Analyzing the Risk of Transporting Crude Oil by Rail

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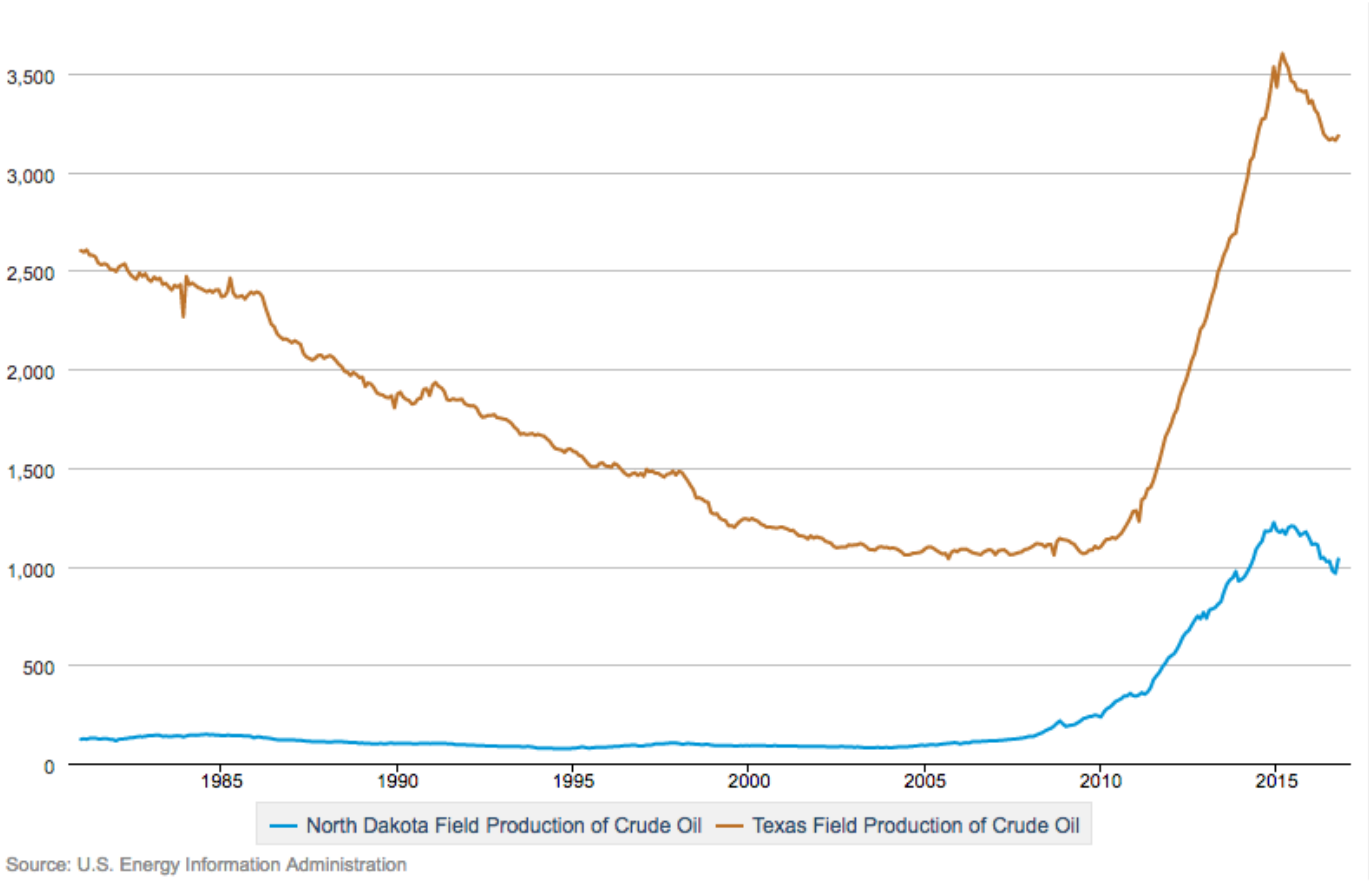
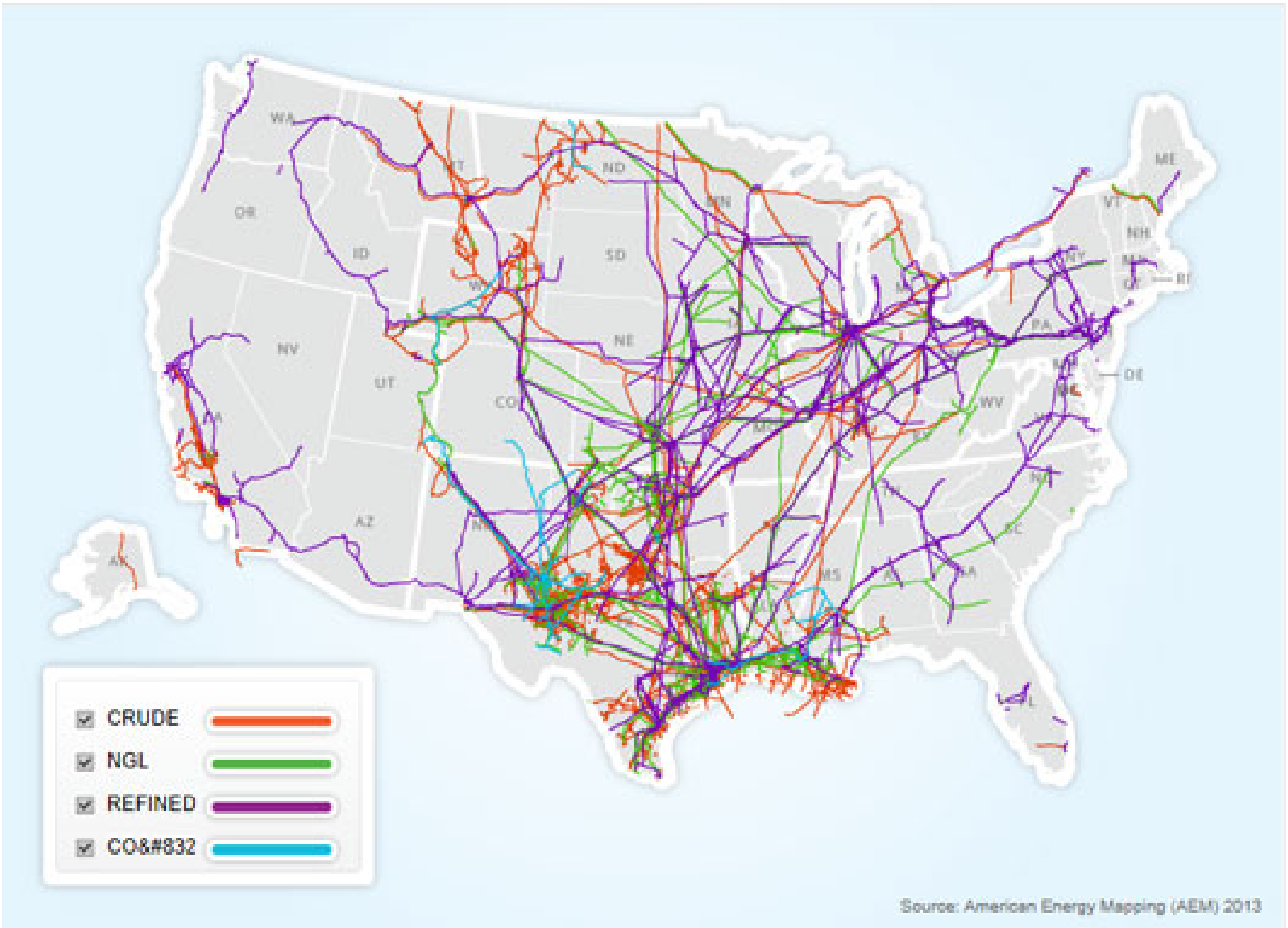
Tight oil production boom: time frame

