Crude by Rail, Option Value, and Railroad Market Power

Proposal for the NBER project on the economics of hydrocarbon infrastructure and transportation

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Proposal summary

Following the boom in shale oil production from the Bakken formation in North Dakota, as well as strong growth in oil sands production from Alberta, transport of crude oil by railroad ("crude-by-rail") has grown from essentially nothing to 0.98 million bbl/d.[1] This development has no recent precedent, since pipeline transportation has been the dominant method of overland long-distance crude oil transport for approximately a century, owing to its low amortized per-barrel-mile cost and regulated tariff structure.[2] What has driven the dramatic increase in crude-by-rail since 2011, and is this phenomenon transitory or a new long-run feature of the U.S. oil market?

This proposal is aimed at one potential explanation for crude-by-rail's growth that has been repeated often anecdotally and in the press: crude-by-rail is attractive to shippers (both refiners and producers) because it allows them to flexibly decide when and where to ship crude in response to changes in geographic price differentials. For instance, a 2013 *Wall Street Journal* article attributed the lack of shipper interest in a proposed crude oil pipeline from West Texas to California to a preference for the flexibility afforded by crude-by-rail transportation. Thus, the first objective of our planned study is to quantify the value of this flexibility in terms of option value. That is, from the perspective of a refinery, what is the value of being able to change the location of its crude supply source in response to changes in local crude prices? And how does this option value compare to the cost premium of rail transportation relative to pipeline transport?

The second objective of our study is to understand the extent to which shippers can actually capture the value of this flexibility in the presence of railroads' ability to price discriminate. Because it is difficult for shippers to challenge railroad tariffs before the Surface Transportation Board, railroads likely have the ability to change their tariffs over time to attempt to capture changes in crude basis differentials. This phenomenon is not merely theoretical, as the rail industry has previously used market power to extract surplus from the energy industry. For example, Busse and Keohane (2007) and Hughes (2011) have shown that railroads have substantial ability to exercise market power and price discriminate in the markets for shipment of

[1] See "U.S. Rail Transportation of Crude Oil: Background and Issues for Congress," Congressional Research Service, December 4, 2014, https://www.hsdl.org/?view&did=760411. This report states that a carload contains about 689 barrels of crude oil and that 258,541 carloads were shipped in the first half of 2014.

[2] As discussed in Granitz and Klein (1996), rail was the dominant form of crude oil transport in the Standard Oil era, and many early pipeline projects were developed as attempts to circumvent the railroad cartel orchestrated by Standard Oil.

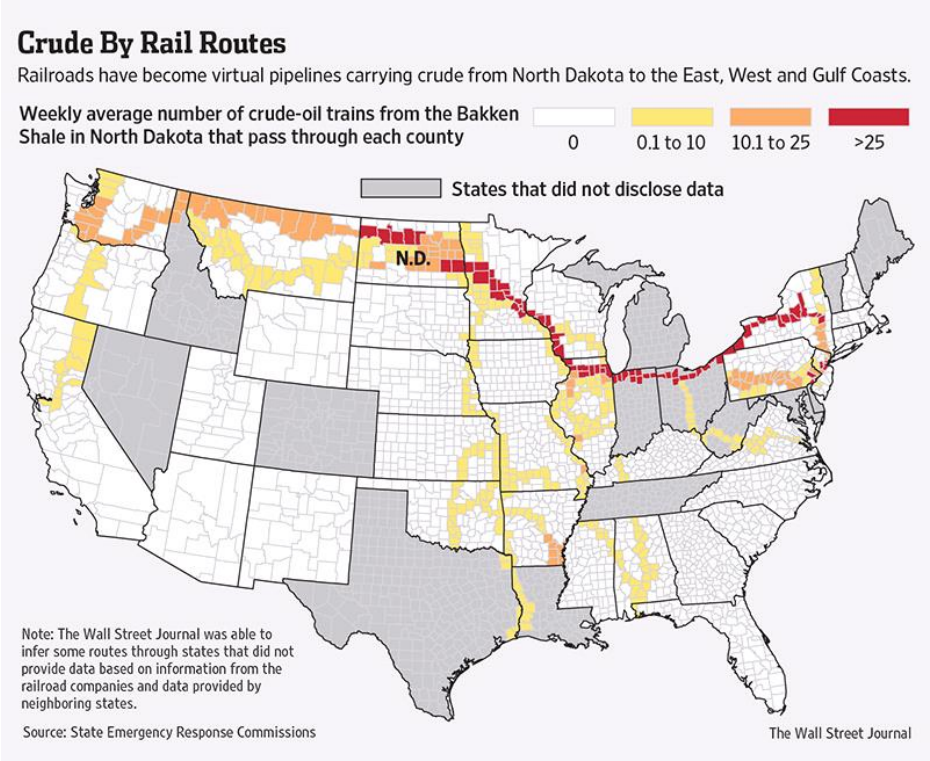


Figure 1: Crude-by-rail traffic. Source: *Wall Street Journal* (2014)

