	128.49	312	-1.45	0.56	1990m1	2015m12
IL	43.31	29.23	9.79	127.60	312	-1.44	0.56	1990m1	2015m12
KS	43.02	29.30	8.98	127.72	312	-1.44	0.56	1990m1	2015m12
KY	42.03	28.72	8.26	123.85	312	-1.44	0.56	1990m1	2015m12
NE	41.19	28.05	8.63	123.77	312	-1.51	0.53	1990m1	2015m12
ND	41.87	28.69	8.62	126.68	312	-1.49	0.54	1990m1	2015m12
OH	43.30	30.03	9.22	129.33	312	-1.37	0.60	1990m1	2015m12
OK	44.33	30.20	9.74	131.37	312	-1.42	0.57	1990m1	2015m12
SD	61.72	24.02	23.31	124.79	163	-1.86	0.35	2002m6	2015m12
EIA FPP: PADD 3									
PADD 3	44.53	31.30	9.31	130.79	312	-1.28	0.64	1990m1	2015m12
AL	45.40	33.11	9.15	130.65	312	-1.31	0.62	1990m1	2015m12
LA	46.91	33.56	9.75	133.74	312	-1.33	0.62	1990m1	2015m12
MS	43.78	32.73	7.71	128.91	312	-1.32	0.62	1990m1	2015m12
NM	43.67	29.73	9.08	130.78	312	-1.43	0.57	1990m1	2015m12
TX	44.05	30.63	9.20	131.33	312	-1.40	0.58	1990m1	2015m12
EIA FPP: PADD 4									
PADD 4	40.97	27.80	8.56	123.09	312	-1.50	0.53	1990m1	2015m12
CO	43.12	28.54	9.65	126.07	312	-1.45	0.56	1990m1	2015m12
MT	41.29	28.56	8.48	126.80	312	-1.55	0.51	1990m1	2015m12
UT	41.50	26.65	9.25	120.63	312	-1.52	0.52	1990m1	2015m12
WY	39.54	27.18	8.10	120.15	312	-1.59	0.49	1990m1	2015m12
EIA FPP: PADD 5									
PADD 5	41.18	33.21	6.17	124.69	312	-1.26	0.65	1990m1	2015m12
AK North Slope	40.25	32.78	5.34	125.77	312	-1.24	0.65	1990m1	2015m12
CA	42.45	33.55	7.38	123.89	312	-1.30	0.63	1990m1	2015m12
FO CA	38.42	31.95	5.01	119.63	305	-1.33	0.61	1990m1	2015m5
Refining									
Imputed vacuum gas oil cut (PADD 1, percent)	0.40	0.04	0.26	0.53	312	.	.	1990m1	2015m12
Imputed vacuum gas oil cut (PADD 2, percent)	0.38	0.02	0.33	0.42	312	.	.	1990m1	2015m12
Imputed vacuum gas oil cut (PADD 3, percent)	0.41	0.02	0.36	0.46	312	.	.	1990m1	2015m12
Imputed vacuum gas oil cut (PADD 4, percent)	0.32	0.03	0.25	0.39	312	.	.	1990m1	2015m12
Imputed vacuum gas oil cut (PADD 5, percent)	0.45	0.02	0.38	0.53	312	.	.	1990m1	2015m12
Imputed vacuum gas oil cut (U.S., percent)	0.41	0.01	0.37	0.44	312	.	.	1990m1	2015m12
Imputed residuum cut (PADD 1, percent)	0.03	0.02	-0.07	0.07	312	.	.	1990m1	2015m12
Imputed residuum cut (PADD 2, percent)	0.10	0.01	0.07	0.13	312	.	.	1990m1	2015m12
Imputed residuum cut (PADD 3, percent)	0.11	0.02	0.05	0.15	312	.	.	1990m1	2015m12
Imputed residuum cut (PADD 4, percent)	0.08	0.02	0.03	0.13	312	.	.	1990m1	2015m12
Imputed residuum cut (PADD 5, percent)	0.19	0.01	0.15	0.22	312	.	.	1990m1	2015m12
Imputed residuum cut (U.S., percent)	0.12	0.01	0.08	0.14	312	.	.	1990m1	2015m12
Avg API: PADD 1	32.53	1.23	29.82	35.39	312	.	.	1990m1	2015m12
Avg API: PADD 2	33.15	0.79	31.12	35.06	312	.	.	1990m1	2015m12
Avg API: PADD 3	30.95	1.15	28.96	33.69	312	.	.	1990m1	2015m12
Avg API: PADD 4	33.62	1.06	31.56	36.75	312	.	.	1990m1	2015m12
Avg API: PADD 5	26.86	1.22	23.99	29.71	312	.	.	1990m1	2015m12
Avg API: TXGC	30.25	1.70	26.97	34.23	312	.	.	1990m1	2015m12
Avg API: U.S.	30.94	0.55	29.75	32.23	312	.	.	1990m1	2015m12
Transport									
Rail/Tanker share from PADDs 2 & 4 to PADD 3	0.09	0.16	0.00	0.60	312	.	.	1990m1	2015m12
Share of crude via rail / barge out of PADDs 2 + 4 (PADD 2 only)	0.21	0.17	0.00	0.70	312	.	.	1990m1	2015m12
Share of crude via rail / barge out of PADDs 2 + 4 (PADD 4 only)	0.13	0.29	0.00	1.00	312	.	.	1990m1	2015m12
Share of crude via rail / barge out of PADDs 2 + 4 (PADDs 2+4)	0.19	0.19	0.00	0.71	312	.	.	1990m1	2015m12

Dickey-Fuller test is for null hypothesis of a unit root.

