

# A Recentered Influence Function Investigation into WTI-Brent Spread and its Macro-fundamental Drivers

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- **WTI-Brent (WB):** Two globally recognized benchmarks.
- **Same Same but Different**
  - API Gravity >10
  - Sulfur Content
  - Location (North Sea v Texas)
  - Logistical challenge (Landblocked Pipeline v Sea proximity)
- **Financial markets price the two differently.**
- **Recent trends**
  - 2011 Shale oil revolution: acute downward pressure on WTI
  - China's breakneck pace of growth over the last two decades
  - Systemwide economic shocks from the COVID-19 pandemic
  - Saudi Arabia and Russia price war
  - 2021 rebound: Brent settled at 78.94 pb and WTI at 75.98
  - 2022 Russia-Ukraine War: Significant price surge and wild swings

- **Literature documents importance of WBS for:**

- Interest rate formation (Doğrul & Soytaş, 2010; Wang & Chueh, 2013)
- Investors' portfolio & producers' inventory decisions (Regnier, 2007)
- Working capital management (Byard et al., 2007)
- Speculation and spillover in energy prices (Kaufmann, 2013)
- Markets' price discovery (Mensi et al., 2014; Dowling et al., 2016)
- Global supply-demand balances (Buyuksahin & Robe, 2014)
- Risk management (Kuck & Scweikert, 2017)

- **There is still paucity of research on:**

- Statistical properties of WBS (Structural Breaks, Mean-reversion, etc.)
- Macro-fundamental antecedents of WBS
- Transmission of global uncertainty to WBS

- **Answers we seek**

- Structural breaks in time-series of WBS
- What are fundamental determinants of WBS?
- Are there cross-quantile differences in the distribution of WBS?
- Are there causal linkages?

## Applied Test Methods

- **Structural Breaks Analysis via Mean and Persistence Shift**
- **Unconditional Quantile Recentered Influence Function**

- **Via Mean**

- Structural change through a change in mean
- Standard OLS-CUSUM test of Brown et al. (1975)

$$wbs_t = \mu + \beta (t \geq t^*) + \epsilon_t$$

- where coefficient  $\beta$  signifies a possible mean shift
- Self-normalized CUSUM for persistent time-series

$$Z_\delta^A := \sup_{\tau \in [\tau_1, \tau_2]} \left| \frac{1}{T^{1/2} \hat{\sigma}_{A, \delta}} \sum_{t=1}^{[\tau T]} \hat{\epsilon}_t^A \right|$$

- **Via Persistence Shift**

- Tradable WBS contract responds well to technical analysis strategies
- Long memory properties of the WBS: Fractional Intergration  $1 > d > 0$

- **Recentered Influence Function (RIF)**

- A *Machine Learning* inspired technique by Firpo et al. (2009)
- Impact of regression covariates on unconditional distributions of WBS

$$\text{RIF} \{y_i, v(F_Y)\} = v(F_Y) + \text{IF} \{y_i, v(F_Y)\}$$

- Fundamental determinants of WBS:
  - Demand Type
  - Supply Type
  - Global Uncertainty
- We look at Mean, IQR, and Variance distributions of WBS

- **Seemingly Unrelated RIF (Rios-Avila, 2020)**

- A system of quantile-specific regression equations
- Marginal effect of covariates on heterogenous quantiles of WBS

- **We use monthly data**
- **Data spans from June 1988 to November 2020**
- **Demand Type Variables**
  - **Aruoba-Diebold-Scotti (ADS) Index:** US business condition in terms of growth, industrial productions, and employment payroll
  - **(ISM) Purchasing Manager Index:** US economic activity based on a survey of purchasing managers
- **Supply Type Variables**
  - **PADD:** Oil flow from Cushing oil hub in Oklahoma to Gulf coast
  - **OILRIGS:** Number of operational oil rigs in the US
  - **CANIMP:** Import of Canadian Oil
- **Uncertainty Variables**
  - **VIX:** CBOE Volatility Index
  - **GPR:** Geopolitical Risk Index

