THE BRENT–WTI SPREAD REVISITED: A NOVEL APPROACH

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OUTLINE

- Introduction
- Scenario development
- Results
- Conclusion

INTRODUCTION: THE GLOBAL MARKET FOR CRUDE OIL

- Two views on the market for crude oil:

1. It is fairly integrated, global and liquid:

- Price of same quality crude in different markets should move in parallel fashion, and price differences should primarily reflect transaction and transportation costs.

2. A second view is that the oil market is somewhat fragmented and regionalized:

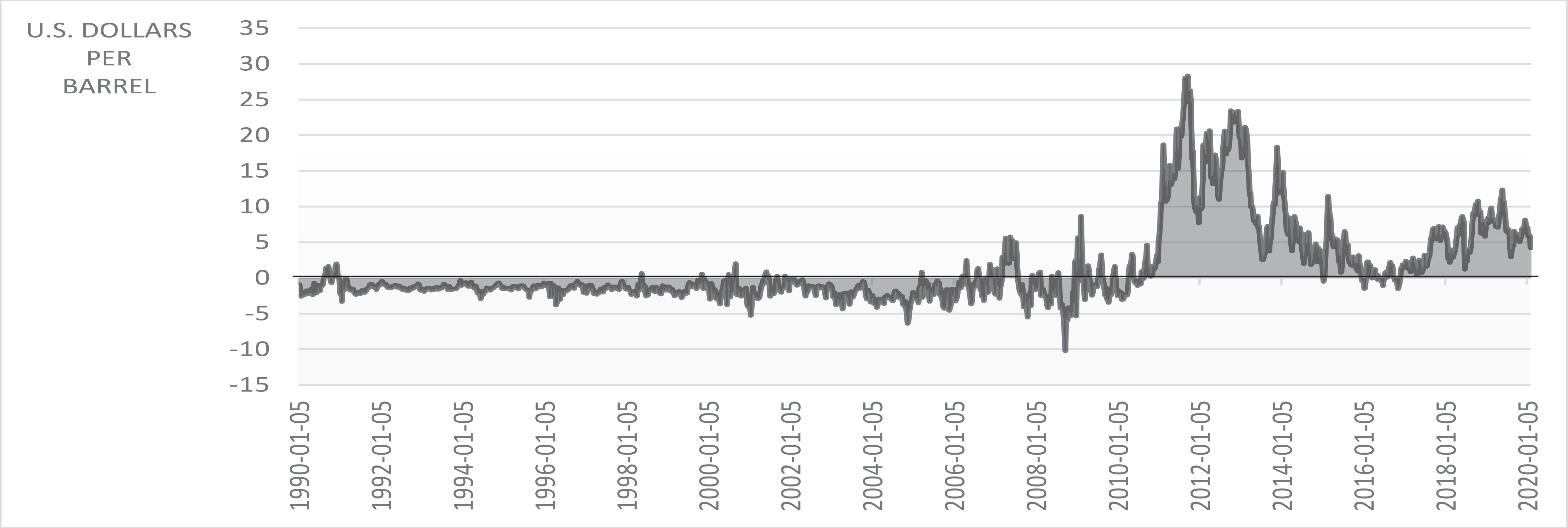
- Prices in different regions are the result of local market conditions and one would not expect oil prices of similar crudes to move together.
  - Our work aims to contribute to the existing literature that:
    - Analyzes to what extent the global market for crude oil is indeed one great pool.
    - Aims at identifying major drivers of the Brent-WTI spread as well as the magnitude of the effect of these drivers.

- Global crude trade is dominated by two benchmark prices:
  - West Texas Intermediate (WTI) which is the primary benchmark in the U.S.,
  - Brent against which most crudes in the rest of the world are quoted; (with the exception of Oman/Dubai which is the dominant benchmark in the Far East.)
  - Oil is still the world's primary source of energy and, it is an input mainly used to produce refined petroleum products such as gasoline, distillates and heavy fuel oil.