Table 8: All crudes: LOOP regressions for 1990m1–2006m12

	δ		μ		D-Fuller	$z_{\delta-1}$	δ	N
Mid-continent crudes								
WTI Cushing	1.005***	(0.00929)	1.463***	(0.266)	-6.346	0.488	1	199
WTI Midland	1.009***	(0.00830)	1.214***	(0.237)	-6.639	1.032	1	199
WTS	0.919***	(0.00727)	1.448***	(0.208)	-6.820	-11.12***	0.919	199
Coastal crudes								
LLS	1.022***	(0.00694)	1.159***	(0.198)	-6.958	3.158**	1.022	199
HLS	0.992***	(0.00651)	1.400***	(0.186)	-7.112	-1.207	1	199
FO USGC	0.939***	(0.0108)	0.398	(0.308)	-9.298	-5.661***	0.939	199
EIA FPP: Stream								
CA Midway-Sunset	0.883***	(0.0239)	-1.726	(0.727)	-4.600	-4.878***	0.883	154
WTI (EIA)	0.980***	(0.0129)	0.630	(0.393)	-4.737	-1.567	1	154
WTS (EIA)	0.924***	(0.0152)	0.281	(0.461)	-4.743	-4.983***	0.924	154
EIA FPP: PADD 1								
PADD 1	0.984***	(0.0138)	0.153	(0.395)	-7.044	-1.131	1	199
PA	0.969***	(0.0137)	1.334	(0.545)	-4.835	-2.256	1	75
EIA FPP: PADD 2								
PADD 2	0.956***	(0.0167)	0.486	(0.476)	-4.094	-2.656**	0.956	199
IL	0.909***	(0.0140)	1.736***	(0.401)	-4.461	-6.464***	0.909	199
KS	0.959***	(0.0156)	0.247	(0.447)	-4.120	-2.632**	0.959	199
KY	0.885***	(0.0131)	1.303***	(0.374)	-5.029	-8.773***	0.885	199
NE	0.932***	(0.0245)	0.134	(0.700)	-2.500	-2.765**	0.932	199
ND	0.927***	(0.0275)	0.417	(0.787)	-4.209	-2.641**	0.927	199
OH	0.976***	(0.0141)	-0.228	(0.404)	-6.525	-1.709	1	199
OK	0.990***	(0.0150)	0.145	(0.429)	-4.609	-0.675	1	199
SD	0.696***	(0.0651)	9.975**	(3.055)	-2.138	-4.669***	0.696	50
EIA FPP: PADD 3								
PADD 3	0.959***	(0.0130)	0.204	(0.371)	-6.508	-3.133**	0.959	199
AL	0.993***	(0.0109)	-0.638	(0.311)	-7.581	-0.648	1	199
LA	1.005***	(0.0142)	0.0578	(0.406)	-6.012	0.320	1	199
MS	0.943***	(0.0144)	-1.210**	(0.413)	-4.802	-3.912***	0.943	199
NM	0.965***	(0.0151)	0.396	(0.431)	-4.966	-2.326	1	199
TX	0.960***	(0.0145)	0.231	(0.416)	-5.087	-2.767**	0.960	199
EIA FPP: PADD 4								
PADD 4	0.907***	(0.0181)	0.544	(0.518)	-3.686	-5.158***	0.907	199
CO	1.007***	(0.0165)	-0.101	(0.470)	-5.644	0.451	1	199
MT	0.934***	(0.0271)	-0.248	(0.773)	-2.775	-2.436	1	199
UT	0.940***	(0.0154)	1.268**	(0.439)	-2.828	-3.926***	0.940	199
WY	0.817***	(0.0219)	1.618**	(0.627)	-4.024	-8.338***	0.817	199
EIA FPP: PADD 5								
PADD 5	0.951***	(0.0340)	-4.210***	(0.970)	-4.618	-1.448	1	199
AK North Slope	0.964***	(0.0307)	-5.130***	(0.878)	-5.898	-1.169	1	199
CA	0.926***	(0.0330)	-2.559**	(0.942)	-3.831	-2.243	1	199
FO CA	0.903***	(0.0380)	-4.570***	(1.087)	-3.160	-2.544	1	199

Standard errors in parentheses

Dynamic OLS with HAC estimator using Bartlett kernel and Andrews (1991) bandwidth selection.

$z_{\delta-1}$ is a t-test of the null that $\delta = 1$ versus $\delta \neq 1$ (an absolute version of LOOP). If we reject the null at the 0.01 level, we use $\hat{\delta}$.

