

Crude by Rail, Option Value, and Pipeline Investment

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EXTENDED ABSTRACT

Between the start of 2010 and end of 2014, transportation of crude oil by railroad (“crude-by-rail”) grew from less than forty thousand barrels per day (bpd) to nearly one million, all within the United States. At its peak, crude oil shippers moved more than 10% of total domestic production by rail. This development has no recent precedent: the U.S. Energy Information Administration only began tracking the crude-by-rail phenomenon in 2010, and statistics published by the American Association of Railroads suggest that crude-by-rail volumes between 2006-2010 were, at most, negligible [12]. The rise of crude-by-rail is somewhat surprising in light of the fact that many early pipeline projects were developed as attempts to circumvent the railroad cartel orchestrated by Standard Oil [4]. Since that time, pipeline transportation has become the dominant form of overland long-distance crude oil transportation, owing to its low amortized per-barrel-mile cost and regulation pricing and access provisions. The sudden resurrection of crude-by-rail is puzzling in light of its relatively high amortized costs and provision by a rail industry known to exercise market power in access pricing. In this paper, we try to understand why crude-by-rail is on the rise again, whether it is a transitory phenomenon or a long-run feature of the U.S. oil market, and how it may affect investment in crude oil pipelines.

The simplest and least controversial explanation for crude-by-rail’s recent ascent is that rail transportation was, until recently, the only feasible way to move newly discovered tight oil resources to demand centers. The remarkable speed at which production grew from the Bakken, Niobrara, and other shale formations in the upper Midwest outpaced both the capacity of existing pipeline infrastructure and the ability of pipeline investors to adequately

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respond. In this story, crude-by-rail is a “stopgap” measure while the years required for pipeline permitting and construction pass. If this is the sole reason behind the ascent of crude-by-rail, it implies that crude-by-rail is merely a transitory phenomenon, driven by an unexpected boom in production in a new place. The delays experienced by recently pipeline projects (DAPL, Keystone XL) are consistent with this story.

An alternative popular explanation, which is not necessarily exclusive of the “delay” explanation, is that crude-by-rail may be an attractive transportation option *in spite of* its higher costs. Because rail infrastructure already exists between the upper Midwest and nearly every major refining center in the country, crude-by-rail allows shippers to flexibly decide when and where to ship crude in response to changes in upstream and downstream prices. Industry observers often make this point: 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 [10]. If this “option value” explanation is sufficiently important, it may be the case that crude-by-rail will be a durable feature of the U.S. oil industry for many years to come.

To characterize the relative importance of the “delay” vs. “option value” stories in explaining the recent rise of crude-by-rail, we use data from a variety of sources to document the revenue gains that shippers experienced in the presence of rail infrastructure, compared to a hypothetical world without rail infrastructure. These data include crude oil prices at major refining centers (Brent on the East Coast, Alaska North Slope on the West Coast, Louisiana Light Sweet on the Gulf Coast, and WTI at Cushing, OK), the local price of Bakken crude oil at Clearbrook, MN, and rail transportation costs from the Bakken to each of the refining centers. We use this data to compute the net revenue per barrel, or “netback,” that a producer would earn after receiving a downstream price and paying for rail transportation. We find that, between late 2010 and early 2017, shippers who could not access available pipeline transit between the upper Midwest and the nearest refining center (Cushing, OK) but were able to use rail transportation to ship to the refining center with the highest netback, earned approximately \$2.30 per barrel more than they would have if their only option was to sell at the local price. During this time period, the option to use rail was “in the money” approximately 31% of the time.

A meaningful portion of this option value is derived from the fact that rail shippers can access a variety of downstream markets, whose prices are not perfectly correlated. As a result, the downstream location that offers the highest netback can change within relatively short time horizons. Over the time period covered by our data, three of the four major refining centers experience at least one “highest netback” event that lasts longer than one month, and there are dozens of changes in the location offering the highest netback. We isolate this

“spatial” component of option value by calculating the value accruing to a railroad shipper who can flexibly choose a destination and subtracting the value accruing to a railroad shipper that only has an option to ship to the Gulf Coast (the location that offers the highest average netback over this time period). We find that the spatial option value offered by rail is worth approximately \$0.40 per barrel, on average. Because these calculations use realized prices, which may feature some spatial convergence due to the arbitrage opportunities provided by the existence of rail, it is fair to characterize this characterization of the spatial option value as a lower bound.

The fact that rail provides positive option value to shippers, on average, suggests that concerns about the exercise of market power by the railroads may be unwarranted. Researchers in other energy-related settings have found that the rail industry practices spatial price discrimination. For example, along routes where coal carloads (see [3]) or ethanol carloads (see [6]) became particularly valuable because of environmental regulations at the destination, railroad carriers charged higher tariffs per unit of distance following the regulations’ implementation. We have examined whether railroads attempt to capture some of the option value of crude-by-rail by increasing their tariffs to a destination when the price of crude oil at that destination rises. Using rail tariff data collected by both the U.S. Surface Transportation Board (which collects tariffs on a random sample of carloads), and Genscape (a private company that conducts telephone surveys of shippers), we find no evidence that tariffs co-move with destination prices.