INTRODUCTION: THE BRENT-WTI SPREAD DEFINED

- Brent-WTI spread is typically defined as: $Spread_t^{Brent-WTI} = P_t^{Brent} - P_t^{WTI}$

INTRODUCTION: THE BRENT-WTI SPREAD 01/1990-01/2020



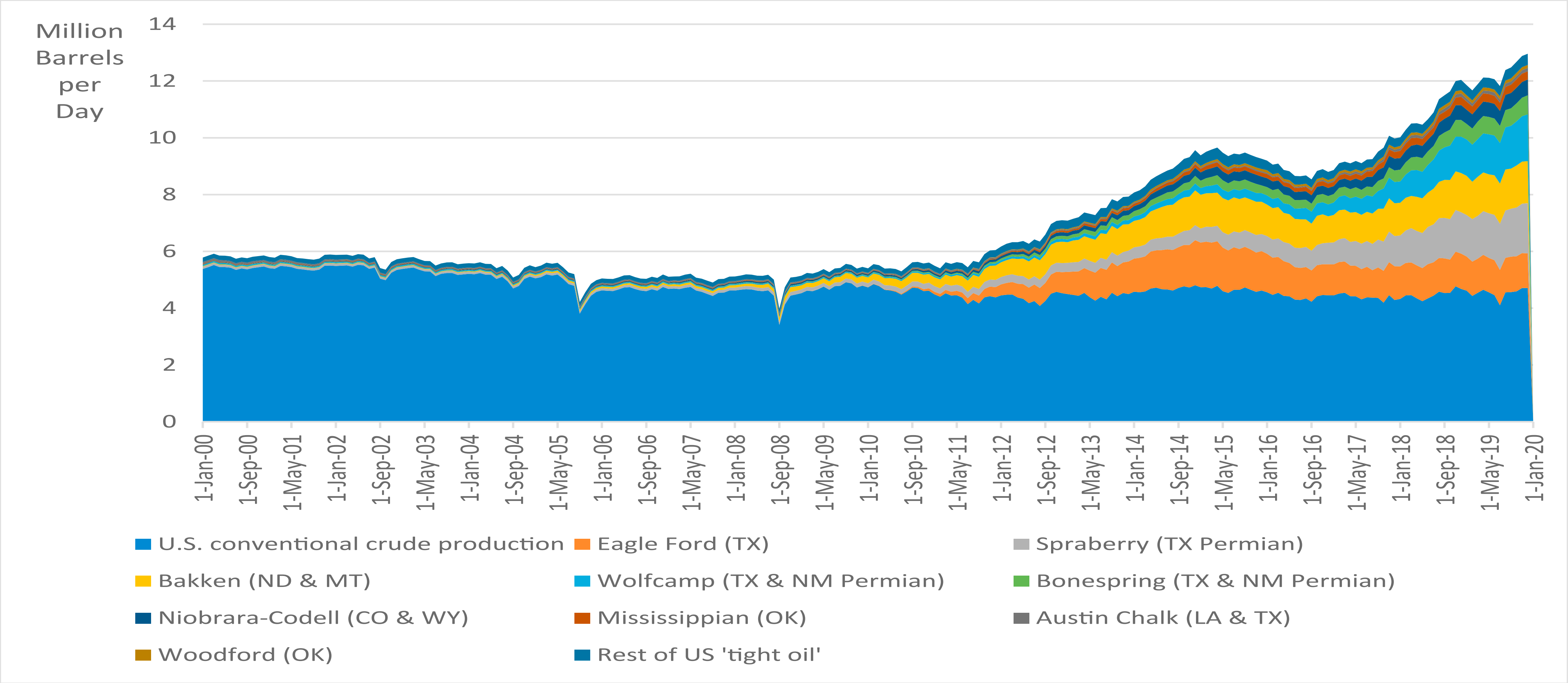
INTRODUCTION: THE SURGE IN U.S. CRUDE PRODUCTION

- The tight oil boom allowed the U.S. once the world's biggest importer of crude oil to become the world's leading producer in 2017.
- In 2019 U.S. crude oil production averaged over 17 MMB/d with 63% coming from tight oil.
- The U.S. in 2019 accounts for 18% of global crude production followed by Saudi Arabia and Russia, each accounting for around 12%.