** $p < 0.01$, *** $p < 0.001$

Table 9: All crudes: price differential break tests, OLS

	Intercepts						Trends						Break tests			Stats	
	α_0		α_1		α_2		β_0		β_1		β_2		$F_{\beta_0=\beta_1}$	$F_{\beta_1=\beta_2}$	$F_{\beta_0=\beta_1=\beta_2}$	N	$\chi^2(6)$
Mid-continent crudes																	
WTI Cushing	1.223***	(0.18)	64.79**	(21.44)	-129.9***	(14.30)	0.0389	(0.03)	-3.499**	(1.11)	5.012***	(0.59)	10.03**	36.73***	36.10***	312	33.67***
WTI Midland	1.127***	(0.14)	71.18**	(23.26)	-150.6***	(13.26)	0.0343	(0.03)	-3.847**	(1.20)	5.741***	(0.54)	10.25**	49.97***	59.90***	312	37.31***
WTS	1.210***	(0.22)	47.07*	(22.02)	-124.5***	(17.82)	0.0297	(0.02)	-2.394*	(1.13)	4.954***	(0.72)	4.529*	24.15***	23.67***	312	33.75***
Coastal crudes																	
LLS	1.040***	(0.13)	12.35**	(4.36)	-17.83	(13.60)	0.0123	(0.02)	-0.591**	(0.22)	0.609	(0.56)	6.987**	4.408*	4.625*	312	24.82***
HLS	1.209***	(0.13)	2.858	(2.62)	4.449	(10.79)	-0.00134	(0.02)	-0.0484	(0.13)	-0.247	(0.44)	0.133	0.175	0.238	312	21.84**
FO USGC	0.275	(0.21)	-2.709	(10.00)	17.26	(14.25)	0.00728	(0.03)	0.231	(0.49)	-0.702	(0.58)	0.211	1.425	0.819	312	23.54***
EIA FPP: Stream																	
CA Midway-Sunset	-2.694***	(0.71)	-29.50***	(7.18)	65.49***	(12.53)	0.0850	(0.09)	1.527***	(0.35)	-2.646***	(0.51)	14.93***	59.77***	30.24***	267	37.17***
WTI (EIA)	0.590	(0.61)	62.99**	(20.24)	-114.4***	(10.98)	-0.0580	(0.07)	-3.546***	(1.05)	4.199***	(0.44)	10.51**	38.49***	45.85***	267	40.91***
WTS (EIA)	-0.199	(0.62)	49.70*	(20.57)	-121.9***	(20.65)	0.0413	(0.08)	-2.644*	(1.06)	4.734***	(0.83)	6.098*	25.01***	16.98***	267	41.74***
EIA FPP: PADD 1																	
PADD 1	-0.319	(0.47)	69.28***	(16.12)	-57.81***	(10.61)	0.000474	(0.05)	-3.976***	(0.83)	1.692***	(0.44)	22.56***	37.64***	19.71***	312	33.14***
PA	3.207*	(1.42)	83.13***	(18.66)	-100.4***	(17.28)	-0.234*	(0.11)	-4.741***	(0.95)	3.410***	(0.73)	20.54***	53.73***	28.13***	188	33.86***
EIA FPP: PADD 2																	
PADD 2	0.192	(0.34)	63.53**	(19.67)	-107.0***	(13.00)	0.0305	(0.06)	-3.570***	(1.02)	3.954***	(0.53)	11.90***	32.42***	27.68***	312	45.79***
IL	1.691***	(0.26)	51.19**	(18.58)	-84.66***	(21.23)	0.00368	(0.05)	-2.733**	(0.96)	3.273***	(0.87)	7.906**	16.35***	8.607***	312	40.51***
KS	0.137	(0.37)	58.97**	(18.24)	-116.6***	(17.33)	0.0124	(0.06)	-3.357***	(0.94)	4.367***	(0.71)	12.18***	32.53***	20.24***	312	37.35***
KY	1.727***	(0.24)	46.90**	(17.21)	-96.80***	(19.53)	-0.0522	(0.04)	-2.531**	(0.89)	3.841***	(0.81)	7.635**	22.01***	12.79***	312	37.38***
NE	-0.396	(0.53)	47.47**	(17.17)	-111.7***	(15.70)	0.0585	(0.09)	-2.831**	(0.89)	4.097***	(0.64)	9.611**	30.79***	20.92***	312	42.91***
ND	-0.137	(0.52)	58.40**	(19.29)	-91.81***	(14.67)	0.0556	(0.10)	-3.284**	(1.00)	3.373***	(0.60)	10.51**	23.89***	16.13***	312	49.78***
OH	-0.0271	(0.34)	57.95**	(18.43)	-51.85***	(11.14)	-0.103**	(0.04)	-3.394***	(0.95)	1.511***	(0.45)	11.78***	18.24***	9.994***	312	32.57***
OK	-0.415	(0.34)	65.89***	(19.68)	-134.3***	(14.88)	0.0324	(0.06)	-3.755***	(1.02)	5.037***	(0.61)	13.23***	43.30***	34.56***	312	38.78***
SD	10.71	(8.80)	31.62^{+}	(19.17)	19.51	(36.43)	-0.0904	(0.62)	-1.017	(0.94)	-0.384	(1.49)	0.487	0.106	0.247	163	34.19***
EIA FPP: PADD 3																	
PADD 3	-0.0824	(0.24)	37.54*	(15.59)	-60.73***	(10.24)	0.0290	(0.04)	-2.033*	(0.80)	2.227***	(0.41)	6.520*	22.16***	17.45***	312	40.49***
AL	-0.882**	(0.28)	16.36**	(6.21)	10.96	(12.85)	0.0000942	(0.04)	-1.033***	(0.31)	-0.762	(0.53)	10.98**	0.192	6.623**	312	28.29***
LA	-0.286	(0.25)	18.37**	(6.80)	-12.92	(9.74)	0.0506	(0.04)	-1.032**	(0.34)	0.352	(0.39)	9.382**	6.905**	5.000**	312	29.50***
MS	-1.347***	(0.24)	14.98	(9.75)	-13.27	(9.59)	0.0147	(0.04)	-0.795	(0.50)	0.426	(0.39)	2.570	3.818^{+}	1.917	312	41.04***
NM	-0.331	(0.47)	64.37**	(21.58)	-148.0***	(12.80)	-0.0268	(0.07)	-3.678***	(1.12)	5.493***	(0.52)	10.19**	48.13***	57.76***	312	44.49***
TX	-0.163	(0.29)	54.33**	(19.18)	-84.17***	(11.78)	0.0434	(0.05)	-2.955**	(0.99)	3.125***	(0.48)	8.887**	24.00***	21.26***	312	38.26***
EIA FPP: PADD 4																	
PADD 4	0.143	(0.37)	50.80**	(18.35)	-102.7***	(12.86)	0.0435	(0.06)	-2.887**	(0.96)	3.808***	(0.52)	8.984**	29.88***	26.41***	312	44.91***
CO	-0.465	(0.30)	61.49**	(19.71)	-134.8***	(8.94)	0.0622	(0.05)	-3.695***	(1.03)	4.860***	(0.36)	12.78***	53.28***	87.54***	312	38.56***
MT	-1.481*	(0.72)	65.16**	(20.84)	-139.0***	(9.65)	-0.0658	(0.13)	-3.953***	(1.09)	4.984***	(0.39)	11.74***	49.94***	76.49***	312	46.38***
UT	1.270**	(0.39)	54.40**	(17.59)	-132.0***	(6.61)	-0.00633	(0.06)	-3.288***	(0.92)	4.835***	(0.26)	12.06***	72.29***	173.5***	312	35.18***
WY	1.198**	(0.43)	36.88^{+}	(19.27)	-70.35**	(22.30)	0.0490	(0.06)	-1.901^{+}	(0.99)	2.766**	(0.91)	3.785^{+}	9.579**	5.229**	312	52.83***
EIA FPP: PADD 5																	
PADD 5	-5.998***	(0.79)	-0.499	(7.14)	-22.08**	(7.95)	0.0562	(0.09)	-0.383	(0.37)	0.512	(0.33)	1.216	3.655^{+}	1.880	312	81.62***
AK North Slope	-6.726***	(0.72)	8.527	(9.35)	-32.37***	(9.40)	0.0722	(0.08)	-0.884^{+}	(0.48)	0.824*	(0.39)	3.728^{+}	9.504**	4.847**	312	71.81***
CA	-4.463***	(1.04)	-10.33*	(4.96)	-9.081	(7.37)	-0.00364	(0.13)	0.174	(0.26)	0.0824	(0.30)	0.330	0.0492	0.178	312	81.48***
FO CA	-6.765***	(1.13)	-9.339	(8.54)	25.47**	(9.72)	-0.0367	(0.16)	-0.131	(0.44)	-1.801***	(0.40)	0.0336	12.25***	10.60***	305	74.56***