# Findings (Structural Break via Mean)

Table: Change-point detection via mean

		0.9	0.95	0.99	Test Statistic 90%	Test Statistic 95%	Test Statistic 99%
CUSUM Ratio Break: August 07, 2010	Against change from I(0) to I(1)	3.51	4.61	7.69	1471.39		
	Against change from I(1) to I(0)	3.51	4.61	7.69	4.01		
	Against change in unknown direction	4.63	5.88	9.24	1471.39		
CUSUM Ratio [Without Directionality] Break: August 07, 2010	Against change from I(0) to I(1)	3.51	4.61	7.69	861.09		
	Against change from I(1) to I(0)	3.51	4.61	7.69	2.36		
	Against change in unknown direction	4.63	5.88	9.24	768.06		
CUSUM Ratio [With Directionality] Break: August 07, 2010	Against change from I(0) to I(1)					762.91	615.2
	Against change from I(1) to I(0)					2.09	1.67
	Against change in unknown direction					692.81	559.92



# Findings (Structural Break via Persistence Shift)

Table: Change-point detection via change in memory

	Regular	LKT	GPH	BW = 0.65	BW = 0.75
Breakpoint	10/11/2010	08/11/2010	10/11/2010	10/11/2010	10/11/2010
d1	0.6732	0.6726	0.6095	0.6497	0.608
sd1	0.0285	0.0285	0.0386	0.0232	0.0349
d2	0.9129	0.9132	0.9262	0.905	0.8745
sd2	0.0264	0.0264	0.0341	0.0214	0.0325

# Findings (RIF)

Table: RIF Regression using Monthly Data

	SPREAD iqr(90 10)	SPREAD iqratio(90 10)	SPREAD variance
ADS	0.33	0.138	0.188
(Robust)	(0.084)***	(0.035)***	-0.098
ISM	0.951	0.391	0.304
(Robust)	(0.419)**	(0.175)**	-0.3
PADD	-0.451	-0.186	-0.127
(Robust)	(0.106)***	(0.044)***	(0.033)***
OILRIGS	0.925	0.39	0.334
(Robust)	(0.131)***	(0.055)***	(0.093)***
CANIMP	0.837	0.348	0.225
(Robust)	(0.153)***	(0.064)***	(0.061)***
VIX	0.38	0.158	0.311
(Robust)	(0.137)***	(0.057)**	-0.201
GPR	-0.168	-0.072	-0.13
(Robust)	(0.066)**	(0.028)**	(0.064)**
CONS	-12.32	-4.17	-4.544
(Robust)	(2.286)***	(0.956)***	(2.275)**

# Findings (SUR RIF)

**Table:** SURE RIF Regression using Monthly Data on Quantiles

	SPREAD 20th Quantile	SPREAD 40th Quantile	SPREAD 60th Quantile	SPREAD 80th Quantile
ADS	0.22	-0.007	-0.018	-0.007
(Bootstrap)	-0.504	-0.1	-0.042	-0.048
ISM	-0.303	0.197	0.092	0.127
(Bootstrap)	-0.322	(0.070)***	-0.072	(0.065)**
PADD	0.061	-0.046	-0.012	-0.035
(Bootstrap)	-0.076	-0.035	-0.014	(0.012)***
OILRIGS	-0.501	-0.076	-0.042	-0.027
(Bootstrap)	(0.124)***	(0.028)***	(0.010)***	(0.008)***
CANIMP	-0.374	-0.21	-0.118	0.003
(Bootstrap)	(0.116)***	(0.027)***	(0.038)***	-0.023
VIX	-0.067	0.026	-0.011	0.017
(Bootstrap)	-0.07	-0.022	-0.016	-0.013
GPR	-0.012	0.015	0.015	0.025
(Bootstrap)	-0.043	-0.01	-0.011	(0.011)**
CONS	9.037	4.846	4.235	3.147
(Bootstrap)	(2.562)***	(0.780)***	(0.258)***	(0.254)***