- The U.S. transitioning to self sufficiency:
  - → Led to a weakening of OPEC's position on the world market for crude
  - → Changed international trade patterns

INTRODUCTION: THE SURGE IN U.S. CRUDE PRODUCTION

U.S. CONVENTIONAL AND TIGHT OIL PRODUCTION (01/2000–01/2021) (BASED ON DATA FROM EIA)



INTRODUCTION: STRUCTURAL CHANGES

DEMAND AND SUPPLY CONDITIONS IN THE WORLD MARKET FOR CRUDE CHANGE OVER TIME

Changes in the demand for crude oil are triggered by changes in:

- Economic growth
- Development
- Preferences
- Regulations

Changes in the supply of crude oil typically occur through changes in:

- The number
- The importance
- The location

of crude oil suppliers.

- New suppliers have emerged
- Demand centers such as Asia have gained substantially in importance
- These changes in market conditions led to changes in trade patterns

SCENARIO DEVELOPMENT:

BRENT AND WTI HAVE DIFFERENT PRICE SETTLEMENT POINTS

WTI

- WTI is quoted and delivered into pipeline and/or storage at Cushing (Oklahoma)

BRENT

- Brent is quoted and delivered Sullom Voe (Shetland Islands) in the North Sea and transported via vessel

We hypothesize that both of the following two factors are important when analyzing the determinants of the Brent-WTI spread:

1. While Brent and WTI have different price settlement points, the place of physical competition can change with changes in market conditions, and therefore does not necessarily coincide with the price settlement point for either of the two crudes.
2. The location of physical competition is at the heart of crude oil traders' calculations when making their buying and selling decisions.

SCENARIO DEVELOPMENT: DATA

We use daily data spanning from September 1st, 2005 to January 31st, 2020.