Standard errors in parentheses. Significance tests against normal distribution: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

OLS with HAC estimator using Bartlett kernel and Andrews (1991) bandwidth selection. Included hurricane dummies. $\chi^2(6)$ is Cumby and Huizinga (1992) statistic for autocorrelation of order 6

Standard errors in parentheses for coefficients, and p-values for test-statistics.

Significance tests against normal distribution: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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Table 10: All crudes: price differential decomposition, OLS

	Shipping		Refining		Stats			Explanatory power		
	γ^{ship}		γ^{api}		F_{ref}	N	$\chi^2(6)$	R^2	R^2_{ship}	R^2_{ref}
Mid-continent crudes										
WTI Cushing	-31.19***	(4.08)	-0.355	(0.26)	1.916	312	30.39***	0.724	0.720	0.00661
WTI Midland	-37.97***	(3.36)	-0.708*	(0.31)	5.321*	312	31.56***	0.755	0.742	0.00608
WTS	-21.02***	(4.44)	-0.777*	(0.38)	4.237*	312	28.30***	0.480	0.448	0.00488
Coastal crudes										
LLS	-9.298***	(2.05)	-0.357*	(0.14)	6.429*	312	23.20***	0.517	0.480	0.0143
HLS	-4.157^{+}	(2.30)	-0.303*	(0.15)	4.105*	312	31.52***	0.221	0.181	0.0698
FO USGC	1.300	(2.48)	-0.370	(0.25)	2.230	312	22.58***	0.158	0.145	0.155
EIA FPP: Stream										
CA Midway-Sunset	10.93***	(1.59)	-0.334	(0.27)	1.501	267	35.92***	0.360	0.351	0.0351
WTI (EIA)	-34.93***	(3.06)	-0.452	(0.39)	1.322	267	34.40***	0.738	0.735	0.000000822
WTS (EIA)	-23.39***	(4.21)	-0.899*	(0.45)	4.051*	267	34.38***	0.510	0.487	0.0123
EIA FPP: PADD 1										
PADD 1	-39.62***	(3.05)	-0.203	(0.35)	0.336	312	37.03***	0.765	0.764	0.00328
PA	-42.21***	(4.00)	-1.634	(1.08)	2.285	188	36.62***	0.755	0.740	0.131
EIA FPP: PADD 2										
PADD 2	-33.91***	(3.64)	-0.235	(0.24)	0.972	312	36.22***	0.776	0.774	0.00574
IL	-22.34***	(4.20)	-0.197	(0.26)	0.584	312	32.31***	0.582	0.579	0.000410
KS	-32.23***	(3.94)	-0.0461	(0.26)	0.0327	312	31.68***	0.739	0.739	0.000500
KY	-18.76***	(4.60)	0.140	(0.27)	0.270	312	30.43***	0.509	0.507	0.0320
NE	-34.62***	(3.26)	-0.0935	(0.27)	0.119	312	37.83***	0.757	0.757	0.00000767
ND	-31.26***	(3.77)	-0.353	(0.26)	1.818	312	41.63***	0.724	0.719	0.00307
OH	-34.60***	(3.20)	0.131	(0.31)	0.180	312	34.81***	0.727	0.726	0.0284
OK	-35.84***	(3.97)	-0.135	(0.25)	0.303	312	35.29***	0.762	0.761	0.00310
SD	-0.653	(4.70)	-0.741	(1.21)	0.374	163	30.42***	0.0341	0.0257	0.0337
EIA FPP: PADD 3										
PADD 3	-19.16***	(1.80)	-0.502*	(0.23)	4.726*	312	37.27***	0.571	0.552	0.00368
AL	-12.85***	(3.01)	-0.0849	(0.26)	0.108	312	43.30***	0.352	0.352	0.00140
LA	-10.71***	(1.71)	-0.280^{+}	(0.16)	3.142^{+}	312	30.91***	0.348	0.337	0.00519
MS	-5.023***	(1.08)	-0.413*	(0.21)	4.003*	312	46.69***	0.161	0.123	0.0477
NM	-39.77***	(3.12)	-0.335	(0.28)	1.391	312	35.64***	0.761	0.759	0.0117
TX	-25.44***	(3.00)	-0.555*	(0.26)	4.472*	312	33.49***	0.632	0.617	0.0000940
EIA FPP: PADD 4										
PADD 4	-31.43***	(3.04)	-0.232	(0.20)	1.306	312	33.57***	0.752	0.750	0.00686
CO	-46.26***	(3.15)	-0.0456	(0.26)	0.0304	312	33.36***	0.833	0.833	0.0000532
MT	-45.33***	(3.64)	0.142	(0.28)	0.256	312	36.38***	0.834	0.833	0.0521
UT	-43.52***	(2.78)	0.326	(0.32)	1.026	312	35.01***	0.838	0.835	0.0707
WY	-16.85***	(3.84)	-0.418	(0.31)	1.789	312	45.23***	0.371	0.360	0.000508
EIA FPP: PADD 5										
PADD 5	-10.29***	(1.46)	-0.139	(0.25)	0.298	312	79.46***	0.356	0.353	0.00181
AK North Slope	-15.20***	(1.33)	-0.337	(0.22)	2.452	312	71.86***	0.539	0.525	0.00181
CA	-5.860**	(1.89)	0.176	(0.32)	0.308	312	87.74***	0.145	0.140	0.0283
FO CA	-19.35***	(4.24)	0.165	(0.44)	0.144	305	82.88***	0.513	0.511	0.0333

Standard errors in parentheses. Significance tests against normal distribution: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

OLS with HAC estimator using Bartlett kernel and Andrews (1991) bandwidth selection. Included hurricane dummies.

