Crude Oil Price Differentials and Pipeline Infrastructure

Proposal for NBER Economics of Hydrocarbon Infrastructure and Transportation workshop

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Introduction

Technological advances in oil production have reshaped the geography of oil markets in the United States. Areas with previously low or declining production, such as the Bakken shale region in North Dakota and the Permian Basin in western Texas, have experienced extremely rapid growth. However, the pace of change in oil production has not been matched by construction of oil transportation infrastructure. Limited crude oil pipeline capacity means that the price received by producers in many growing regions is much lower than the oil price at major market hubs. These price differentials reflect the cost of transporting oil by pipeline alternatives such as rail, which can be more than ten times higher. Shipments of oil by rail in the U.S. have grown from 0.6 million barrels/month in 2010 to 33.5 million barrels/month in 2015. Nonetheless, over the past five years, there has also been considerable investment in new or reconfigured oil pipelines. This has gradually narrowed the price differentials between regions.

The research in this proposal will analyze the relationship between oil pipeline investment and the prices that producers receive for crude oil. For each of the oil producing regions in the U.S., it will estimate the marginal cost of transportation for additional oil production and how this has evolved over time as a result of changes to the pipeline network. This can then be related to producer oil price differentials to provide an estimate of the value of

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pipeline infrastructure to oil producers. The analysis will be an input into a larger project about the incentives for firms, both independent pipeline operators and vertically-integrated oil producers, to invest in new pipelines.

Oil pipelines and price differentials

The changing geography of the oil industry in the United States created regional separation in oil prices. The best-known oil price differential is that between the pipeline and storage hub at Cushing, Oklahoma and the center of the refining industry on the Gulf Coast. Cushing is the location for physical settlement of the world's most liquid oil futures contract, West Texas Intermediate (WTI). The commonly-used measure of Gulf Coast prices is Light Louisiana Sweet (LLS). Before late 2010, the price difference between LLS and WTI was often less than \$1/barrel. This increased to nearly \$30/barrel by September 2011, but has since decreased to about \$5/barrel in May 2015.

Buyuksahin et al. (2013) and Omar (2014) studied the price differential between the major oil benchmarks and its relationship to physical and financial variables. Borenstein and Kellogg (2014) examined the effect of price separation between WTI and LLS on the prices of refined products. They found that the crude oil price difference was not reflected in the prices of refined products, presumably because there is separate infrastructure for refined product distribution that was not subject to the same capacity constraints.

McRae (2015) studies the configuration decision for the Seaway pipeline that connects Cushing to the Gulf Coast. This pipeline was almost unused during 2011, because it was configured to flow from the high-price to the low-price region. When the pipeline was reversed, it led to an immediate narrowing in the WTI and LLS price differential. The paper argues that the pipeline was not reversed earlier because one of its owners, ConocoPhillips, operated oil refineries that benefited from acquiring oil at the depressed WTI price. This vertical integration between regulated (pipeline) and unregulated (refining) businesses led to inefficient operation of the pipeline.

Despite the focus by researchers on the WTI and LLS (or Brent) price differentials, these are far from being the only relevant price differences in the crude oil market. Figure 1 shows both the LLS-WTI price differential and the difference in monthly wellhead prices for producers in the PADD 3 (Gulf Coast) and PADD 2 (Midwest) regions. These two differences are not highly correlated. Before the Seaway pipeline reversal, the LLS-WTI difference was almost three times greater than the PADD 3–PADD 2 price difference. The PADD 3–PADD

2 difference peaked in early 2012 and then fell steadily over time, despite a subsequent large increase in the LLS-WTI difference. The wellhead price differences between regions reflect the aggregation of the changing capacity constraints throughout the entire pipeline network, whereas the LLS-WTI price difference is driven primarily by constraints on a single corridor between the Gulf Coast and Cushing.

Figure 2 provides an example of one of these other capacity constraints, for the transportation of crude oil out of the Permian Basin in west Texas. The top line shows an estimate of the total capacity of refineries in the Permian Basin and pipelines flowing out of the region.[1] The second line shows the monthly production from the Permian Basin. The bottom line shows the price discount received by oil producers in the Permian Basin (the difference between the WTI price at Cushing and the WTI price at Midland, Texas). In late 2012, when production was close to available outflow capacity, the Permian Basin price fell to more than $10/barrel below the Cushing price. Reversal and expansion of the Longhorn pipeline relaxed the constraints for a while, eliminating the price discount, but continued production growth in the Permian Basin led to a discount of $20/barrel in mid-2014.[2] This was much greater than the LLS-WTI price differential at that time, which was less than $5/barrel (see Figure 1).

As illustrated by Figure 2, investment in pipeline capacity out of the Permian Basin—including the Longhorn, BridgeTex and Permian Express pipelines—provided large economic benefits to oil producers in that region. The objective of this research proposal is to formalize this analysis and expand it to cover all oil producing regions and all oil pipeline investments.

Proposed research

The first step of this research will be to produce a monthly panel dataset, by oil producing region, of production, prices, refining capacity and pipeline capacity. This dataset will then be used to estimate how changes in pipeline capacity, either through reversals, capacity additions, or new construction, affect the prices that oil producers receive in each region. In theory, the price difference between oil supplying regions and demand centers should be equal to the marginal cost of transporting one additional barrel of oil between the two regions. This will be the cost of pipeline shipment, if there is spare pipeline capacity, otherwise it

[1] The capacity data is based on media reports of the dates of pipeline changes. It does not incorporate changes in refinery capacity due to outages.

[2] The price differential appears to fall in advance of the expansion in pipeline capacity. This may reflect oil storage in anticipation of the higher prices.

will be the cost of alternatives for shipping such as rail.