# Findings (RIF (Robustness Check))

Table: RIF Regression (Robustness Check)

	SPREAD iqr(90 10)	SPREAD iqratio(90 10)	SPREAD variance
ADS	0.300	0.125	0.2
(Robust)	(0.103)***	(0.042)***	-0.124
BALTIC	-0.273	-0.116	0.06
(Robust)	(0.130)**	(0.054)**	-0.101
KILIAN	0.15	0.062	-0.116
(Robust)	-0.202	-0.084	-0.128
PADD	-0.647	-0.27	-0.14
(Robust)	(0.164)***	(0.069)***	(0.063)**
OILRIGS	0.961	0.405	0.342
(Robust)	(0.145)***	(0.061)***	(0.087)***
CANIMP	1.181	0.494	0.24
(Robust)	(0.227)***	(0.094)***	(0.081)***
VIX	0.171	0.071	0.268
(Robust)	-0.132	-0.055	-0.191
GPR	-0.175	-0.074	-0.133
(Robust)	(0.065)***	(0.027)***	(0.070)*
CONS	-7.56	-2.194	-3.128
(Robust)	(1.313)***	(0.550)***	(1.477)**

# Country-level RIF (Robustness Check)

Table: RIF Quantiles, Country Level Test-results

	Spread iqr(90 10)							
	Algeria	Angola	Egypt	Libya	Nigeria	Norway	Russia	UK
PROD	0.518	0.331	-2.017	-46.303	3.361	-0.103	2.504	-1.272
	-0.355	-0.285	(0.819)**	(14.012)***	(0.603)***	-0.54	(0.665)***	(0.532)**
ADS	0.291	0.239	0.336	0.328	0.338	0.274	0.26	5.796
	-0.269	-0.271	-0.268	-0.265	-0.257	-0.271	-0.263	-4.216
ISM	0.517	0.68	0.624	0.706	0.032	0.688	0.475	-0.551
	-0.599	-0.587	-0.583	-0.578	-0.573	-0.589	-0.578	-1.145
PADD	-0.293	-0.351	-0.412	-0.721	0.234	-0.472	-0.184	-0.718
	-0.185	(0.173)**	(0.146)***	(0.164)***	-0.187	(0.159)***	-0.16	(0.240)***
OILRIGS	0.936	0.95	1.05	1.026	0.75	0.997	0.91	1.173
	(0.126)***	(0.127)***	(0.115)***	(0.114)***	(0.120)***	(0.134)***	(0.116)***	(0.214)***
CANIMP	0.238	0.082	-0.766	0.573	0.784	0.46	-0.74	-0.512
	-0.395	-0.503	-0.622	(0.348)*	(0.341)**	-0.411	-0.477	-0.747
VIX	0.358	0.329	0.317	0.341	0.287	0.357	0.351	0.499
	(0.138)**	(0.140)**	(0.138)**	(0.136)**	(0.132)**	(0.139)**	(0.135)**	(0.204)**
GPR	-0.15	-0.13	-0.172	-0.184	-0.158	-0.16	-0.172	-0.146
	-0.112	-0.115	-0.111	(0.110)*	-0.107	-0.112	-0.11	-0.162
CONS	-5.182	-4.823	-9.059	-6.424	-1.009	-8.738	5.289	-18.414
	-4.026	-4.7	(3.083)***	(3.151)*	-3.289	(3.261)***	-4.847	-12.735

# Concluding remarks

- Significant regime change in late 2010
- Positive association between demand-type variables and WBS
- COVID-19 pandemic's induced demand shocks
- Supply-type factors exhibit stronger correlation
- OPEC+ policy decisions, higher volumes of production, and rising Canadian oil import