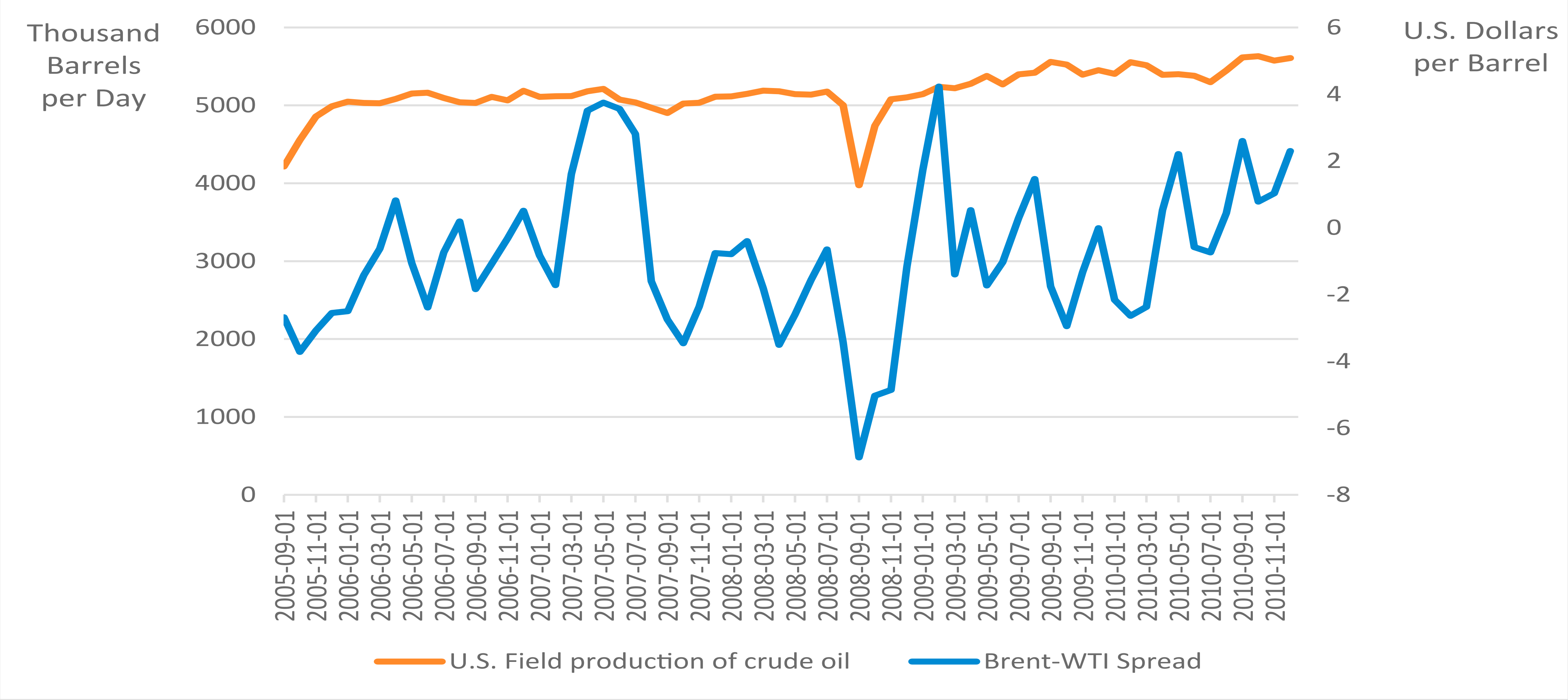
- Data on U.S. crude oil production, storage capacity utilization rates in Cushing (OK) and PADD2, as well as spot prices for Brent and WTI were sourced from the U.S. Energy Information Administration's data browser.
- Prices for Dated Brent, WTI and Brent futures, WTI and Brent spot prices, as well as international maritime freight rates where sourced from Bloomberg.

SCENARIO DEVELOPMENT:
THREE DIFFERENT SCENARIOS BASED ON THE CHANGING LOCATION OF PHYSICAL COMPETITION BETWEEN THE TWO CRUDES OVER TIME

Scenario description.

Scenario	Time frame	Location of physical competition
SC1 – Smooth increase in U.S. crude production	September 2005–December 2010	Cushing (OK) U.S.
SC2 – Infrastructure shortcomings & U.S. Crude Oil Export Ban	January 2011–December 2015	United States Gulf Coast (USGC)
SC3 – U.S. rise on the global market	January 2016–December 2019 (or January 2020)	Amsterdam-Rotterdam-Antwerp (ARA)

SCENARIO DEVELOPMENT:
SC1 – SMOOTH INCREASE IN U.S. CRUDE PRODUCTION



SCENARIO DEVELOPMENT:

SC1 – CUSHING (OK) IS THE LOCATION OF PHYSICAL COMPETITION BETWEEN BRENT AND WTI

EXAMPLE

- A trader deciding at t_0 to buy Brent for sale at Cushing:
  - He will buy the crude at t_0 , it will be loaded on a carrier at Sullom Voe and transported to the USGC (14 days)/
  - From the USGC the crude will be transported via pipeline to Cushing (30 days).
  - The shipment of Brent will be available at the Cushing hub 2 months after it was shipped and compete against physical barrels of WTI at that point in time.

