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Price discovery in crude oil futures

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ABSTRACT

This study examines price discovery among the two most prominent price benchmarks in the market for crude oil, WTI sweet crude and Brent sweet crude. Using data on the most active futures contracts measured at the one-second frequency, we find that WTI maintains a dominant role in price discovery relative to Brent, with an estimated information share in excess of 80%, over a sample from 2007 to 2012. Our analysis is robust to different decompositions of the sample, over pit-trading sessions and non-pit trading sessions, segmentation of days associated with major economic news releases, and data measured to the millisecond. We find no evidence that the dominant role of WTI in price discovery is diminished by the price spread between Brent that emerged in 2008.

1. Introduction

Several studies have examined the time series properties and statistical relationships among various crude oil prices. For instance, Bachmeier and Griffin (2006) examine daily prices for five different crude oils — WTI, Brent, Alaska North Slope, Dubai Fateh, and the Indonesian Arun — and conclude that the world oil markets are tightly linked with each other. Similarly, Hammoudeh et al. (2008) find evidence of cointegration in four oil benchmark prices (WTI, Brent, Dubai and Maya, see also Kleit, 2001; Bentzen, 2007). An obvious implication of this result is that supply and demand shocks that affect prices in one region quickly spillover to other regional markets.

The fact that crude oil markets are geographically fragmented, and yet remain susceptible to common global risk factors, poses somewhat of a challenge to market participants in determining precisely how price discovery is established. Price leadership of a benchmark is important to establish given its implications for reference pricing in the trade of physical and financial contracts. Furthermore, from a market microstructure perspective, the benchmark's contribution to price discovery provides insights into its ability to process information and attract informed traders in markets where they are traded.

There has been a great deal of interest in examining the dynamics between WTI and Brent prices. It has been argued that in economic terms the spread between WTI and Brent prices should reflect a quality differential, and is driven by underlying factors that are specific to each market. In equilibrium, the price of WTI should equal the price of Brent after adjusting for carrying cost and the quality discount (Alizadeh and Nomikos, 2004). Any mispricing in the relationship is likely to attract arbitrage opportunities in spot and derivative markets, thus forcing convergence. Historically Brent has traded at a slight discount to WTI,[1] although the relationship reversed in recent years with Brent trading at a substantial premium to WTI. The inversion in the price spread has been attributed to localized factors such as the dramatic increase in U.S. oil production combined with capacity constraints in the transportation and storage infrastructure of domestic crude oil (cf. Baumeister and Kilian, 2013). As a result of these changes, some studies cast doubt on the continued viability of WTI as an international benchmark (Bentzen, 2007), and argue that the ongoing decoupling of WTI from other U.S. and international crude grades is evidence that WTI is a 'broken benchmark' (Fattouh, 2007, 2011). Borenstein and Kellogg (2014) also question the leading role of WTI by showing that the

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[1] Both Brent and WTI are classified as a 'light sweet' oil blend which means that they are easy to refine compared to heavier and sour oil blends. However, since Brent is relatively denser and has a higher sulfur content than WTI, based purely on its physical properties Brent is expected to trade at a discount to WTI.

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relative price decrease of WTI does not pass through to wholesale gasoline and diesel prices.

It is important to note that the discussions surrounding the relative merits of WTI and Brent as price benchmarks are closely intertwined with the price discovery function in crude oil futures markets. This paper examines the price discovery relationship between two of the most widely referenced international oil price benchmarks — West Texas Intermediate (WTI) and Brent. Specifically, we apply the Hasbrouck (1995) information share (IS) model to estimate the degree of price discovery. This model is based on the econometrics of cointegrated vector autoregressions, assuming that cointegrated price series fluctuate around a common, unobserved "efficient" price. Hasbrouck defines the information share as the proportion of the variance in the common price process that is attributable to a particular price series. Additional details on the model and its applicability are provided in Section 3. Our sample is January 2, 2007 to April 27, 2012, a period during which there has been a remarkable surge in U.S. oil production. Since both WTI and Brent have highly liquid futures markets, we use futures prices sampled at the one-second interval.

In a related study, Kao and Wan (2012) also apply the Hasbrouck IS model to daily prices of WTI and Brent futures over the 1991–2009 sample. These authors find that price discovery in WTI has been impaired due to production, transportation and inventory bottlenecks in the U.S., and conclude that since 2004 Brent has led the price discovery process. We extend their analysis in two important dimensions that have important implications for the empirical results.

First, we use high frequency data, at the one-second and millisecond frequency. The data in Kao and Wan (2012) are daily, and so do not capture intraday dynamics that are most relevant in price discovery. That is, intraday dynamics are important because oil futures markets are very liquid, fully reflecting new information within minutes (cf. Elder et al., 2013). Hasbrouck (1995) uses data at a one-second frequency, cautioning that "if the observation interval is so long that the sequencing cannot be determined… the initial change and the response will appear to be contemporaneous." Second, our use of high frequency data permits us to avoid the rolling estimation procedure in Kao and Wan (2012), which uses windows of 1 to 5 years. Such a long window imposes excessive structure on the underlying dynamics, likely rendering the estimates of information share unreliable (cf. Hasbrouck, 1995).