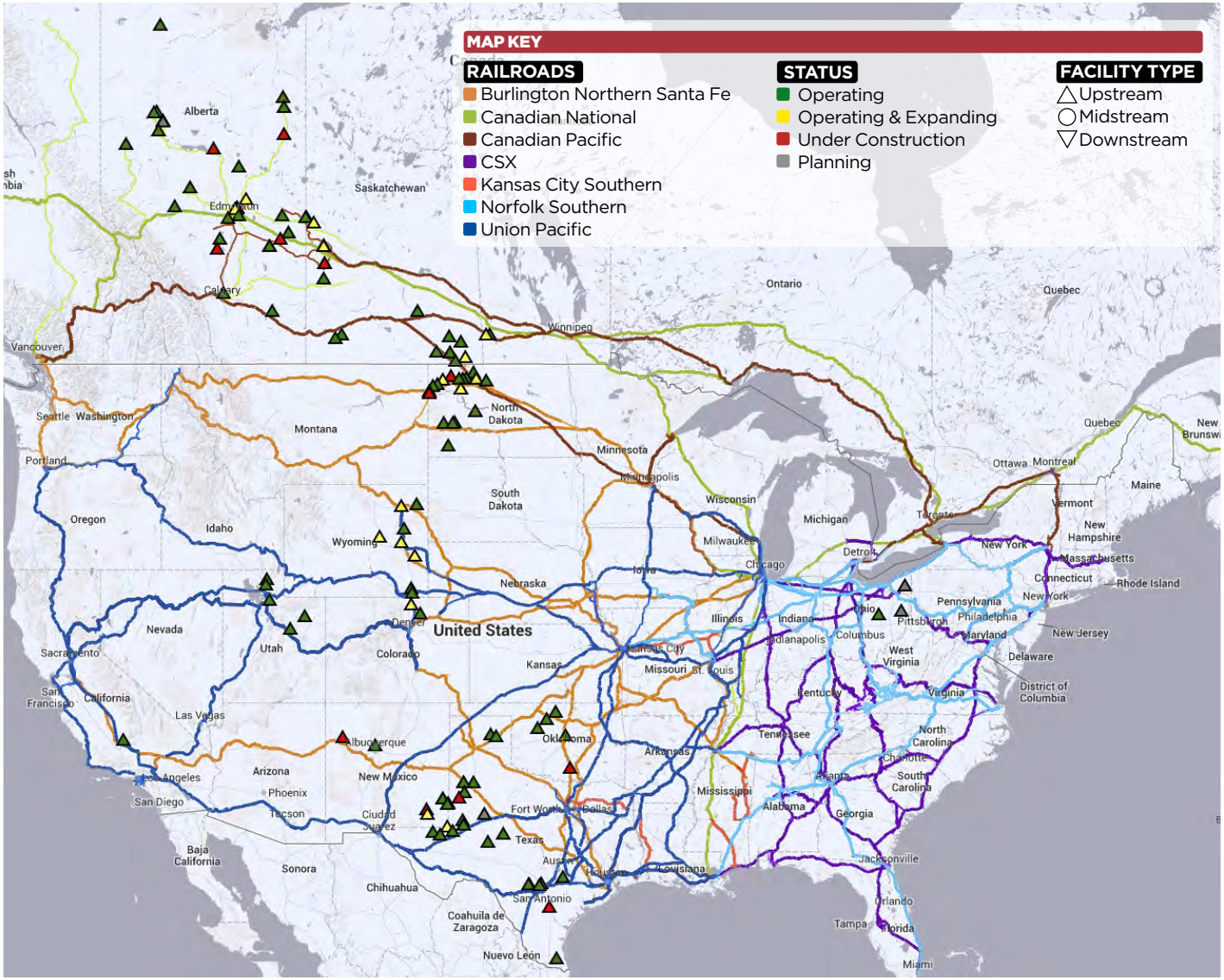
- some impact from fracking in 2008
- fracking boom really shows up in 2010