F_{ref} is joint test for significance of refining variables. $\chi^2(6)$ is Cumby and Huizinga (1992) statistic for autocorrelation of order 6

Table 11: All crudes: price differential decomposition, Instrumental Variables

	Shipping		Refining		Stats			Explanatory power			IV	
	γ^{ship}		γ^{api}		χ^2_{ref}	N	$\chi^2(6)$	R^2	R^2_{ship}	R^2_{ref}	Overid: $\chi^2(2)$	Endog: $F_{2,319}$
Mid-continent crudes												
WTI Cushing	-31.78***	(3.90)	-0.413	(0.29)	2.009	326	31.59***	0.720	0.715	0.00737	2.038	1.173
WTI Midland	-38.98***	(3.11)	-0.784*	(0.33)	5.751*	326	32.82***	0.752	0.738	0.00598	3.016	3.625*
WTS	-21.53***	(4.47)	-0.798^{+}	(0.42)	3.697^{+}	326	29.85***	0.475	0.444	0.00415	0.694	1.067
Coastal crudes												
LLS	-9.789***	(2.07)	-0.379**	(0.14)	6.865**	326	28.43***	0.503	0.461	0.0168	3.488	12.27***
HLS	-4.589*	(2.33)	-0.324*	(0.16)	4.223*	326	37.43***	0.217	0.169	0.0739	1.699	6.500**
FO USGC	1.133	(2.44)	-0.301	(0.25)	1.424	326	23.22***	0.154	0.138	0.150	2.031	2.129
EIA FPP: Stream												
CA Midway-Sunset	11.08***	(1.60)	-0.340	(0.31)	1.174	281	39.41***	0.351	0.341	0.0353	0.472	0.699
WTI (EIA)	-35.88***	(2.84)	-0.546	(0.43)	1.601	281	35.35***	0.732	0.726	0.0000276	3.191	3.567*
WTS (EIA)	-24.11***	(4.21)	-0.966^{+}	(0.51)	3.551^{+}	281	35.32***	0.506	0.484	0.0115	1.620	1.423
EIA FPP: PADD 1												
PADD 1	-40.93***	(3.40)	-0.299	(0.39)	0.594	326	45.77***	0.747	0.745	0.00559	5.337^{+}	5.151**
PA	-43.20***	(3.56)	-1.696^{+}	(0.92)	3.375^{+}	202	37.13***	0.757	0.737	0.106	1.566	2.341^{+}
EIA FPP: PADD 2												
PADD 2	-34.45***	(3.42)	-0.278	(0.27)	1.096	326	38.55***	0.769	0.766	0.00623	1.865	1.287
IL	-22.76***	(4.05)	-0.240	(0.29)	0.679	326	33.20***	0.573	0.571	0.000137	1.321	0.714
KS	-32.84***	(3.78)	-0.107	(0.29)	0.142	326	33.73***	0.732	0.731	0.000601	1.926	1.831
KY	-18.92***	(4.46)	0.181	(0.30)	0.354	326	31.06***	0.504	0.503	0.0370	0.706	1.023
NE	-35.33***	(3.18)	-0.151	(0.29)	0.278	326	40.03***	0.751	0.750	0.000945	1.878	2.352^{+}
ND	-31.42***	(3.59)	-0.361	(0.30)	1.455	326	43.43***	0.717	0.712	0.00215	0.295	0.371
OH	-35.68***	(3.31)	0.0726	(0.33)	0.0475	326	37.00***	0.714	0.714	0.0165	4.448	3.855*
OK	-36.54***	(3.76)	-0.168	(0.28)	0.358	326	37.01***	0.756	0.755	0.00463	2.009	2.226
SD	1.031	(4.45)	-1.340	(1.18)	1.293	177	31.72***	0.0528	0.0218	0.0533	1.791	1.546
EIA FPP: PADD 3												
PADD 3	-19.79***	(1.61)	-0.526*	(0.24)	4.619*	326	38.37***	0.562	0.540	0.00472	3.139	1.887
AL	-13.43***	(3.27)	-0.0879	(0.28)	0.0993	326	51.76***	0.331	0.330	0.00255	6.598*	4.292*
LA	-11.19***	(1.70)	-0.297^{+}	(0.17)	3.140^{+}	326	34.21***	0.335	0.320	0.00720	5.157^{+}	3.853*
MS	-5.211***	(1.02)	-0.423^{+}	(0.22)	3.598^{+}	326	48.87***	0.160	0.116	0.0525	0.940	1.051
NM	-40.92***	(2.89)	-0.410	(0.32)	1.672	326	36.36***	0.757	0.754	0.0131	3.587	4.253*
TX	-26.11***	(2.76)	-0.597*	(0.29)	4.314*	326	34.29***	0.628	0.611	0.0000339	1.635	1.738
EIA FPP: PADD 4												
PADD 4	-31.79***	(2.86)	-0.254	(0.22)	1.314	326	34.49***	0.748	0.745	0.00694	1.686	0.776
CO	-47.40***	(2.98)	-0.116	(0.27)	0.189	326	34.87***	0.826	0.826	0.00401	4.456	4.461*
MT	-45.67***	(3.50)	0.131	(0.31)	0.175	326	39.56***	0.826	0.825	0.0466	1.285	1.468
UT	-44.20***	(2.67)	0.292	(0.34)	0.749	326	37.77***	0.830	0.828	0.0630	2.386	2.802^{+}
WY	-16.72***	(3.79)	-0.410	(0.34)	1.462	326	46.46***	0.368	0.358	0.000514	2.356	0.0752
EIA FPP: PADD 5												
PADD 5	-10.63***	(1.58)	-0.172	(0.28)	0.391	326	84.81***	0.348	0.344	0.00150	2.040	1.652
AK North Slope	-15.86***	(1.49)	-0.424^{+}	(0.23)	3.329^{+}	326	83.97***	0.514	0.498	0.000787	3.791	3.482*
CA	-5.955**	(1.93)	0.178	(0.35)	0.258	326	88.81***	0.141	0.137	0.0250	1.187	0.505
FO CA	-19.94***	(4.52)	0.130	(0.47)	0.0753	303	81.12***	0.511	0.510	0.0243	3.092	1.554

Standard errors in parentheses. Significance tests against normal distribution: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

IV with HAC estimator using Bartlett kernel and Andrews (1991) bandwidth selection. Included hurricane dummies.

