Physical Market and WTI/Brent Price Spread

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The prices of West Texas Intermediate (WTI) and Brent used to move closely together but diverged in from 2010 onward.

WTI and Brent are of similar quality and are used for very similar purposes, thus price differentials between these two creates an arbitrage opportunity.
Literature Review

- WTI/Brent crude oil price spread changed from a stationary time series to a non-stationary time series in 2010 (Chen, Huang and Yi, 2015)

- Factors identified as contributing to WTI/Brent price spread
  - Macroeconomic conditions or business activity (Büyüksahin et al., 2013)
  - China demand (Li, Mizra and Otsubo, 2015)
  - Canadian crude imports (Büyüksahin et al., 2013)
  - Inventory at Cushing, Oklahoma (Büyüksahin et al., 2013; Li, Mizra and Otsubo, 2015)
  - Financial market liquidity and activity (Büyüksahin et al., 2013; Heidorn, 2015)
Research Question

- Have there been any structural breaks in WTI/Brent spread behavior?
- What physical market factors are driving the variations in WTI/Brent spread?
- Can we use a better modeling technique, e.g. Structural Vector Autoregressive Model (SVAR), to better explain the WTI/Brent spread behavior?
Methodology


- Physical market variables
  - WTI supply: US field production + Canadian crude imported into PADD2
  - Brent supply: Norway production
  - WTI demand: Purchasing Manager Index (PMI)
  - Brent demand: Kilian’s measure of monthly global real economic activity
Methodology

- Estimate Structural Vector Autoregressive Model for each sub-sampl
  - SVAR Model
    - $B_0 Y_t = B_1 Y_{t-1} + B_2 Y_{t-2} + \cdots + B_p Y_{t-p} + \varepsilon_t$
    - $B_0^{-1} B_0 Y_t = B_0^{-1} B_1 Y_{t-1} + B_0^{-1} B_2 Y_{t-2} + \cdots + B_0^{-1} B_p Y_{t-p} + B_0^{-1} \varepsilon_t$
    - $Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + u_t$, where $u_t = B_0^{-1} \varepsilon_t$
  - Identification Method: Recursiveness Assumption

$$
\begin{bmatrix}
  u_{t,\text{WTI\_supply}} \\
  u_{t,\text{Norway\_production}} \\
  u_{t,\text{PMI}} \\
  u_{t,\text{Kilian}} \\
  u_{t,\text{spread}} \\
\end{bmatrix}
 =
\begin{bmatrix}
  b_{11} & 0 & 0 & 0 & 0 \\
  b_{21} & b_{22} & 0 & 0 & 0 \\
  b_{31} & b_{32} & b_{33} & 0 & 0 \\
  b_{41} & b_{42} & b_{43} & b_{44} & 0 \\
  b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \\
\end{bmatrix}
\begin{bmatrix}
  \varepsilon_{t,\text{WTI\_supply\_shock}} \\
  \varepsilon_{t,\text{Norway\_production\_shock}} \\
  \varepsilon_{t,\text{PMI\_shock}} \\
  \varepsilon_{t,\text{Kilian\_shock}} \\
  \varepsilon_{t,\text{spread\_shock}} \\
\end{bmatrix}
$$
Data: Jan 1994 – Mar 2016 (Monthly)

WTI Supply

Norway Production
Data: Jan 1994 – Mar 2016 (Monthly)

PMI

Global Economic Activity Index
Structural Break Test Result

- Breakpoint: Dec 2010 (95% Confidence Interval: Aug 2010 to Jan 2011)
  - WTI/Brent spread is stationary before and after structural break
Impulse Response Function – WTI Supply

Sub-sample 1

Sub-sample 2
Impulse Response Function – WTI Supply

- Sub-sample 1:
  - WTI/Brent price spread shows negative response to an unexpected increase in WTI supply in the first 2 months

- Sub-sample 2:
  - WTI/Brent price spread shows positive response to an unexpected increase in WTI supply after the 3rd month
Impulse Response Function – Norway Production

Sub-sample 1

Sub-sample 2
Impulse Response Function – Norway Production

- Sub-sample 1:
  - WTI/Brent price spread shows positive response to an unexpected increase in Norway production instantaneously, but the impacts of Norway production shock disappear progressively after the 3rd month.

- Sub-sample 2:
  - WTI/Brent price spread shows positive response to an unexpected increase in WTI supply, but the impact is not statistically significant.
Impulse Response Function – Purchasing Manager Index

Sub-sample 1

Sub-sample 2
Sub-sample 1:
- WTI/Brent price spread shows insignificant response to shocks from U.S. demand, which is proxied by PMI.

Sub-sample 2:
- WTI/Brent price spread shows insignificant response to shocks from U.S. demand, which is proxied by PMI.
Impulse Response Function – Global Economic Activity Index

Sub-sample 1

Sub-sample 2
Impulse Response Function – Global Economic Activity Index

- Sub-sample 1:
  - WTI/Brent price spread shows insignificant response to shocks from international demand, which is proxied by Kilian’s Global Real Economic Activity Index.

- Sub-sample 2:
  - WTI/Brent price spread shows insignificant response to shocks from international demand, which is proxied by Kilian’s Global Real Economic Activity Index.
Conclusion

- There is a structural break in WTI/Brent price spread around Dec 2010 during the period from Jan 1994 to Mar 2016.

- Comparing to other physical market variables, Norway production (Brent supply) has the most significant and consistent impact on WTI/Brent price spread, both before and after the structural break. More specifically, an unexpected increase in Norway production will cause an increase in WTI/Brent spread.