VARIABLES

- Intertemporal Price of WTI futures, *IPWTIf*
- Transportation costs for Brent, *TransCBrent*
- Utilization rate of crude storage in PADD2, *StorUtP2*

- OUR COST CALCULATIONS ARE BASED ON:
  - LARGE CRUDE CARRIER 135,000 METRIC TONS OR 989,550 BARRELS
  - TRANSPORTATION COST FOR BRENT INCLUDE:
    - MARITIME TRANSPORTATION COSTS
    - WATERBORNE AND PIPELINE LOSSES
- NOTE THAT THERE ARE ADDITIONAL FIXED COSTS FOR BRENT:
  - LIGHTERING FEES, PIPELINE TRANSPORTATION COSTS FROM USGC TO CUSHING ,IMPORT TARIFF

SCENARIO DEVELOPMENT:
SC1 – MODEL

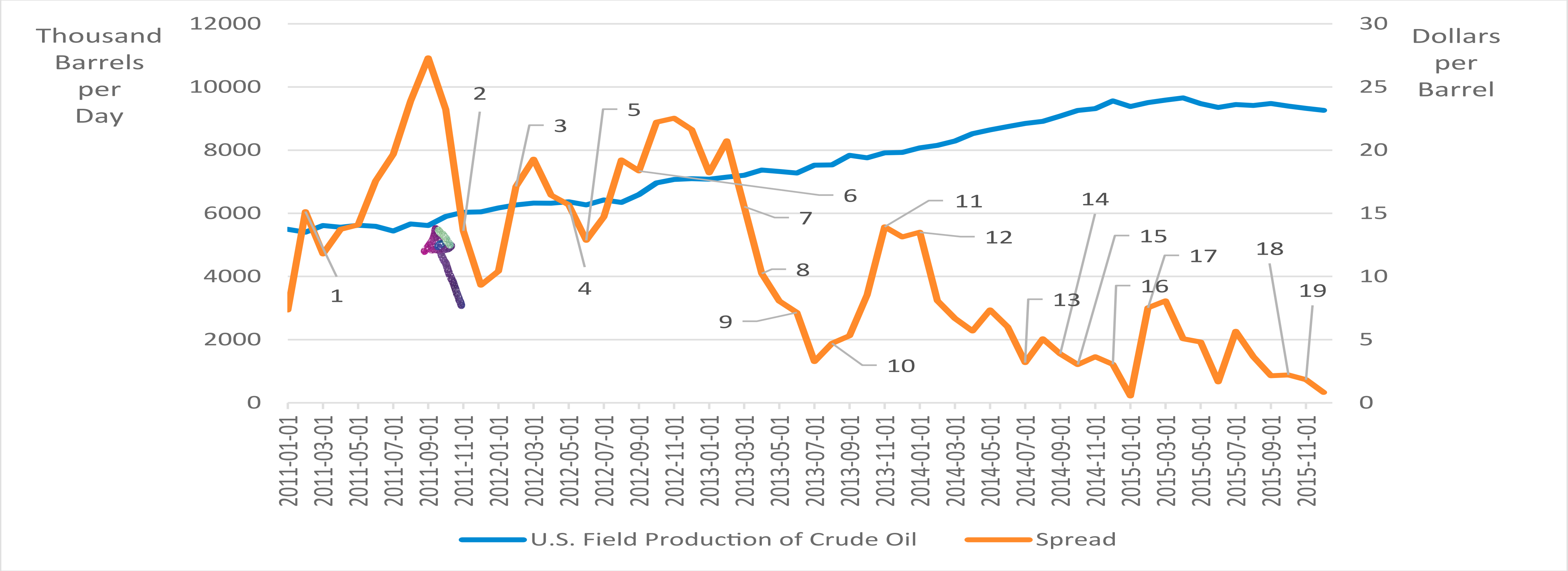
- To estimate the Brent-WTI spread in SC1 we use 1948 daily observations. We performed an Augmented Dickey-Fuller (ADF = 12) test and found that Yt, the Brent-WTI spread as defined in Eq. (1) is stationary at the 1% level. We used an ARIMAX (4, 0, 2) and a GARCH (1,1) model specified as follows:

$$Y_t = \theta_0 + \theta_1 Y_{t-1} + \theta_2 Y_{t-2} + \theta_3 Y_{t-3} + \theta_4 Y_{t-4} + \Gamma_1 e_{t-1} + \Gamma_2 e_{t-2} + \Phi_1 IPWTIf_t + \Phi_2 TransCBrent_t + \Phi_3 StorUtP2_t + \varepsilon_t \quad (2)$$

$$\sigma_t^2 = \omega_0 + \alpha_1 e_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + v_t \quad (3)$$