F_{ref} is joint test for significance of refining variables. $\chi^2(6)$ is Cumby and Huizinga (1992) statistic for autocorrelation of order 6

Overid $\chi^2(2)$ is Wooldridge (1995) test of overidentifying restrictions.

Endog $F_{2,319}$ is regression-based test of exogeneity of the instrumented variables.

Table 12: All crudes: price differential break tests, AR(2)

	Intercepts						Trends						Break tests			Stats	
	α_0		α_1		α_2		β_0		β_1		β_2		$F_{\beta_0=\beta_1}$	$F_{\beta_1=\beta_2}$	$F_{\beta_0=\beta_1=\beta_2}$	N	$\chi^2(6)$
Mid-continent crudes																	
WTI Cushing	0.264^{*}	(0.10)	14.86^{**}	(5.39)	-26.98^{*}	(11.27)	0.00377	(0.01)	-0.805^{**}	(0.28)	1.052^{*}	(0.44)	8.120^{**}	9.545^{**}	5.151^{**}	310	1.549
WTI Midland	0.239^{**}	(0.08)	16.72^{**}	(5.78)	-31.04^{*}	(13.97)	0.00429	(0.01)	-0.906^{**}	(0.30)	1.195^{*}	(0.55)	8.900^{**}	9.071^{**}	5.418^{**}	310	2.269
WTS	0.288^{**}	(0.11)	12.59^{*}	(5.24)	-27.31^{*}	(12.63)	0.00358	(0.01)	-0.646^{*}	(0.27)	1.094^{*}	(0.50)	5.684^{*}	8.695^{**}	4.825^{**}	310	3.092
Coastal crudes																	
LLS	0.336^{***}	(0.09)	3.887^{*}	(1.61)	-8.958^{+}	(5.05)	0.00147	(0.01)	-0.188^{*}	(0.08)	0.331	(0.20)	5.251^{*}	5.419^{*}	3.768^{*}	310	2.574
HLS	0.524^{***}	(0.11)	1.149	(1.49)	-0.254	(5.41)	-0.00116	(0.01)	-0.0175	(0.07)	-0.0168	(0.22)	0.0470	0.0000107	0.0266	310	2.013
FO USGC	0.138	(0.12)	-1.897	(5.73)	4.857	(14.59)	-0.000275	(0.02)	0.144	(0.29)	-0.198	(0.59)	0.245	0.243	0.160	310	3.007
EIA FPP: Stream																	
CA Midway-Sunset	-0.910^{**}	(0.32)	-11.73^{*}	(4.99)	24.06^{**}	(9.02)	0.0204	(0.03)	0.611^{*}	(0.26)	-0.976^{**}	(0.36)	5.258^{*}	9.357^{**}	4.680^{*}	265	1.147
WTI (EIA)	0.238^{+}	(0.14)	16.77^{**}	(5.99)	-27.99^{**}	(9.84)	-0.0259	(0.02)	-0.941^{**}	(0.32)	1.034^{**}	(0.38)	8.289^{**}	11.90^{***}	5.992^{**}	265	3.012
WTS (EIA)	0.0292	(0.16)	14.34^{*}	(5.82)	-29.65^{**}	(11.27)	0.00175	(0.02)	-0.762^{*}	(0.30)	1.154^{**}	(0.45)	6.336^{*}	11.02^{**}	5.623^{**}	265	1.646
EIA FPP: PADD 1																	
PADD 1	-0.0661	(0.13)	21.25^{***}	(5.53)	-19.91^{*}	(8.94)	-0.00668	(0.01)	-1.224^{***}	(0.30)	0.617^{+}	(0.35)	16.69^{***}	13.73^{***}	8.939^{***}	310	1.567
PA	1.456^{*}	(0.67)	21.75^{***}	(5.62)	-30.08^{**}	(11.16)	-0.110^{*}	(0.05)	-1.246^{***}	(0.30)	1.064^{*}	(0.43)	14.15^{***}	14.80^{***}	8.461^{***}	186	1.885
EIA FPP: PADD 2																	
PADD 2	0.0698	(0.09)	18.66^{**}	(6.35)	-26.31^{*}	(10.45)	0.00224	(0.02)	-1.045^{**}	(0.34)	0.972^{*}	(0.40)	9.436^{**}	10.51^{**}	5.551^{**}	310	2.642
IL	0.355^{**}	(0.11)	11.83^{*}	(4.67)	-16.49^{+}	(9.10)	-0.00329	(0.01)	-0.633^{**}	(0.24)	0.641^{+}	(0.36)	6.787^{**}	7.699^{**}	4.479^{*}	310	1.770
KS	0.0347	(0.08)	13.52^{**}	(4.93)	-24.64^{*}	(10.09)	-0.00130	(0.01)	-0.769^{**}	(0.26)	0.930^{*}	(0.39)	8.495^{**}	10.08^{**}	5.442^{**}	310	1.006
KY	0.375^{**}	(0.12)	11.13^{*}	(4.52)	-19.50^{*}	(9.39)	-0.0159	(0.01)	-0.601^{*}	(0.23)	0.778^{*}	(0.38)	6.293^{*}	8.842^{**}	4.865^{**}	310	1.463
NE	-0.0520	(0.10)	11.22^{*}	(4.48)	-24.05^{*}	(9.51)	0.00441	(0.02)	-0.662^{**}	(0.24)	0.893^{*}	(0.36)	7.694^{**}	11.12^{***}	5.878^{**}	310	1.748