Infrastructure issues: oil pipeline siting

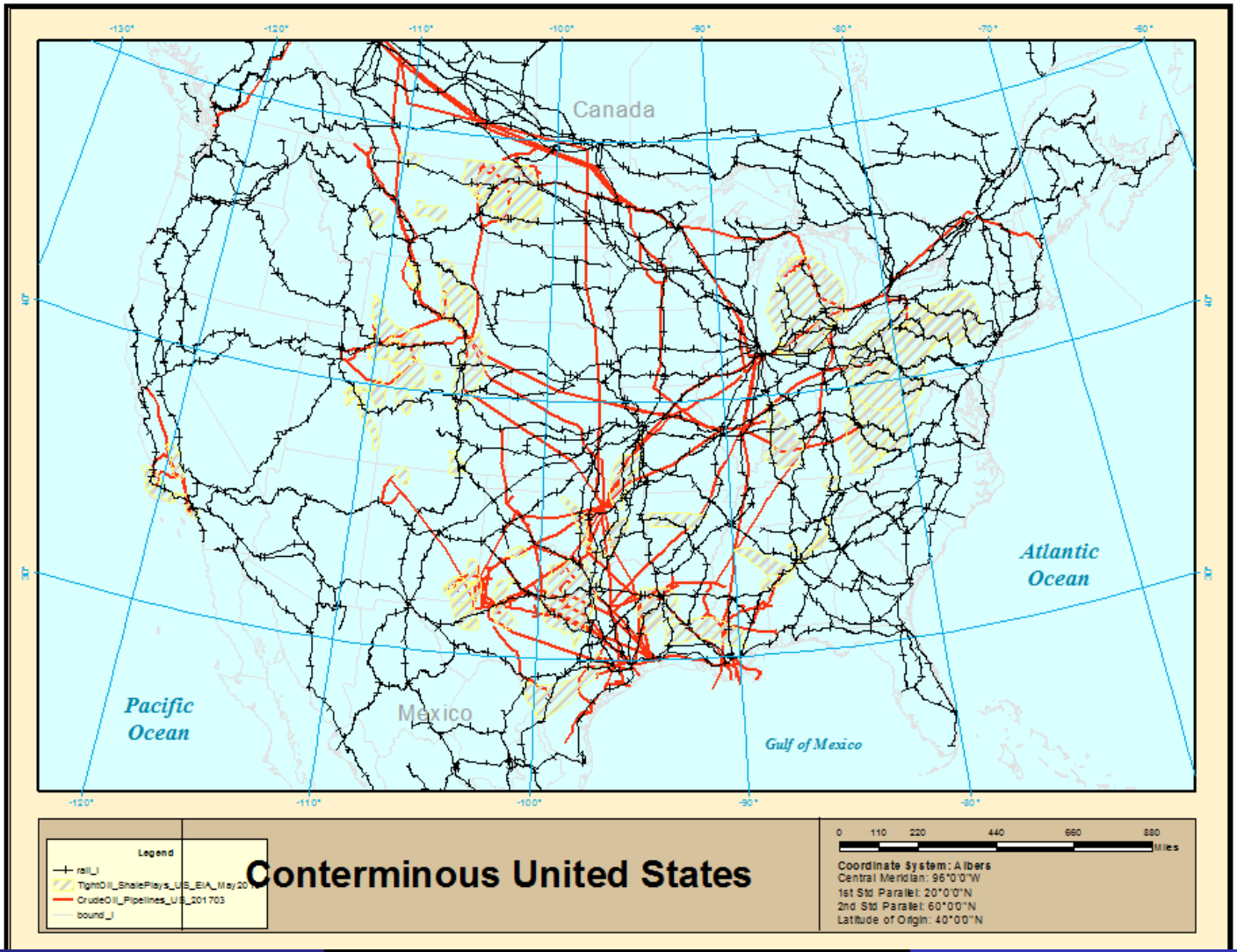


Infrastructure issues: rail siting



Infrastructure issues: rail vs. pipeline siting

with crude oil pipelines.png



July 6, 2013: Lac-Mégantic, Quebec

December 30, 2013: Casselton, North Dakota

April 30, 2014: Lynchburg, Virginia

February 16, 2015: Mount Carbon, West Virginia

March 5, 2015: Galena, IL

Pushback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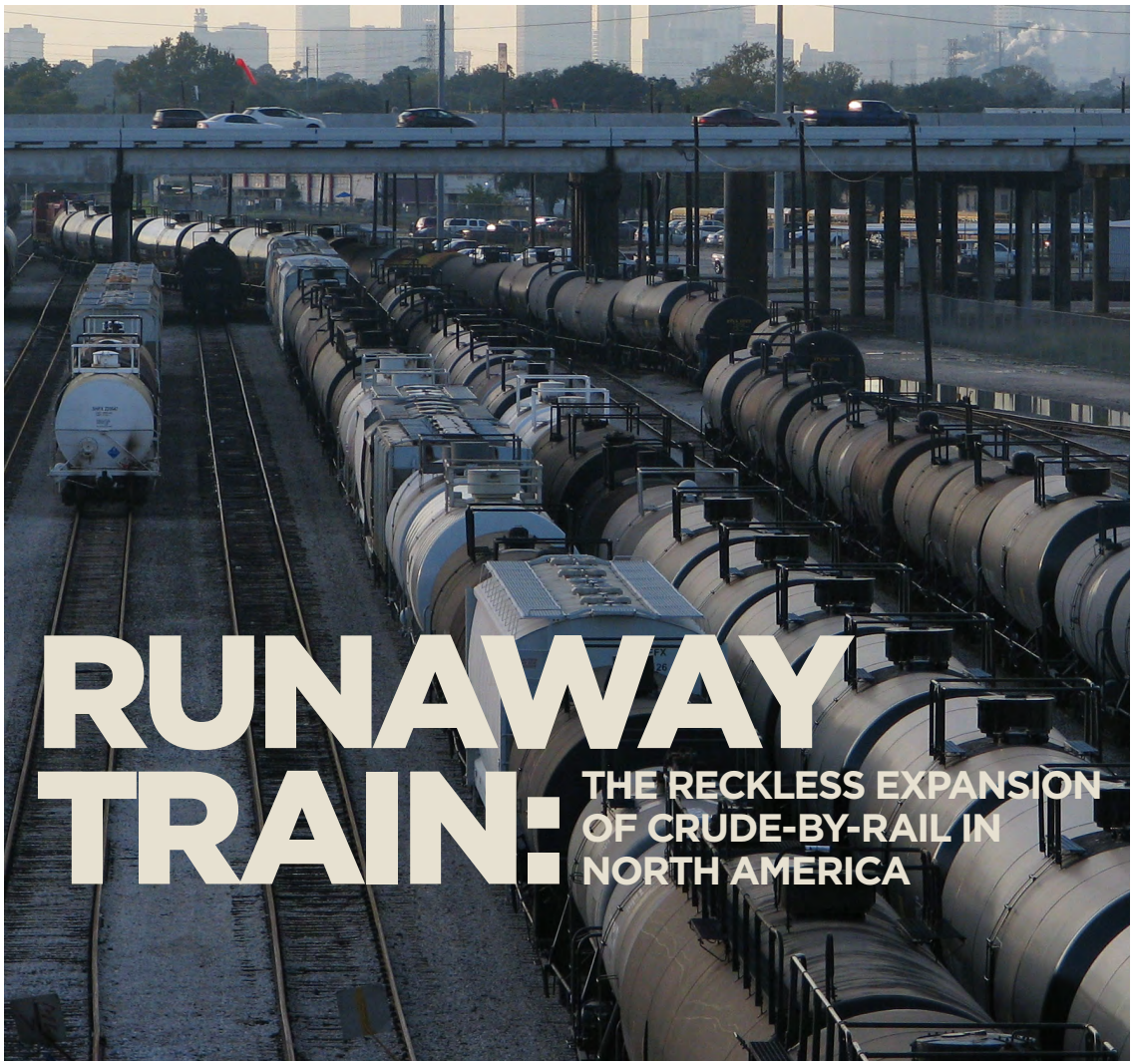
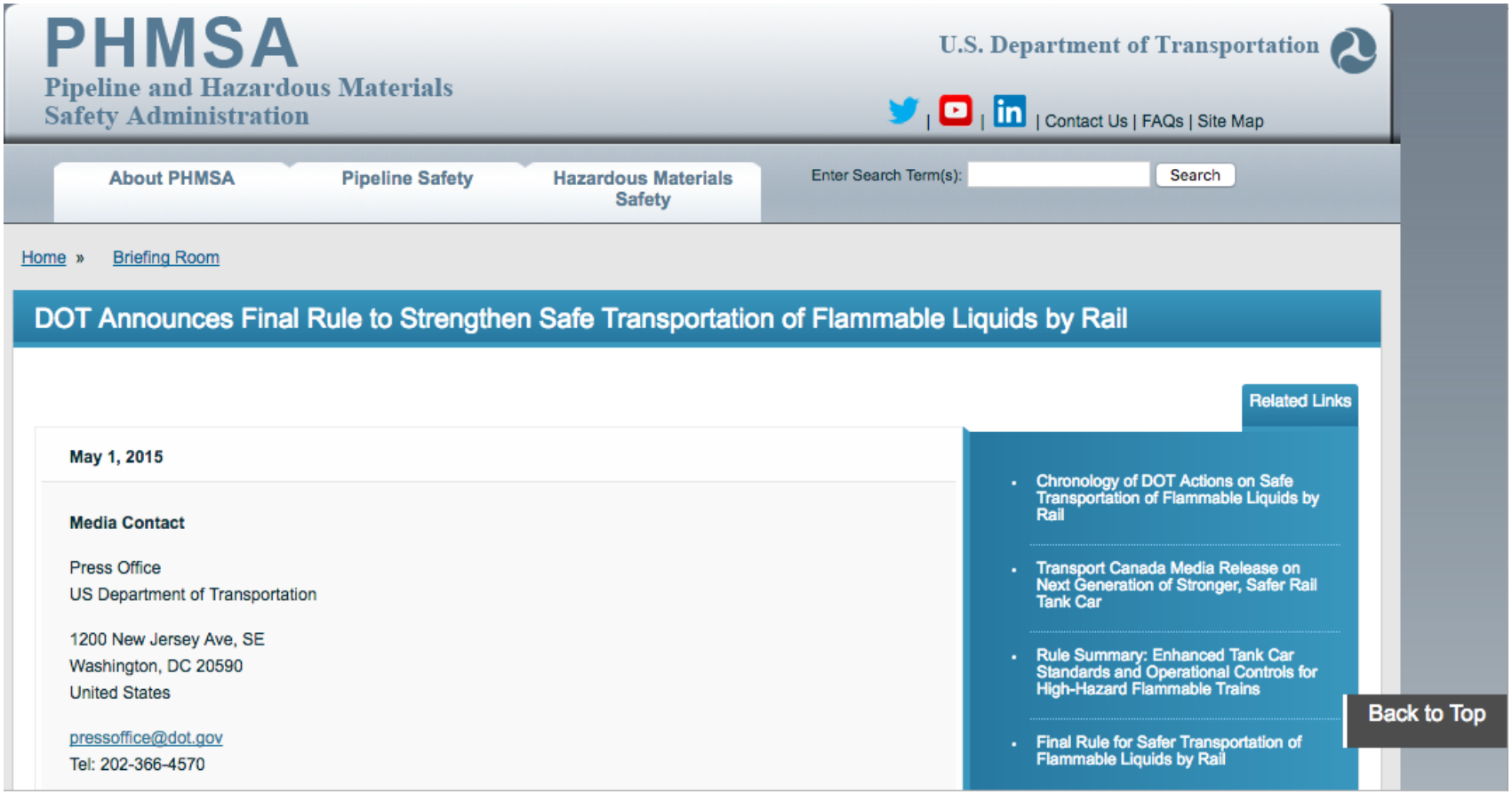


Regulatory pushback



PHMSA
Pipeline and Hazardous Materials Safety Administration

U.S. Department of Transportation

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DOT Announces Final Rule to Strengthen Safe Transportation of Flammable Liquids by Rail

May 1, 2015

Media Contact

Press Office
US Department of Transportation

1200 New Jersey Ave, SE
Washington, DC 20590
United States

pressoffice@dot.gov
Tel: 202-366-4570

Related Links

- Chronology of DOT Actions on Safe Transportation of Flammable Liquids by Rail
- Transport Canada Media Release on Next Generation of Stronger, Safer Rail Tank Car
- Rule Summary: Enhanced Tank Car Standards and Operational Controls for High-Hazard Flammable Trains
- Final Rule for Safer Transportation of Flammable Liquids by Rail

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Serious Incidents: 2009 – 2014

Originating State	Frequency	Percent
Colorado	1	4.35
Delaware	1	4.35
Kansas	1	4.35
Montana	2	8.7
New Mexico	1	4.35
North Dakota	15	65.22
Texas	1	4.35
Wyoming	1	4.35
Total	23	100