SCENARIO DEVELOPMENT: SC2 – INFRASTRUCTURE SHORTCOMINGS AND U.S. CRUDE OIL EXPORT BAN (01/2011–12/2015)

FIG. U.S. FIELD PRODUCTION OF CRUDE VS. BRENT-WTI SPREAD (USGC IS THE LOCATION OF PHYSICAL COMPETITION)



SCENARIO DEVELOPMENT:
SC2 – INFRASTRUCTURE SHORTCOMINGS AND U.S. CRUDE OIL EXPORT BAN

Example

In SC2 with the place of physical competition having moved to the USGC the time needed by traders to get Brent or WTI to the Houston hub is the same for both crudes.

- Traders buying WTI or Brent at time t_0 will have the physical barrels arrive at the Houston hub 2 months later.

Variables

- IPWTIf : intertemporal price of WTI futures
- IPBrentf: intertemporal price of Brent futures
- ShareTBR: share of crude transported by tanker, barge or rail over the total amount of crude oil transported from the Midwest (PADD2) and the Rocky Mountains (PADD4) to the USGC (PADD3).
- USP/PL : ratio of U.S. crude production to pipeline capacity.
- StorUtP2 : storage utilization rate at PADD2.
- LLS-WTI: is a proxy for the cost of transportation of WTI from Cushing to the USGC

SCENARIO DEVELOPMENT:
SC2 – INFRASTRUCTURE SHORTCOMINGS AND U.S. CRUDE OIL EXPORT BAN

- In SC2 we use 1826 daily observations spanning from January 2011 to December 2015. In Eq. (4) Yt is the Brent-WTI spread at time t, as specified in Eq. (1). The ADF (24) test shows that Yt is stationary at the 1% level and the Box-Ljung test shows that residuals are not white noise.

- To estimate the Brent-WTI spread in SC2 we use a Markov-Switching Model of the form:

  Where S_t indicates the regime for t=1,2

$$y_t = \alpha_{0S_t} + \alpha_{1S_t} IPWTIf_{1t} + \alpha_{2S_t} IPBrentf_{2t} + \alpha_{3S_t} ShareTBR_{3t} + \alpha_{4S_t} \frac{USP}{PL}_{4t} + \alpha_{5S_t} LLS - WTI_{5t} + \alpha_{6S_t} ITRelP_{6t} + \alpha_{7S_t} StorUtP2_{7t} + e_{tS_t} \qquad (4)$$

SCENARIO DEVELOPMENT:

SC3 – THE U.S. RISE ON THE GLOBAL MARKET, CLEARING LOCATION AMSTERDAM-ROTTERDAM-ANTWERP (ARA) HUB 2016-2020

Background

- January 2016 – January 2020:
  - Lifting of the U.S. crude oil export ban
  - Continued increase in U.S. crude oil production which reduced crude imports to 40% of domestic consumption
  - Further expansion of pipeline infrastructure
  - Full integration of the U.S. crude market with the world market
  - Growth in major demand centers such as Asia has further contributed to the adjustment of trade patterns.

Variables

- IPWTIf
- IPBrentf
- ShareTBR
- LLS-WTI
- StorUtP2
- MTransCWTI: maritime transportation cost for WTI from the USGC to the Amsterdam-Rotterdam-Antwerp hub

SCENARIO DEVELOPMENT:
SC3 – MODEL

- In SC3 we use 1492 daily observations spanning from January 2016 to January 2020. The ADF (24) test shows that Yt is stationary at the 5% level and the Box-Ljung test shows that the residuals are not white noise. We use a Markov Switching Model of the form:

$$y_t = \alpha_{0St} + \alpha_{1St} IPWTIf_{1t} + \alpha_{2St} IPBrentf_{2t} + \alpha_{3St} ShareTBR_{3t} + \alpha_{4St} LLS - WTI\_P_{4t} + \alpha_{5St} StorUtP2_{5t} + \alpha_{6St} MTransCWTI_{6t} + e_{tSt} \qquad (5)$$