coal and ethanol, respectively. To the extent that railroads' price discrimination is perfect, they can appropriate the full option value from shipping crude-by-rail. If this is the case, it becomes difficult to argue that a primary factor in the expansion of crude-by-rail is shippers' preference for flexibility. In fact, under this story, railroad market power actually distorts shippers' transportation mode choice in favor of pipelines, suggesting that other factors (such as regulatory, financing, or coordination barriers to pipeline construction) may be responsible for the rise of crude-by-rail.

Data and Methods

We will focus, at least initially, on railroad transport of crude oil to U.S. East Coast refineries. We do so because the East Coast is the primary rail destination of Bakken crude oil, as shown in Figure 1. Moreover, there is little pipeline capacity to U.S. East Coast refineries, as shown in Figure 2. As a result, these refineries can acquire crude oil from two possible sources: Bakken crude delivered by rail, or foreign crude delivered by tanker.[3] Any option value created by crude-by-rail will come from refiners' ability to switch between these two sources.

To assess crude-by-rail's option value to an East Coast refiner, the primary data requirement is high-frequency data on local spot crude oil prices. Spot prices for Bakken crude (traded at Clearbrook, Minnesota) are available from Bloomberg, and we already possess these

[3] U.S. East Coast refiners may also procure crude from U.S. Gulf Coast refineries delivered by barge on the Intra-coastal Waterway. However, we suspect that such crude would be expensive due to Jones Act requirements. We ignore this possibility for now, but we will investigate it further over the course of our study.

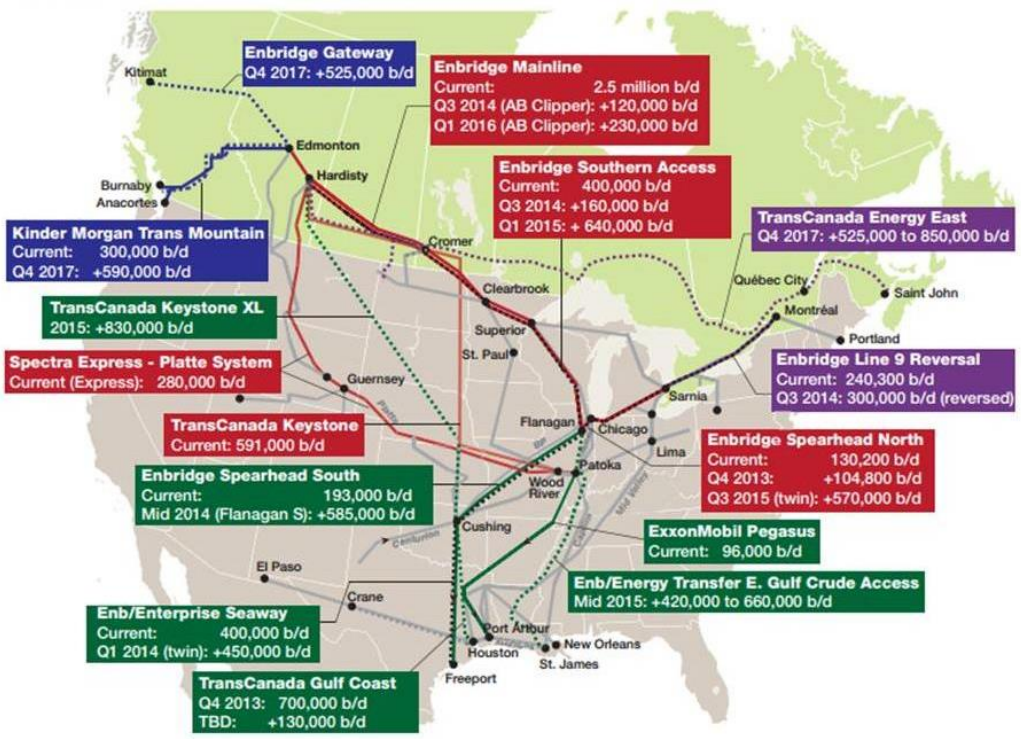


Figure 2: Crude oil pipelines. Source: *Investing Daily* (2013)