Crude Oil Rail Incidents: 2009 – 2014

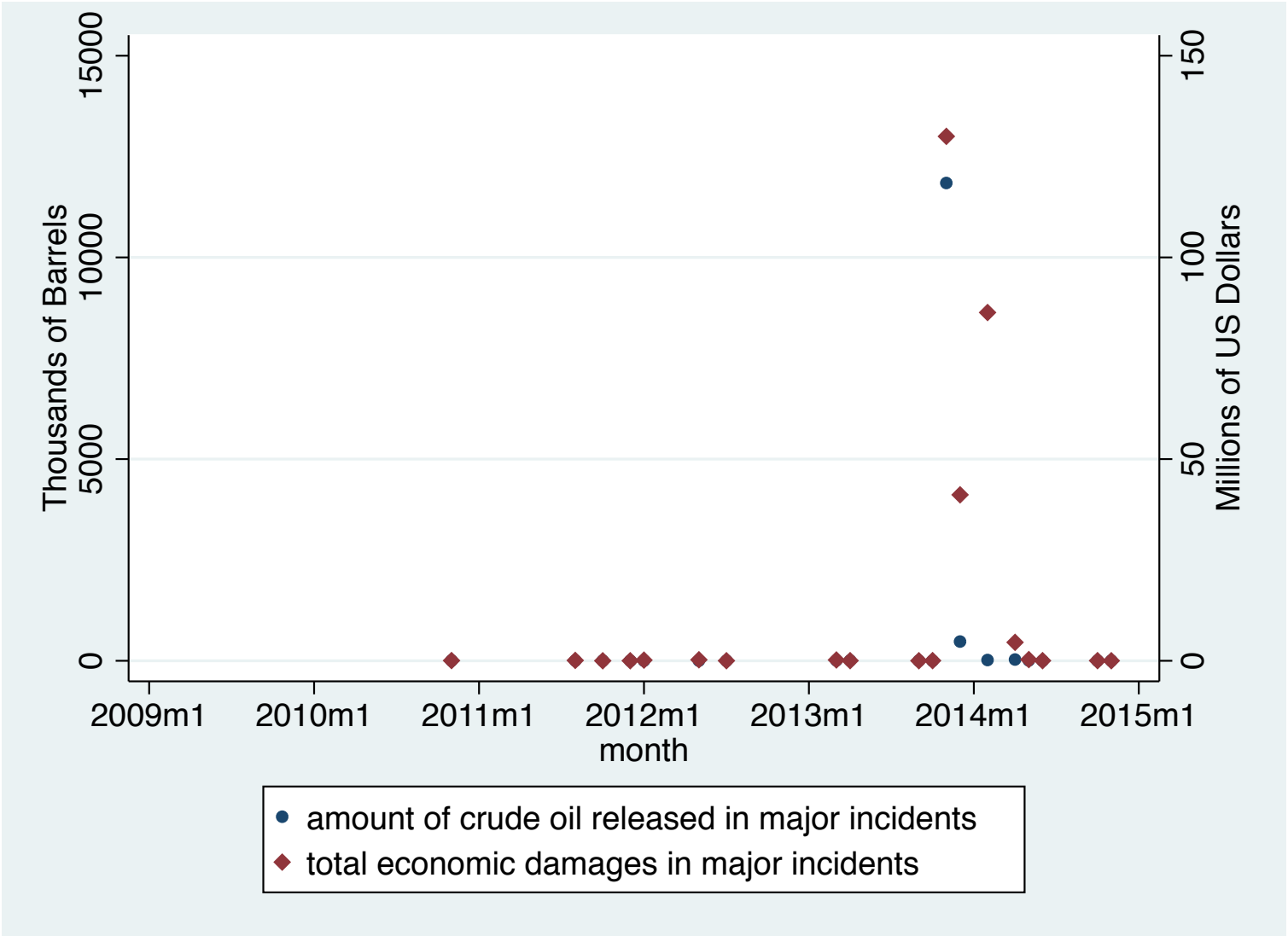
A. Serious Incidents

Fraction of weeks	Number of weeks between events			
with an event	Mean	Std. Dev.	Median	Skewness
0.07	13.23	20.34	6.50	3.18