ND	-0.00464	(0.15)	20.99^{**}	(6.80)	-25.35^{*}	(10.81)	0.00835	(0.03)	-1.172^{**}	(0.36)	0.924^{*}	(0.42)	10.54^{**}	11.29^{***}	6.190^{**}	310	5.517
OH	0.00575	(0.11)	15.48^{**}	(5.00)	-15.39^{+}	(8.88)	-0.0318^{*}	(0.01)	-0.910^{***}	(0.27)	0.476	(0.35)	10.83^{**}	8.766^{**}	5.901^{**}	310	1.787
OK	-0.0686	(0.09)	15.61^{**}	(5.42)	-29.45^{**}	(10.84)	0.00142	(0.01)	-0.889^{**}	(0.29)	1.113^{**}	(0.42)	9.222^{**}	11.31^{***}	5.918^{**}	310	2.747
SD	4.568	(3.35)	10.96^{+}	(5.89)	12.80	(10.48)	-0.166	(0.24)	-0.424	(0.30)	-0.433	(0.43)	0.438	0.000256	0.276	161	3.468
EIA FPP: PADD 3																	
PADD 3	-0.0168	(0.09)	13.56^{**}	(5.22)	-21.46^{*}	(8.47)	0.00541	(0.01)	-0.732^{**}	(0.27)	0.796^{*}	(0.33)	7.387^{**}	11.34^{***}	5.831^{**}	310	1.586
AL	-0.451^{**}	(0.14)	8.089	(4.94)	2.621	(9.28)	-0.00356	(0.02)	-0.515^{*}	(0.26)	-0.271	(0.38)	3.859^{+}	0.286	2.141	310	1.757
LA	-0.158	(0.12)	9.320^{*}	(4.40)	-8.849	(8.44)	0.0254	(0.02)	-0.525^{*}	(0.23)	0.268	(0.34)	5.658^{*}	3.753^{+}	3.116^{*}	310	0.346
MS	-0.543^{***}	(0.13)	6.327	(4.11)	-6.581	(6.65)	0.00403	(0.01)	-0.333	(0.21)	0.222	(0.27)	2.493	2.690	1.609	310	0.417
NM	-0.0521	(0.10)	16.97^{**}	(6.04)	-35.27^{**}	(11.46)	-0.0123	(0.01)	-0.965^{**}	(0.32)	1.318^{**}	(0.44)	8.678^{**}	13.45^{***}	6.795^{**}	310	2.862
TX	-0.0292	(0.09)	14.86^{**}	(5.67)	-20.73^{*}	(8.73)	0.00678	(0.01)	-0.808^{**}	(0.29)	0.774^{*}	(0.34)	7.493^{**}	9.962^{**}	5.132^{**}	310	2.508
EIA FPP: PADD 4																	
PADD 4	0.0471	(0.09)	15.81^{**}	(5.47)	-26.64^{*}	(10.59)	0.00782	(0.02)	-0.891^{**}	(0.29)	0.988^{*}	(0.41)	9.478^{**}	11.59^{***}	6.293^{**}	310	2.834
CO	-0.0887	(0.10)	15.93^{**}	(5.72)	-34.09^{**}	(12.42)	0.00811	(0.01)	-0.956^{**}	(0.32)	1.248^{**}	(0.47)	9.157^{**}	11.37^{***}	5.958^{**}	310	2.329
MT	-0.371^{+}	(0.20)	20.92^{***}	(6.30)	-35.62^{**}	(12.67)	-0.0266	(0.03)	-1.250^{***}	(0.34)	1.276^{**}	(0.48)	12.43^{***}	14.47^{***}	7.875^{***}	310	3.548
UT	0.329^{*}	(0.13)	13.78^{**}	(5.24)	-31.57^{*}	(12.65)	-0.0108	(0.02)	-0.827^{**}	(0.29)	1.176^{*}	(0.48)	7.892^{**}	9.950^{**}	5.309^{**}	310	3.516
WY	0.336^{**}	(0.12)	13.33^{*}	(6.18)	-15.94	(12.17)	0.0128	(0.02)	-0.688^{*}	(0.32)	0.623	(0.49)	4.771^{*}	4.933^{*}	3.098^{*}	310	4.006
EIA FPP: PADD 5																	
PADD 5	-1.781^{***}	(0.33)	0.350	(3.67)	-8.597	(7.06)	0.00866	(0.02)	-0.142	(0.19)	0.234	(0.28)	0.644	1.177	0.612	310	1.195
AK North Slope	-2.165^{***}	(0.41)	4.242	(3.98)	-12.17	(9.47)	0.0121	(0.02)	-0.366^{+}	(0.20)	0.334	(0.38)	3.355^{+}	2.480	1.927	310	1.519
CA	-1.301^{***}	(0.30)	-3.204	(4.21)	-5.137	(6.68)	-0.00551	(0.02)	0.0608	(0.22)	0.127	(0.27)	0.0940	0.0366	0.168	310	2.541
FO CA	-1.531^{***}	(0.41)	-2.017	(3.99)	0.727	(10.64)	-0.0153	(0.02)	-0.0367	(0.20)	-0.202	(0.45)	0.0117	0.107	0.0974	303	4.021

Standard errors in parentheses. Significance tests against normal distribution: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

OLS with HAC estimator using Bartlett kernel and Andrews (1991) bandwidth selection. Included 2 lags of $pd_{c,t}$ and hurricane dummies.