Our primary empirical result is that we find evidence that WTI maintains a dominant role in price discovery relative to Brent, with an estimated information share in excess of 80%. Our analysis is robust to different decompositions of the sample, over pit trading sessions and non-pit trading sessions, segmentation of days associated with major economic news releases, and data measured to the millisecond. We find no evidence that the dominant role of WTI in price discovery is diminished by the price spread between Brent that emerged in 2008.

The remainder of the study is organized as follows. The data and methodology are presented in Sections 2 and 3, respectively. Section 4 discusses the empirical results. The final section concludes.

2. Data

The key data utilized is the intraday transaction futures prices for WTI and Brent light sweet crude oil for the period January 2, 2007 to April 27, 2012.[2] The data is obtained from TickData. The WTI futures (Ticker: CL) are traded simultaneously on the electronic (CME Globex and ClearPort) and open outcry markets. The electronic market is open Sunday to Friday, 6:00 pm–5:15 pm and the open outcry market is open Monday to Friday, 9:00 am–2:30 pm (all times U.S. Eastern Time). The Brent futures contracts (Ticker: B) are traded on the InterContinental Exchange (ICE) electronic platform, Sunday to Friday, 8:00 pm to 6:00 pm on the following day.[3] The contract unit for both WTI and Brent is 1000 barrels and the prices are quoted in U.S. dollars. For majority of the sample, January 2, 2007 to June 30, 2011, transaction prices are available at 1-second intervals. Beginning July 1, 2011 trades are reported at 1/1000 of each second. We use this latter subsample to conduct robustness tests.

At any given point in time there are many outstanding futures contracts with different expirations and transaction prices. The WTI crude oil futures are listed nine years forward using the following listing schedule: consecutive months are listed for the current year and the next five years; in addition, the June and December contract months are listed beyond the sixth year. The Brent crude oil futures are listed in consecutive months up to 7 years forward, although most of the longer-dated contracts are thinly traded. The first nearest (front) contracts are typically the most liquid. Following standard procedures, we form a continuous series by splicing price observations from contracts with the most number of transactions.

Fig. 1 plots the end-of-month WTI and Brent prices and the spread (left axis) for the full sample period. The two prices track each other closely between 2007 and 2010. Beginning 2011, the spread between the two price series widens considerably. The bottom two panels of Fig. 1 also plot the monthly total volume and numbers of trades of the most active contracts for both WTI and Brent. The data indicate a slight increase in both the volume and number of trades for WTI relative to Brent.

The summary statistics reported in Table 1 confirm these observations. Panel A of Table 1 reports the annual maximum, minimum and average prices of the most active WTI and Brent contracts. During 2007 and 2008, the mean difference between the WTI and Brent prices is positive and relatively small in magnitude (less than $2). The mean difference becomes slightly negative in 2009 and 2010, and then widens considerably in 2011 and 2012, to −$15. Throughout the sample period both WTI and Brent prices are volatile. Prices were particularly volatile in 2008 when the maximum prices for both WTI and Brent exceeded $140. The minimum prices for WTI and Brent were $33.55 (in 2009) and $36.20 (in 2008). Panel B of Table 1 presents the daily average volume, number of trades and trade size. Trade size, which provides an indication of the type of market participant, is defined as the daily average volume divided by the total number of trades. The volume for WTI tended to increase through the sample, whereas the volume for Brent was relatively stable, except for a large drop in 2009. A comparable drop in volume did not occur for WTI. From 2007 to 2011, the average daily volume of WTI relative to Brent increased from 1.58 times to 2.20 times, and until 2010, the trade size in WTI was larger than Brent. Beginning 2011 there is a reversal in the trade–size relationship between WTI and Brent, coinciding with the expanding negative spread.

We also use two sets of economic news announcements as proxies for information arrival. The first relates to the U.S. Employment Situation Report which is typically released at 8:30 am on the first Friday of each month. This report is widely followed by financial markets, and represents a broad measure of economic activity that includes data on the unemployment rate, labor force participation, the duration of unemployment as well as data from both the household and establishment surveys. Ex ante, we expect this report to contain a relatively high level of independent information about the state of the economy. The other proxy is the EIA (U.S. Energy Information Administration) weekly petroleum status report. The report provides information on weekly changes in petroleum inventories in the U.S., produced both locally and abroad. Market analysts and investors follow the inventory

[2] We start the sample in 2007, when transaction volume is also available. Volume is used to identify the most active contracts in constructing the futures price time series.

[3] Due to the difference between the period of British Summer Time (BST) and the daylight saving time (DST) in the U.S., the InterContinental Exchange makes temporary changes to the trading hours. BST begins at 01:00 GMT on the last Sunday of March and ends at 01:00 GMT on the last Sunday of October. DST begins on the second Sunday of March and ends on the first Sunday of November.

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