A Comparison of the Risk of Transporting Crude Oil: Rail vs. Pipeline

By Charles F. Mason

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See footnote at end of text.

On 6 July, 2013, a freight train derailed in the Quebec town of Lac-Mégantic, killing 47 people, spilling over one million gallons of crude oil, and causing widespread destruction. Estimated damages exceeded $100,000,000. Horrific as this event was, it was not singular, nor was 2013 a unique year: statistics compiled by the U.S. Department of Transportation point to a stream of train derailments in the U.S. between 2010 and 2014. Economic damages associated with these train incidents rose from slightly less than $5 million in 2010 to over $30 million in 2014. These patterns are particularly noteworthy in light of trends in U.S. tight oil production over the past decade, particularly from the Bakken play – which was the source of the crude on the train that derailed in Quebec, and which is relatively isolated in relation to the existing delivery infrastructure.

An alternative to using rail to transport crude oil is to expand the pipeline infrastructure. This approach is also somewhat controversial, as evidenced by the recent difficulties experienced in siting the Dakota Access Pipeline and the Keystone XL Pipeline. As with shipping oil by rail, a central concern with the Dakota Access Pipeline was the potential for oil spills.

Combined, these observations point to the policy significance of assessing the risks of transporting crude oil by pipeline and by rail. I undertake that task in this paper. The data that I use in this analysis is mainly drawn from the Energy Information Administration (EIA) website and the Department of Transportation website dedicated to releases of sensitive materials into the environment, under the auspices of the Pipeline and Hazardous Materials Safety Administration (PHMSA)[1].

I start by illustrating trends in oil shipments, both by rail and by pipeline, between 2010 in 2016. (The starting date for this analysis is dictated by a change in reporting at PHMSA, which took effect at the start of 2010). In Figure 1, I show monthly deliveries of crude oil by pipeline (the solid line) and by rail (the dashed line). Rail deliveries of oil experienced a marked increase between 2011 and 2013, rising from a very low level to over 20 million barrels per month; oil shipments by rail then stayed at around 20 million barrels per month through the end of 2015. Over the course of the past few years, however, they have decreased to roughly 10 million barrels per month. At about the same time that oil by rail was taking off, pipeline deliveries experienced a slight decrease – falling from around 55 million barrels per month (in 2010) to close to 40 million barrels per month (in late 2011). Since then, pipeline deliveries have steadily increased, rising to well over 80 million barrels per month by the end of 2016. These temporal patterns provide a useful backdrop to the discussion of incidents associated with the transport of crude oil.

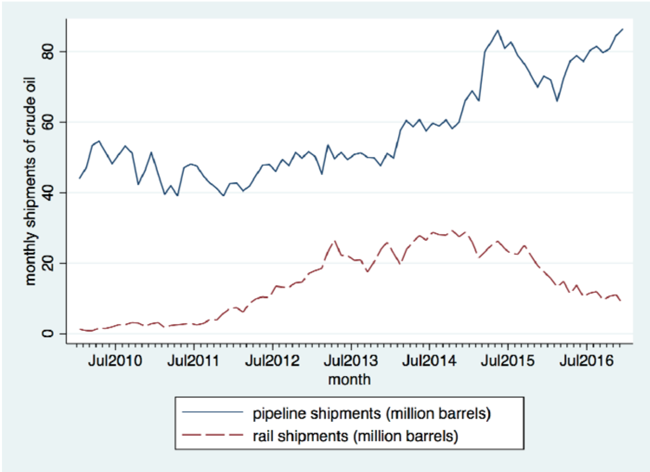

Figure 1: Crude Oil Shipments

Mode	N	mean	median	std. dev.	max
Rail	75	4152	0.570	32558	281989
Pipeline	84	411.1	7.590	1140	8193

Table 1: Summary Statistics for Oil Spills

Information summarizing crude oil spills between 2010 and 2016 is contained in Table 1. Here I show, for each mode of transport, the number of incidents reported during the seven year period; the average monthly amount spilled (in barrels); the median monthly spill size; the standard deviation of the distribution of spills; and the largest reported amount of crude oil spilled. While the number of spills associated with pipeline and rail deliveries was reasonably similar, the average spill associated with rail is an order of magnitude larger than for pipeline. On the other hand, the median spill associated with pipeline deliveries is an order of magnitude larger than for rail deliveries. These two points suggest a significantly skewed distribution governing the size of spills for rail, a point that is corroborated by the significantly larger standard deviation for rail than for pipeline and the substantially larger maximum spill associated with rail.

While the information in Table 1 is evocative, it tells us little about the pattern of oil spills over time. Information on this temporal pattern is conveyed in Figure 2. In this diagram, I show the number of incidents per million barrels shipped for both pipeline (the solid line) and rail (the dashed line with dots). Pipeline spill rates have remained relatively constant, at about one incident per 3 million barrels shipped throughout the sample period. Rail spill rates, by contrast, were dramatically larger between 2010 and 2014. In particular, there were a number of months between 2010 and 2011 in which there was at least one incident for each million barrels shipped. Between 2012 and 2014, rail spill rates tended to hover in the range between on spill for each 1 – 2 million barrels shipped. Since the end of 2014, spill rates for deliveries of crude oil by rail and by pipeline have been roughly the same.