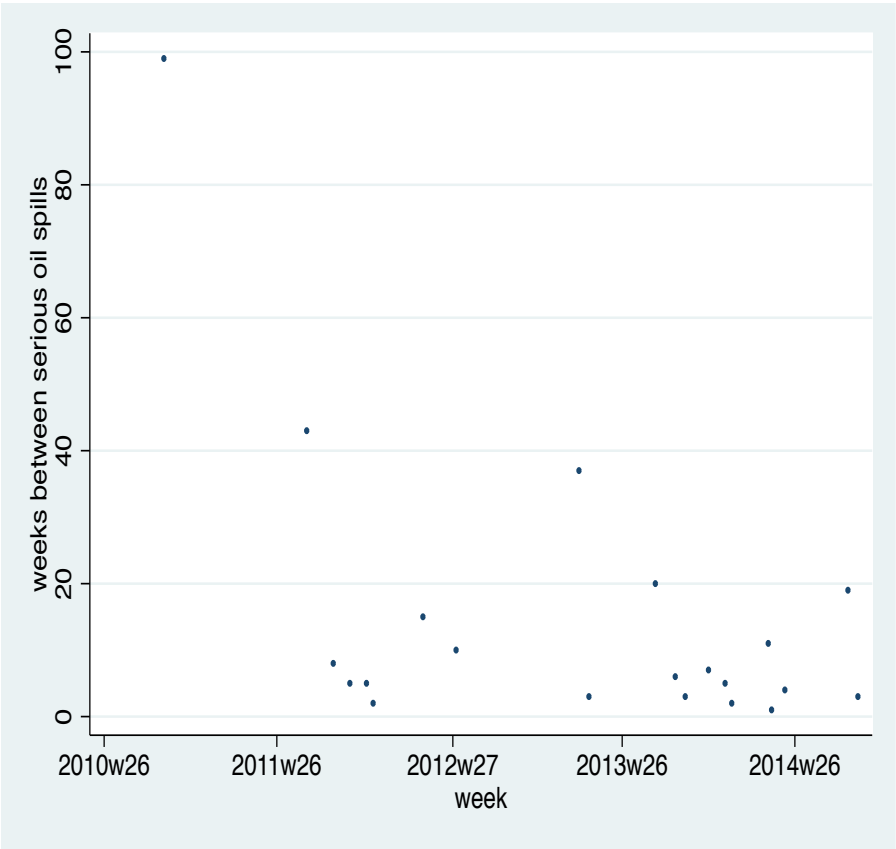
B. Minor Incidents

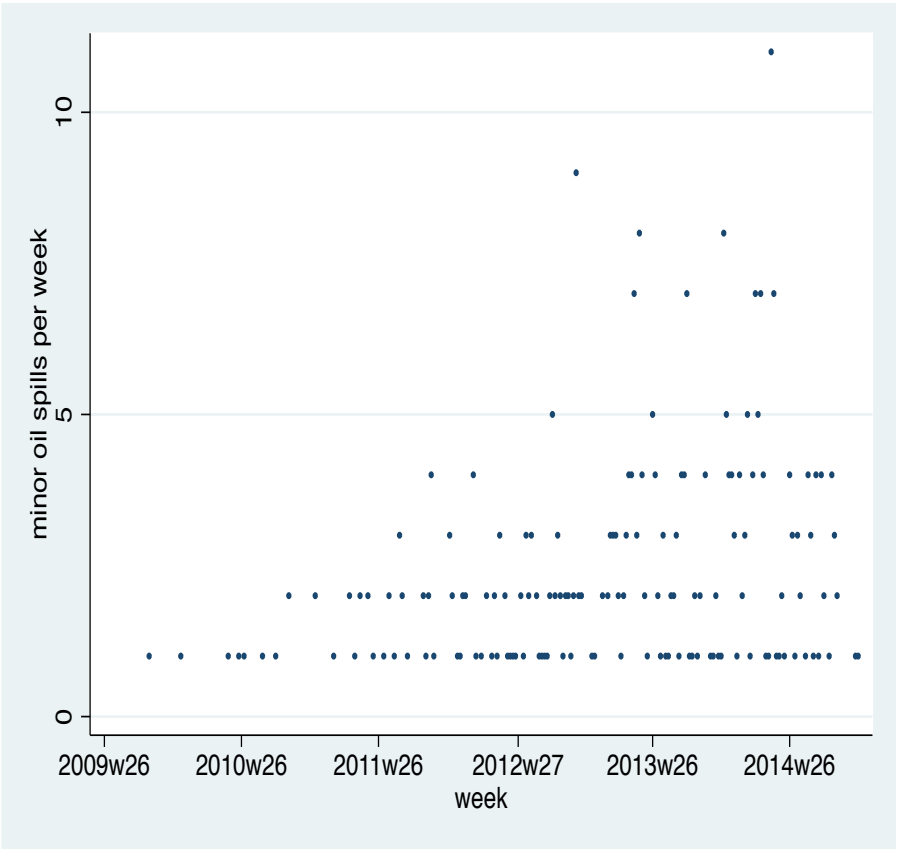
Fraction of weeks	Number of events per week			
with an event	Mean	Std. Dev.	Median	Skewness
0.50	2.27	1.72	2.00	2.08