prices through January 2015. The EIA collects data on imported crude prices as a part of their surveying efforts for Form 856. Spot prices for Brent crude, also readily available from the EIA, may also serve as a useful proxy for the price East Coast refiners face for imported crude. The option value of crude-by-rail depends directly on the future volatility of the basis differential between the Bakken price and the price of imports, and can be calculated using standard option valuation techniques (i.e., via the literature started in Black and Scholes (1973). The option value will also depend on the "strike price differential" at which crude-by-rail becomes profitable relative to foreign crude; this differential is equal to the marginal cost of rail transport from the Bakken to the East Coast. Anecdotally, this cost is approximately $10 per barrel; we aim to learn more about this cost over the course of the project, ideally leveraging the collective wisdom of the broader set of hydrocarbon infrastructure projects that the NBER ultimately sponsors.

Following the option value calculation, we will then seek to understand the extent to which railroad market power can distort refiners' decisions and the share of surplus that railroads are able to capture. First, we will simply ask whether the flow of crude-by-rail responds to changes in the basis differential in a manner consistent with a competitive marketplace (equivalent to how flows would respond in the case of perfect price discrimination by the railroads). To do so, we will make use of railroad shipping quantity data, which are available through the public version of the waybill dataset.[4] These data mask the rates charged by the railroads, but the sample does permit inference on quantity flows, up to a constant scalar multiplier (the sampling rate). Freight quantity may also be available through state emergency response commissions.[5] In addition, we could make use of EIA data: Form 820 collects data on

[4] The waybill data are described and available at http://www.stb.dot.gov/stb/industry/econ_waybill.html.
[5] *The Wall Street Journal* used such data, obtained via an open records request, to create figure 1.

refinery-level crude oil receipts by transportation mode, and Form 856 collects data on refinery-level import volumes. We will use these data to study the extent to which rail vs. tanker import volumes shift in response to changes in the basis differential between Bakken and international crude, which will inform the extent to which railroad markups distort crude oil flows (distortions should occur if railroads cannot perfectly price discriminate).

Finally, were we able to obtain access to the confidential waybill data, we would be able to observe the rates charged by railroads and directly assess the effectiveness with which they can price discriminate and capture value. Our understanding from conversations with Ken Boyer is that a recent National Academy study on the rail industry is the first academic study that has been granted access to these data. Our hope is that the overall NBER project, with backing from Sloan, will be sufficiently strong that access can be obtained for participating researchers (we suspect that our proposal will not be the only one that could benefit from the confidential waybill data).

Should we find that the rail industry captures a substantial share of the available option value, we will then investigate the potential barriers to additional pipeline construction. Much of the motivation for pipeline construction in the early part of the 20th century was driven by rail industry market power, so it is puzzling that today's industry has responded to a geographically concentrated surge in new production by using rail. A particularly promising line of inquiry concerns the coordination issues inherent in obtaining long-term shipping commitments that are typically required to finance pipeline construction. Bakken producers, on their own, may be disinclined to commit to long-term pipeline capacity given the rapid well-level production declines associated with shale oil as well as the risk of adverse price shocks. East Coast refineries, meanwhile, may face a public goods problem in that they would all benefit from a pipeline (with regulated rates that would undercut the railroads), but no individual refinery wants to take on the long term commitment (since such a commitment would become a burden at any time the crude price differential fell below the full amortized per-barrel cost of pipeline transport). We propose to model this public goods game and use calibrated simulations to assess the severity of the public goods problem. Counterfactuals involving more concentrated upstream and downstream industry structure and greater degrees of vertical integration than currently exist may shed light on why pipelines have lost the market dominance that they enjoyed in the past.

Qualifications of the principal investigators

Thomas Covert has written on Bakken drilling and production in Covert (2015). He also has a finance background, including a publication in the *Journal of Financial Economics* (Asquith, Au, Covert, and Pathak 2013a) and another working paper (Asquith, Covert, and Pathak 2013b). Ryan Kellogg has written extensively on the U.S. oil and gas industry. His published papers on the option value of drilling (Kellogg 2014) and on the depressed price of crude oil in the Mid-west (Borenstein and Kellogg 2014) are particularly relevant to this project. Covert's CV is available at http://home.uchicago.edu/~tcovert/webfiles/cv.pdf, and Kellogg's CV is available at http://www-personal.umich.edu/~kelloggr/KelloggCV.pdf

Potential or Apparent Conflicts of Interest or Sources of Bias

Neither Thomas Covert nor Ryan Kellogg has any financial or other ties that could create actual or perceived conflicts of interest or bias.

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