Most of the required data is already contained in existing publicly available databases. However, it is not stored in a format that makes it easy to combine different datasets. Although there are data providers who compile and sell this data, these proprietary datasets are expensive and often have usage restrictions that make them unsuitable for research. One goal of this research is to produce a dataset of regional crude oil demand and supply balances that can be used by other researchers. This will contribute to research on, for example, production decisions by oil producers or refineries.

Sources for this data include the following:

1. Crude oil pipeline operating and financial statistics are available from FERC Form 6 data and the Department of Transportation PHMSA data. Pipeline tariffs are available in the FERC eTariff database. The EIA has compiled an incomplete map of crude oil pipelines from publicly available sources. To my knowledge, there is not yet a crosswalk available to combine these different pipeline data sources.

2. The EIA collects firm-level wellhead price and quantity information on Form EIA-182. Monthly region-level production is reported on the Drilling Productivity Reports for selected production regions. Wellhead price data is only publicly reported at a state-level. This makes it difficult to analyze within-state differences.

3. Oil shipments by rail out of each oil producing region can be compiled from Surface Transportation Board data.

4. Refining capacity in each oil producing region can be calculated from Form EIA-812 data.

The longer term goal for this project is to understand the decision by firms to invest in new or upgraded pipelines. As discussed in McRae (2015), these investment incentives may depend on other businesses owned by each firm, whether these are oil wells, oil refineries or other oil pipelines. Of particular interest will be the contrast between the investment decisions for oil pipelines and that for natural gas pipelines, given the large differences in regulatory structure between the two types of pipeline. As a result, this research will be a useful complement to parallel work on natural gas pipeline infrastructure.

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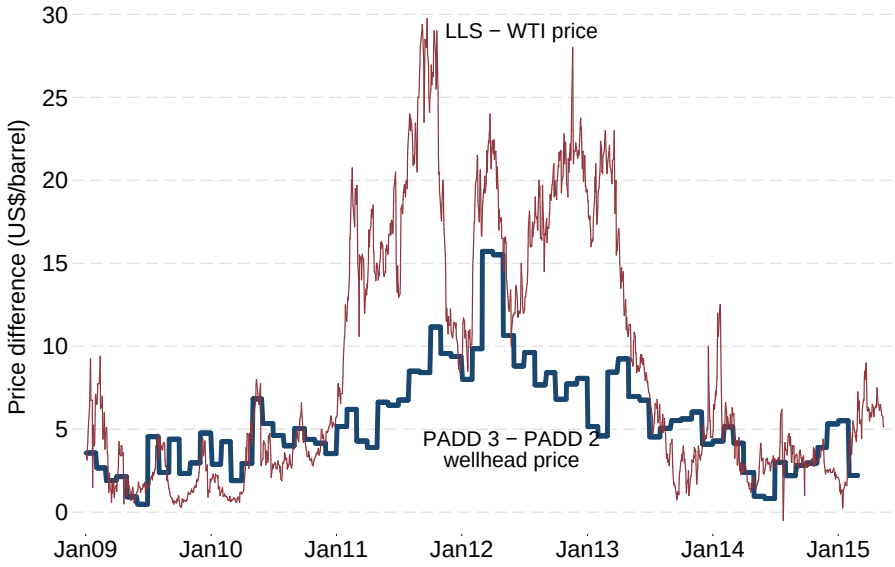
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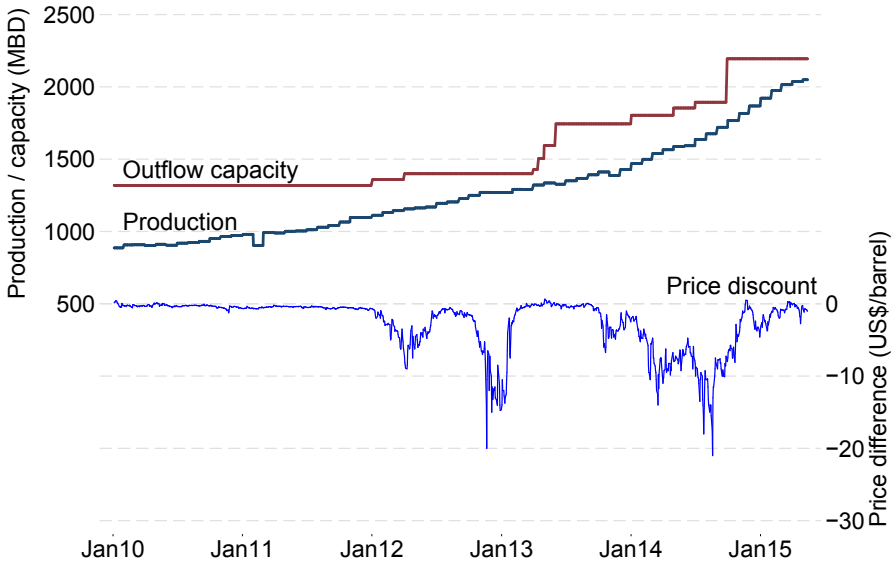
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Figure 1: Oil price discounts for PADD 2 region, 2009–2015



Notes: Difference between the daily LLS and WTI Cushing price is from Bloomberg. Difference between the monthly average wellhead price for PADD 3 and PADD 2 producers is from EIA.

Figure 2: Permian Basin production, pipeline capacity and price discount, 2010–2015



Notes: Price discount is the difference between the daily WTI Cushing and WTI Midland prices, from Bloomberg. Permian Basin production data is from the EIA Drilling Productivity Report. Approximate pipeline and refining capacity is from RBN Energy reports and Reuters news reports.

DISCLOSURE STATEMENT

The author declares that he has no relevant or material financial interests that relate to the research described in this proposal.