Major Incidents: Qty of Oil Spilled, Econ Damages

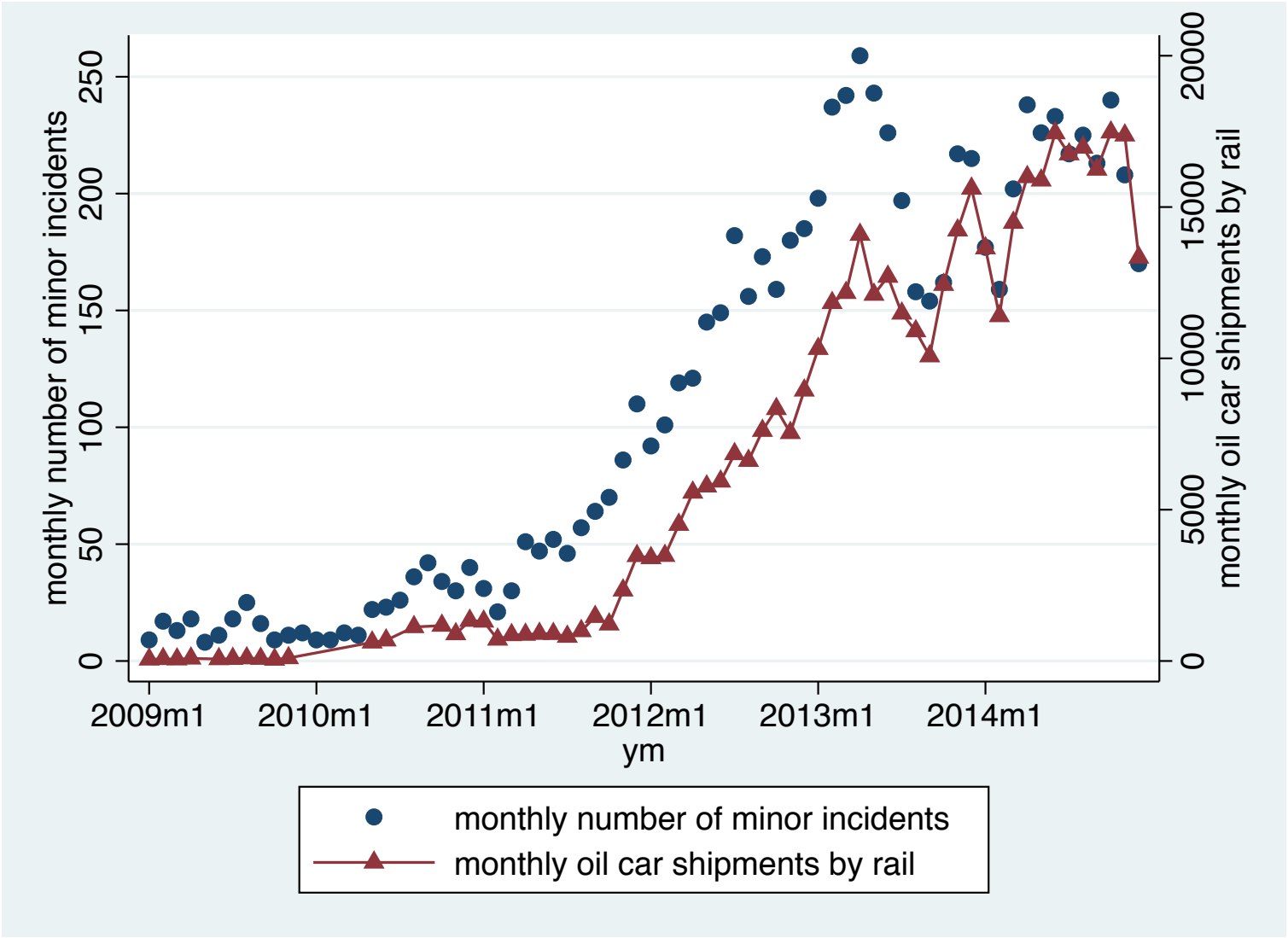


Minor Incidents and Time Between Major Incidents

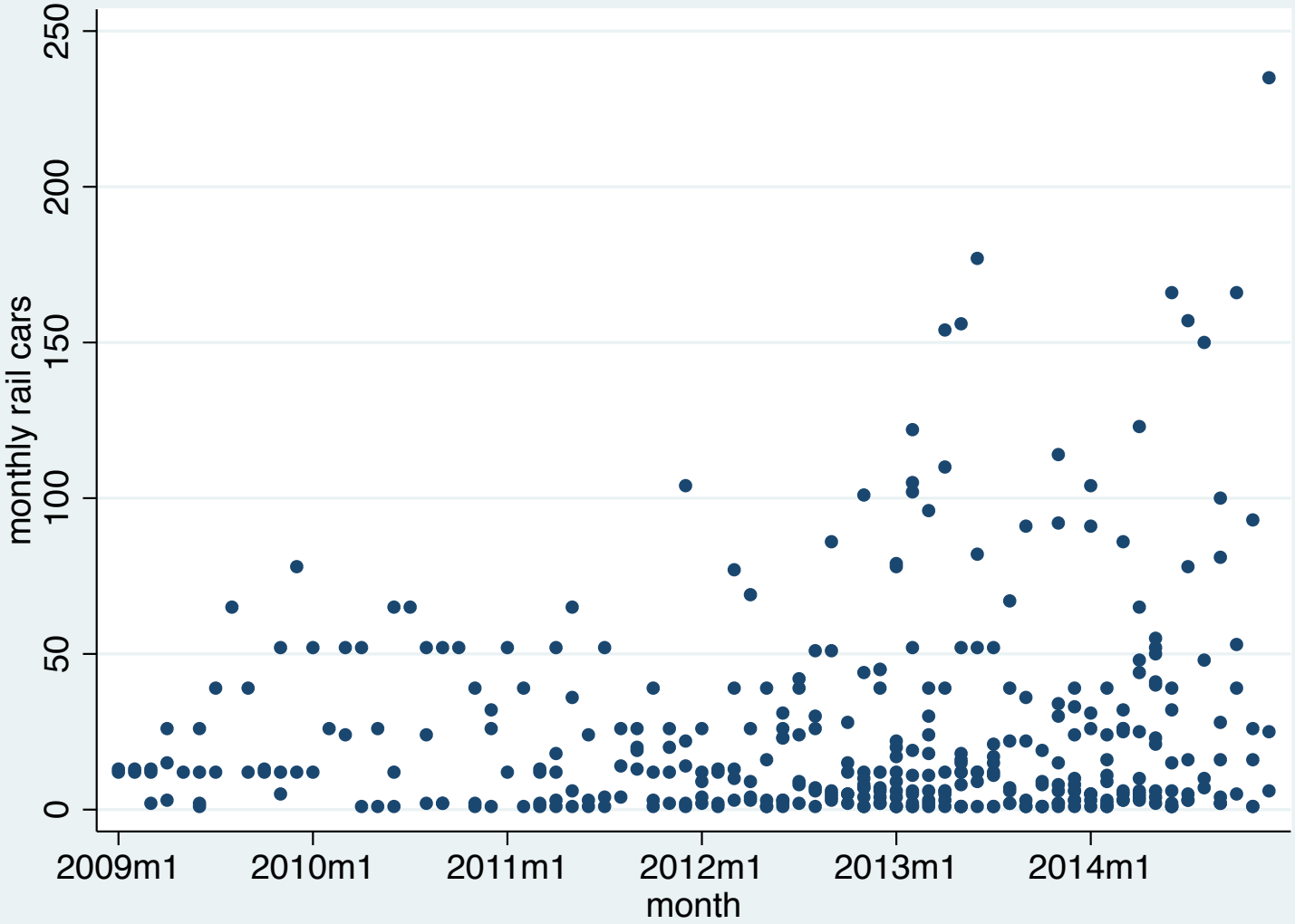




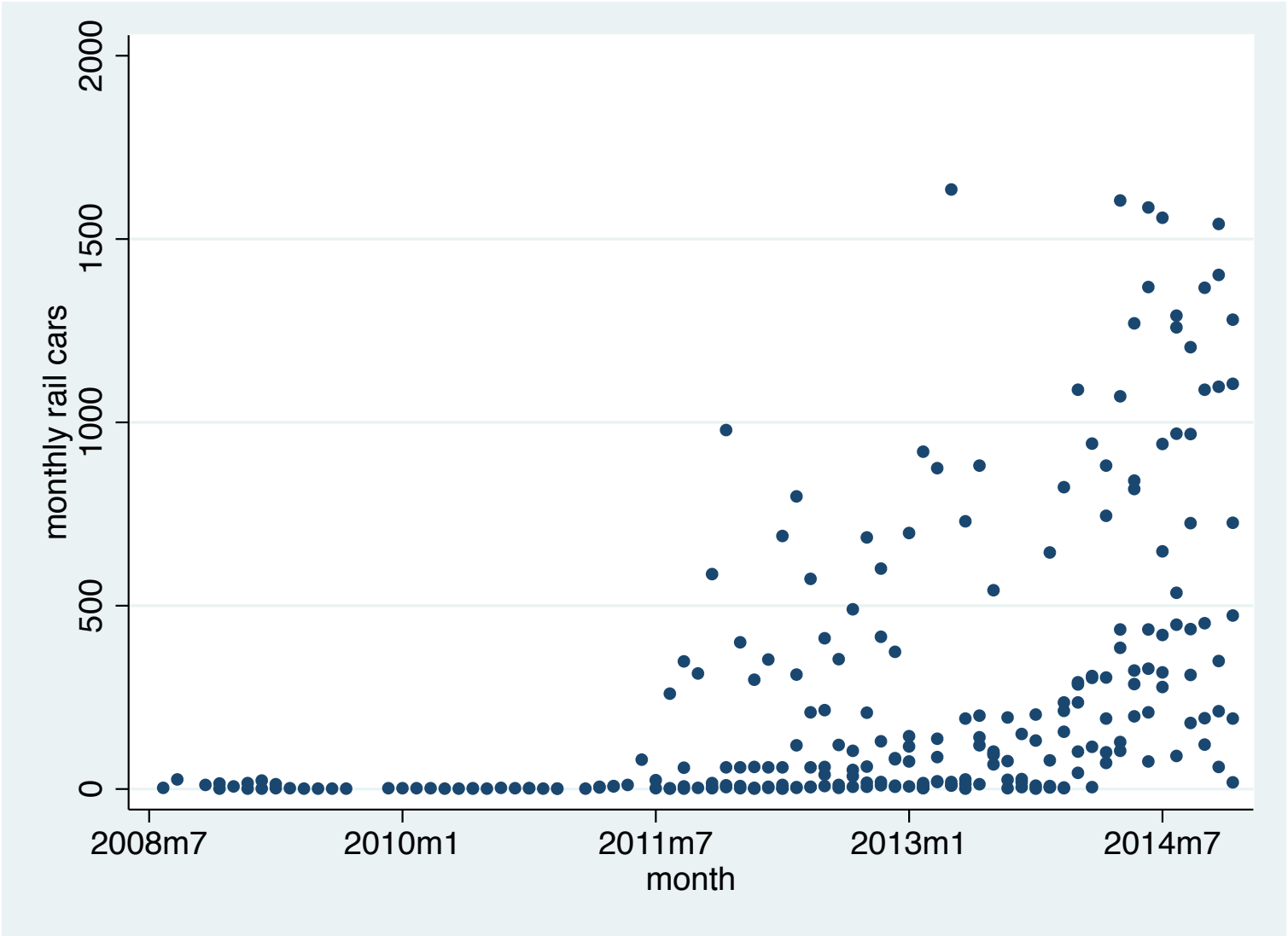
Minor Rail Incidents vs. Rail Oil Traffic