$\chi^2(6)$ is Cumby and Huizinga (1992) statistic for autocorrelation of order 6

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Table 13: All crudes: price differential decomposition, AR(2)

	Shipping		Refining		LRM: Ship		LRM: Refining		Stats		
	γ^{ship}		γ^{api}		$\widetilde{\gamma}^{ship}$		$\widetilde{\gamma}^{api}$		F_{ref}	N	$\chi^2(6)$
Mid-continent crudes											
WTI Cushing	-5.669**	(1.94)	-0.0163	(0.08)	-30.09***	(5.23)	-0.0866	(0.39)	0.0457	310	1.714
WTI Midland	-7.947***	(2.04)	-0.112	(0.08)	-37.74***	(5.64)	-0.534^{+}	(0.32)	2.142	310	1.532
WTS	-4.392**	(1.38)	-0.137^{+}	(0.08)	-20.88***	(5.60)	-0.652^{+}	(0.34)	2.940^{+}	310	2.756
Coastal crudes											
LLS	-2.695***	(0.66)	-0.0572	(0.04)	-9.711***	(2.25)	-0.206	(0.14)	1.924	310	3.350
HLS	-1.445*	(0.59)	-0.0659	(0.04)	-4.688*	(2.14)	-0.214	(0.14)	2.311	310	4.482
FO USGC	0.428	(1.61)	-0.150	(0.12)	0.897	(3.37)	-0.314	(0.26)	1.476	310	2.780
EIA FPP: Stream											
CA Midway-Sunset	3.176*	(1.35)	-0.0840	(0.13)	10.18***	(2.97)	-0.269	(0.38)	0.433	265	1.092
WTI (EIA)	-7.886***	(2.04)	-0.0396	(0.11)	-34.96***	(4.49)	-0.176	(0.48)	0.127	265	4.494
WTS (EIA)	-5.533***	(1.67)	-0.171	(0.13)	-23.52***	(5.05)	-0.727	(0.49)	1.617	265	2.287
EIA FPP: PADD 1											
PADD 1	-6.582***	(1.91)	0.0370	(0.07)	-39.15***	(6.24)	0.220	(0.46)	0.256	310	4.341
PA	-6.617**	(2.26)	0.00763	(0.31)	-43.26***	(8.69)	0.0499	(2.06)	0.000592	186	2.898
EIA FPP: PADD 2											
PADD 2	-8.249***	(2.13)	-0.00825	(0.07)	-33.18***	(4.36)	-0.0332	(0.29)	0.0130	310	3.842
IL	-3.912**	(1.33)	-0.00368	(0.07)	-21.16***	(4.97)	-0.0199	(0.36)	0.00304	310	2.328
KS	-5.602**	(1.86)	0.0343	(0.06)	-31.24***	(5.22)	0.191	(0.38)	0.293	310	1.821
KY	-3.070**	(1.19)	0.0698	(0.07)	-17.16***	(5.08)	0.390	(0.41)	1.075	310	1.457
NE	-6.367***	(1.86)	0.0244	(0.07)	-33.77***	(5.10)	0.129	(0.37)	0.132	310	2.397
ND	-9.984***	(2.23)	-0.0560	(0.10)	-30.43***	(3.98)	-0.171	(0.29)	0.338	310	6.456
OH	-6.339***	(1.90)	0.0806	(0.07)	-34.10***	(5.68)	0.434	(0.40)	1.343	310	2.860
OK	-6.463**	(2.05)	0.0280	(0.07)	-34.86***	(5.25)	0.151	(0.39)	0.167	310	3.698
SD	-0.580	(1.67)	-0.00548	(0.34)	-2.654	(7.69)	-0.0251	(1.54)	0.000266	161	2.945
EIA FPP: PADD 3											
PADD 3	-6.299***	(1.46)	-0.142^{+}	(0.08)	-19.33***	(3.04)	-0.435^{+}	(0.24)	2.881^{+}	310	2.197
AL	-4.810***	(1.43)	-0.00326	(0.09)	-12.97***	(3.34)	-0.00879	(0.23)	0.00144	310	7.368
LA	-5.122***	(1.21)	-0.121	(0.08)	-10.76***	(2.30)	-0.255^{+}	(0.15)	2.541	310	0.970
MS	-1.937*	(0.89)	-0.144*	(0.07)	-5.044*	(2.38)	-0.376*	(0.16)	4.383*	310	1.023
NM	-8.831***	(2.35)	-0.0371	(0.08)	-39.60***	(5.20)	-0.166	(0.34)	0.221	310	3.238
TX	-6.176***	(1.57)	-0.108	(0.08)	-25.48***	(4.06)	-0.446	(0.29)	1.783	310	4.135
EIA FPP: PADD 4											
PADD 4	-8.713***	(2.16)	-0.0270	(0.07)	-30.60***	(3.83)	-0.0949	(0.25)	0.135	310	2.574
CO	-9.038**	(2.79)	0.0708	(0.07)	-45.02***	(6.07)	0.353	(0.41)	0.913	310	1.866
MT	-13.15***	(3.28)	0.112	(0.09)	-44.46***	(4.79)	0.380	(0.31)	1.740	310	3.983
UT	-7.968**	(2.74)	0.130^{+}	(0.07)	-42.31***	(5.82)	0.690	(0.43)	3.671^{+}	310	2.821
WY	-4.831**	(1.55)	-0.110	(0.09)	-16.06***	(4.24)	-0.366	(0.30)	1.417	310	3.705
EIA FPP: PADD 5											
PADD 5	-3.139***	(0.95)	-0.0192	(0.08)	-10.40***	(2.65)	-0.0636	(0.25)	0.0646	310	1.649
AK North Slope	-5.162***	(1.21)	-0.0797	(0.09)	-15.41***	(2.58)	-0.238	(0.25)	0.869	310	2.086
CA	-1.653^{+}	(0.95)	0.0559	(0.07)	-6.016^{+}	(3.19)	0.203	(0.28)	0.564	310	3.385
FO CA	-3.327**	(1.28)	0.0542	(0.07)	-20.44***	(5.66)	0.333	(0.47)	0.542	303	4.607

Standard errors in parentheses. Significance tests against normal distribution: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

OLS with HAC estimator using Bartlett kernel and Andrews (1991) bandwidth selection. Included 2 lags of $pd_{c,t}$ and hurricane dummies.

F_{ref} is joint test for significance of refining variables. $\chi^2(6)$ is Cumby and Huizinga (1992) statistic for autocorrelation of order 6