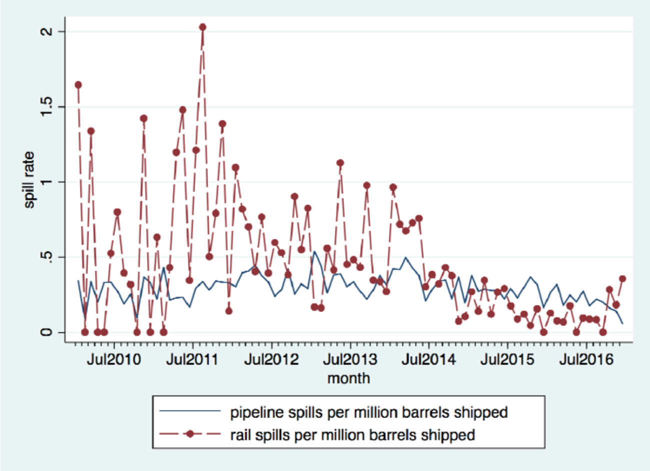

Figure 2: Crude Oil Spill Rates

The distribution over the magnitude of these spills also bears some similarities, but only for relatively smaller spills. Figure 3 shows histograms for oil spills associated with deliveries by rail (panel a) and for deliveries by pipeline (panel b); in both diagrams, I show the distribution associated with spills less than 400 barrels. These distributions appear to be quite similar; in particular, there is a pronounced spike for very small spills, with relatively less weight placed on medium-sized spills. In light of the discussion above, this observation points to the likely difference between the pattern of larger spills comparing rail and pipeline deliveries.

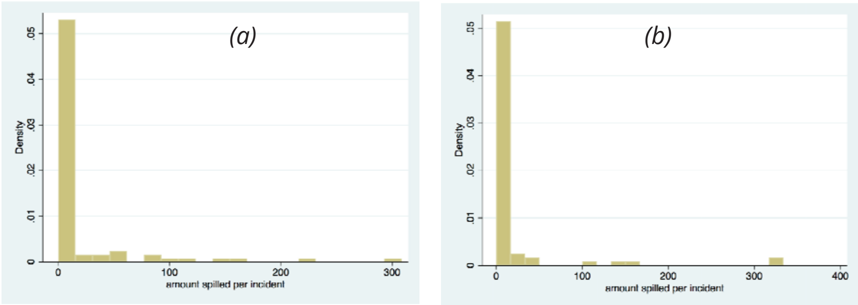

Figure 3: Histogram of Smaller Oil Spills (panel a: pipeline; panel b: rail)

Month	Spilled	Shipped	Rate
Rail			
Nov-13	281989	23.681	19.1626
Dec-13	11309	25.876	0.7033
Feb-15	8627	21.506	0.6456
Mar-15	2635	23.14	0.1832
May-15	2336	26.255	0.1432
Jun-16	1011	10.48	0.1552
Pipeline			
July-10	8193	50.619	0.0865
October-14	4009	58.054	0.0369
March-13	3156	53.461	0.0315
June-15	3002	80.832	0.0198
May-13	2371	51.35	0.0247
October-11	2044	41.096	0.0266
July-11	1511	47.477	0.0170
May-12	1500	47.732	0.0168
15-May	1150	85.984	0.0071
10-Sep	1131	51.221	0.0118

Table 2: Major Crude Oil Spills: Rail vs. Pipeline

I investigate this potential difference in Table 2. Here, I list all months with spills in excess of 1,000 barrels, by mode of transport. As with the overall distribution, large spills are a bit more common with pipelines than rail; that said, the largest 3 spills are associated with rail. This observation is consistent with the observations above (that both the average and maximum spills are larger for rail than pipeline).

It is interesting to reflect on these points in combination with the evidence in Figure 1. That visual evidence indicates that pipelines shipped substantially more oil than did rails throughout the sample period. The third column in Table 2 gets at this point, by listing the monthly deliveries of crude oil (in millions of barrels), for each of the two transport modes. It is apparent that not only is the magnitude of oil spills associated with pipeline deliveries somewhat smaller than for rail (when focusing on the largest spills), the volume of crude delivered by pipeline is much larger than that of rail.

These points suggest that the rate at which oil is spilled from any given amount shipped is likely to be larger for rail than for pipeline, perhaps markedly so. On top of that, the distribution network from the major tight oil plays is roughly three times longer for pipelines (entailing some 1872 kilometers) than for rail lines (621 kilometers). Combined with the points made above, this last observation suggests the rate associated with shipments of oil is much smaller for pipeline than for rail, a point that is fleshed out in the fourth column of Table 2. There, I list the ratio of the volume of oil spilled in a given month to the multiple of the volume of oil transported (in millions of barrels) and the length of the transport network (1872 for pipelines, 621 for rail). Clearly, the rate of spillage – measured in this way, and for the largest spills – is much larger for rail than pipeline.

Taken together, these data indicate that the risk associated with shipping crude oil is noticeably larger for rail deliveries than for pipeline deliveries. The number of spills is a bit larger for pipelines, and medium size spills are somewhat more likely with pipelines, but the volume of spills associated with the largest spills is substantially larger for rail. Placing this information in the context of the magnitude of deliveries associated with the two transport modes, in conjunction with the geographic length of the delivery mode, adds further weight to the conclusion that rail is a riskier method for transporting crude oil than are pipelines.

Footnote

[1] The EIA data, at https://www.eia.gov/petroleum/data.php#imports, includes information on shipments of crude oil by rail and by pipeline (the latter is organized as shipments between PADDs); PHMSA provides data on incidents for shipments by pipeline and rail. The former can be accessed at https://www.phmsa.dot.gov/pipeline/library/data-stats/flagged-data-files, and the latter at https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/IncrSearch.aspx.