Rail Oil Traffic: Small Shipping States



Rail Oil Traffic: Large Shipping States



Annual Rail Shipments Of Crude Oil Originating in US

year	oil shipments	rail cars carrying oil	rail cars per shipment
2009	167	942	5.6
2010	294	9554	32.5
2011	665	15818	23.8
2012	1762	74525	42.3
2013	2508	147940	59
2014	2508	186954	74.5
Total	7904	435708	55.1

Data

- Incidents
  - PHMSA reports
    - any (self-reported) “incident” (restrict to crude oil)
    - can be minor (common) or serious (infrequent)
    - observations collected for 1 Jan 2009 – 31 Dec 2014
    - info on amount oil released, total econ. damage, originating state
- Rail Traffic
  - DOT waybill sample
    - most large carrier shipments
    - detailed information on every shipment, 2009 - 2014
    - retained all shipments carrying oil, originating in US
- merged these sets
  - aggregated to monthly observations
    - “obs.”: number of oil cars shipped in month t from a state k
    - no. incidents (0 – 8)
    - no. serious incidents (0/1)
    - amt. oil spilled; total costs

Time Between Serious Incidents

	Regression model		
regressor	Cox	Exponential	Weibull
Cumulative number of minor incidents	-0.025*** (0.009)	-0.019* (0.011)	-0.019* (0.010)
constant		-2.255*** (0.504)	-1.956*** (0.272)
p			0.905 (0.146)
χ^2 statistic	7.644***	3.101*	3.599*

Standard errors in parentheses

*: significant at 10%; **: significant at 5%; ***: significant at 1%

Logit Analysis of Serious Incidents

	(1)	(2)	(3)	(4)
# minor incidents, past 3 mos.	0.363**	0.363**	0.305*	0.310***
	(0.168)	(0.165)	(0.166)	(0.052)
# minor incidents, past 6 mos.	-0.218	-0.219	0.003	
	(0.197)	(0.192)	(0.092)	
# minor incidents, past 9 mos.	0.134	0.141		
	(0.204)	(0.104)		
# minor incidents, past 12 mos.	0.005			
	(0.133)			
constant	-4.190***	-4.190***	-4.117***	-4.116***
	(0.318)	(0.314)	(0.296)	(0.296)
χ^2	37.390	36.512	35.834	35.731

Rail Car Shipments and Minor Incidents

	Poisson		Neg. Binomial	
	(1)	(2)	(3)	(4)
Thousand cars	0.205***	0.136***	0.236***	0.154***
	(0.014)	(0.006)	(0.018)	(0.024)
constant	-1.333***		-1.378***	-0.387
	(0.104)		(0.104)	(0.257)
State-level FE?	no	yes	no	yes
N	681	562	681	562
χ^2	229.0	442.7	167.1	42.7

Standard errors in parentheses

*: significant at 10%; **: significant at 5%; ***: significant at 1%

Rail Shipments and (a) Oil Spilled, (b) Total Damages

Dep. Vbl.:	(a) Quantity of Oil Spilled		(b) Total Economic Damages	
	Poisson	Neg. Binomial	Poisson	Neg. Binomial
	(1)	(2)	(3)	(4)
Thousand cars	0.026***	0.137***	0.215***	0.227***
	(0.007)	(0.021)	(0.004)	(0.022)
constant		-2.333***		-4.183***
		(0.126)		(0.122)
State-level FE?	yes	yes	yes	yes
N	562	562	539	539
χ^2	16.03	42.80	2587	102.3

Standard errors in parentheses

*: significant at 10%; **: significant at 5%; ***: significant at 1%

Impact on expected damages

- above results can be used to infer the expected impact of a one unit increase in rail traffic
- in Poisson model:

$$\mathcal{E}(D) = \exp(\hat{\beta}\,\overline{x}),$$

  - one unit = 1,000 rail cars
  - $\hat{\beta} = 0.215$ is the estimated coefficient on rail traffic in Poisson model
  - the average value of dollar damages is \$3,375
- thus, the expected value of total economic damages is

$$0.215 \times \$3,375 \approx \$725$$

Conclusion

- statistically important, negative relation b/w accumulated minor incidents and time between serious events
- statistically important, positive rel'n b/w rail traffic and pdf over minor incidents
  - adding 10,000 rail cars shipping oil $\Rightarrow$ .4 add'n'l incidents / week
  - each add'n'l 3 minor incidents (past 3 mos.) $\Rightarrow$ one add'n'l serious event
- fixed effects largest for states with significant tight oil production
  - OK, ND, TX, NM, WY
- statistically important positive rel'n b/w rail traffic and pdf over costs
  - implies impact on expected costs: marginal impact of one-unit increase in rail shipments = $725
  - costs reported in database include
    - lost product and damaged capital (private costs)
    - costs from response, closure of main transportation arteries (social costs)
  - costs *do not* include
    - social costs associated with environmental damages from oil spills
    - property damages resulting from serious events (*e.g.*, spill-induced fires)
    - value of lost life