In contrast to rail tariffs themselves, there is some evidence that other components of crude-by-rail costs do positively co-vary with the gross benefits provided by crude-by-rail. In addition to paying tariffs to the railroads, crude-by-rail shippers must lease (or own) tanker cars, which were initially in short supply [11]. Genscape data on tanker car lease prices show that their correlation with global oil prices is large and positive (about 85%). In particular, both lease rates and oil prices are relatively high until the middle of 2014, and both series show a precipitous decline between mid-2014 and early 2016. It is not definitive that this correlation is causal, and even if it were, it would not necessarily indicate the exercise of market power. As documented in [11], when lease prices (and oil prices) were coincidentally high, tank car manufacturers had backlogged orders for more than a year, so the fall in lease rates between 2014 and 2016 may simply be the response of newly available supply hitting the market and the relaxation of a capacity constraint.

Finally, if crude-by-rail is indeed here to stay, it may affect investment in new pipelines. Pipelines have large fixed costs with potentially significant economies of scale and negligible variable costs. This cost structure is similar to many other “natural monopoly” industries, and as a result, pipeline investment and operations are tightly regulated, usually under cost-

of-service rules with common carrier access. Shippers finance pipeline construction by signing “ship-or-pay” contracts that commit them to paying a minimum quantity of per-barrel fees, which allow the pipeline to recover its capital expense. Absent rail transportation, crude oil production in excess of pipeline capacity must be consumed locally, at low prices. The resulting wedge between the upstream and downstream price is the reward to the shippers that committed to the pipeline, since they are able to access the high downstream price while other upstream holders of oil cannot. Rail transportation makes it possible to move this excess crude oil production to high demand centers, at a variable cost that may sometimes be worth paying, causing an increase in the upstream oil price. As a result, the availability of crude-by-rail reduces the incentive to build larger pipelines, or to build them at all in the case of the aforementioned West Texas to California project.

To quantify the impact of crude-by-rail on the incentives to invest in pipeline capacity, we develop a model in which crude oil shippers can use either a pipeline or a railroad to arbitrage oil price differences between an upstream supply source, where the volume of oil production is sensitive to the local oil price, and a downstream market, where the oil price is stochastic. To use the pipeline, a shipper must sign a firm ship-or-pay commitment, with a tariff equal to the average per-barrel cost of the line. Railroad shippers need not make a commitment but must instead pay a variable cost of transportation that is potentially increasing in the total volume that is shipped by rail.

The model yields an equilibrium condition that equates the pipeline tariff—which must be paid by committed shippers whether they ship oil or not—to the expected benefit of using the pipeline, which is the expected difference between upstream and downstream prices. This expected difference is sensitive to both the capacity of the pipeline and the cost of railroad transportation. If crude-by-rail is low cost, the size of the difference is effectively capped, thereby limiting the returns to pipeline investment. The expected difference is also strictly decreasing in the pipeline’s capacity (since a larger pipeline is congested less frequently), so that the model yields a unique equilibrium level of capacity commitment.¹ Given this equilibrium condition, we may evaluate how changes in the value of crude-by-rail, parameterized by changes in rail’s per-barrel cost, affect the equilibrium pipeline capacity.

We calibrate our model to match, as best we can, market conditions in June 2014, when the Dakota Access Pipeline (DAPL) announced that it had received firm commitments from shippers. Completion of DAPL was expected to bring the sum of pipeline capacity out of the Bakken with local refining capacity to 1.323 million bpd [1], relative to forecasts that

¹The equilibrium condition for the level of pipeline capacity has an analogue to models of investment in baseload versus peaker electric generation units when load is stochastic. See [2] for a simple model of baseload versus peaker investment that is similar to the pipeline versus rail model used here.

Bakken production would reach 1.5 million bpd within a few years [7]. The literature on the price-responsiveness of shale oil and gas ([5], [8], [9]) suggests the the price elasticity of shale oil supply is between 0.3 and 0.7.

Our calibrated model indicates that the development of crude-by-rail has likely had economically meaningful effects on equilibrium investment in pipeline capacity. We find that a \$1 per barrel decrease in the cost of rail transportation, a change of about 9% relative to current levels, results in a decrease in equilibrium pipeline capacity of between 30,000 and 67,000 bpd. These effects are likely to be lower bounds, as they do not allow for any economies of scale in pipeline construction.

Overall, our analysis suggests that crude-by-rail will be more than a transient presence in the U.S. crude oil market. Both spatial and intertemporal variation in crude oil prices generate option value that can be unlocked with railroad transportation but not with pipelines, and we do not find evidence that this option value is fully captured by the railroad carriers themselves. While the very large volumes of crude-by-rail that were realized several years ago may have been driven in part by the long lead times associated with pipeline permitting and construction, crude-by-rail can still add value even after construction of new pipeline capacity (such as DAPL) is completed. In particular, our model of pipeline investment implies that shippers will not be willing to underwrite pipeline capacity investments that are so large that railroad transportation is excluded in high oil price environments.

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