RESULTS: SC1

- SC1 – Cushing (OK) clearing location (09/2005–12/2010)

$$Spread_t = -7.676967 + 2.098061\ Y_{t-1} - 1.204441\ Y_{t-2} + 0.0482\ Y_{t-3} + 0.057859\ Y_{t-4} - 1.633019\ e_{t-1} + 0.641631\ e_{t-2} + 1.20822\mathrm{IPWTIf_t} + 0.734242\ \mathrm{TransCBrent_t} + 8.09149\ StorUtP2_t + \varepsilon_t \quad (6)$$

$$\sigma_t^2 = 0.015419 + 0.038960\ e_{t-1}^2 + 0.952022\ \sigma_{t-1}^2 + v_t \quad (7)$$

RESULTS: SC2

- SC2 (01/2011-12/2015)

Scenario 2 coefficients for Markov Switching Model regimes 1&2[301].

	Regime 1		Regime 2	
	Coefficient (S.E.)	Sign. Codes	Coefficient (S.E.)	Sign. Codes
Intercept	−2.6660 0.1849	***	−9.3469 0.4295	***
IPWTIf	−0.4544 0.0767	***	−0.4544 0.0767	***
IPBrentf	1.0533 0.0100	***	0.0632 0.0081	***
ShareTBR	2.1700 0.4163	***	2.1700 0.4163	***
USP/PL	0.7641 0.1020	***	8.3206 0.2981	
LLS-WTI	0.0218 0.0082	**	0.0218 0.0082	**
Res.S.E.	1.553471		1.466345	
R^2	0.9542		0.9168	

Signif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '' 1.

Table 6
Transition probabilities in SC2.

	Regime 1	Regime 2
Regime 1	0.990393348	0.05721865
Regime 2	0.009606652	0.94278135

RESULTS: SC3

Table 7
SC 3 coefficients for regimes 1 & 2.[331].

	Regime 1		Regime 2	
	Coefficient (S.E.)	Sign. Codes	Coefficient (S.E.)	Sign. Codes
Intercept	3.0236 0.7322	***	0.2024 0.5918	
IPWTIf	−0.0023 0.0087		−0.0187 0.0082	*
IPBrentf	−0.2300 0.0240	***	−2.0037 0.0632	***
ShareTBR	−102.5117 3.5078	***	−23.0791 1.4517	***
LLS-WTI	−0.0148 0.0189		0.1784 0.0164	***
StorUtP2	11.2229 1.2686	***	4.6189 0.9266	***
MTransCWTI	7.1238 0.5911	***	2.1803 0.2654	***
Res.S.E.	1.409547		1.212764	
R^2	0.7368		0.7955	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 '' 1.

Table 8
Transition probabilities in SC3.

	Regime 1	Regime 2
Regime 1	0.98447495	0.008688349
Regime 2	0.01552505	0.991311651

CONCLUSION

- A novel approach to contribute to two strands of existing literature:
  - The first strand aims to uncover whether or not the world market for crude is truly 'one great pool'.
  - The second strand aims at identifying major drivers of the Brent-WTI spread as well as the magnitude of the effect of these drivers.

  - We analyzed the importance of changing trade flows due to changes in supply and demand of crude oil worldwide focusing on the emergence of the U.S. as an important player on the international energy scene.
  - The three scenarios highlight how as a consequence of altered trade flows, the location of physical competition between Brent and WTI changes.
  - Our results provide estimates of the impact that variables driving crude oil traders' decisions have on the Brent-WTI spread.

- Additionally, we find that the change in the relationship between Brent and WTI that has been observed in the past decade appears to be fundamental, suggesting that the historical premium of WTI to Brent in the futures market is unlikely to return in the near future.

THANK YOU!!!

- Questions?
- Email: economics.ir@gmail.com