No One Else to Blame? Local Monopoly and Toxicity

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January 6, 2025

(preliminary)

Abstract

Local monopoly creates accountability: Without rivals to deflect blame, monopolists may find it optimal to reduce pollution to avoid legal or reputational repercussions. This paper examines how market concentration in the North American oil industry impacts environmental outcomes. Using project-level data and historical land grant allocations to establish causality, we show that higher market concentration reduces the use of toxic chemicals in oil production. Supporting evidence from self-reported harm and tort litigation data confirms that operators in concentrated markets face greater scrutiny and legal risks. Our findings reveal a novel environmental benefit of market concentration.

Keywords: market concentration, toxicity, accountability, fracking, land allocation

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1 Introduction

In this paper, we explore one unexpected mechanism for reducing toxicity that emerges from the structure of the market itself: monopoly power. Local monopolists may face unique accountability pressures due to their visibility and lack of competitors. Without rivals to deflect blame, monopolists may find it optimal to reduce pollution to avoid legal or reputational repercussions.

The North American oil sector provides a compelling case study. Over the past few years, this industry has experienced significant consolidation through mergers and acquisitions, leading to higher levels of market concentration. In this paper, we explore whether market concentration has the unintended effect of reducing the use of toxic chemicals in oil production. Using project-level data, we analyze how local market structure—measured by the Herfindahl-Hirschman Index (HHI) at the county level—affects environmental outcomes. We show that higher market concentration is associated with lower levels of toxicity.

To establish causality, we exploit the land grants given to railroad companies in the 19th century. To avoid giving up too much land, the government retained ownership of the even-numbered sections in each township within 20-miles of the railroad tracks, while granting the odd-numbered sections to railroad companies. As a result, the land grants were distributed in a checkerboard pattern, creating a useful variation in land ownership. Although the surface land could have been sold afterward, the railroad companies frequently retained the mineral rights. Three transcontinental roads passed through oil-rich counties in multiple states: the Northern Pacific line passed through North Dakota and Montana; the Union Pacific line passed through Wyoming; and the Atchison, Topeka, and Santa Fe Railway passed though Colorado and Kansas (this line also crossed New Mexico, but was built far from the oil-rich counties of Eddy and Lea). Importantly, the land allocations predated the discovery of oil, making them plausibly exogenous to current oil exploration activities.

We find that wells located on odd-numbered sections in oil-rich counties of "treatment" states—those traversed by three transcontinental railroads—exhibit lower toxicity compared to even-numbered sections. This pattern is absent in "control" states without significant railroad grants, such as Oklahoma and New Mexico.

Further analysis reveals the role of legal accountability in driving this relationship. Wells located further from those of competing operators are associated with lower toxicity, suggesting that monopolistic operators are more likely to reduce pollution when they are solely accountable for local environmental outcomes. In contrast, when multiple operators are active in the same area, legal accountability diminishes, and toxicity levels rise. Interestingly, we also observe increased toxicity for wells situated far from all prior drilling activity, possibly reflecting the higher chemical demands of "wild" wells in unexplored regions.

To further support the proposed mechanism, we examine whether operators in concentrated markets face increased risks of accountability for contamination. Using data on self-reported harm from hydraulic fracturing collected by the Pennsylvania Alliance for Clean Water and Air (PACWA) and tort litigation cases compiled by Watson (2024), we find a positive correlation between market concentration and both reported harm intensity and litigation activity. These findings further support our mechanism, although limitations such as legal variations across states and incomplete litigation records are acknowledged.

Our findings contribute to several strands of literature. First, we identify a novel mechanism by which market structure affects environmental outcomes, complementing existing studies that primarily focus on output reduction in monopolistic markets (e.g., Asker et al. (2024)). Second, we propose a new instrument for local market concentration in the oil industry, leveraging the checkerboard structure of historical land grants. Our approach is similar to Smith (2024) who uses historical land allocations to railroad companies to study the long-term effects land concentration, and Decaire and Wittry (2021) who use data on parcels deeded to settlers to measure the effect of landownership fragmentation on strategic learning. Finally, our paper adds to the growing body of research on the local impacts of market power, highlighting the interplay between firm behavior, legal accountability, and pollution; see Berger et al. (2022).

By demonstrating the unintended environmental benefits of market concentration in the oil sector, our study offers new insights into the complex relationship between industrial organization and sustainability.

2 Data and Background Information

Well-Level Toxicity Measure We use FracFocus data to identify chemicals used to frack an oil well.[1] Operators self-report chemicals information to FracFocus. As many states made reporting to FracFocus mandatory only as late as in 2013, we begin our sample in 2014. The FracFocus data contains detailed information about the composition of fracturing fluid for each treatment job. Each chemical is identified by a unique CAS number and the dataset contains information about the PercentHighAdditive, which shows the maximum of each component of the product used.

We rely on the Globally Harmonized System of Classification and Labelling of Chemicals (GHS)[2] an internationally recognized standard established by the United Nation to identify toxic chemicals. According to this standard, each chemical is assigned one of the three signal words: danger, warning or caution. We denote a chemical as toxic if its signal word is danger. Finally, for each well we calculate the total PercentHighAdditive of toxic chemicals, which serves as out main well-level measure of toxicity.[3]

Well-Level Data FracFocus also contains information about the date of each treatment, location, and operator who owns a well. Addtionally, FracFocus flags all wells located on Federal and Indian lands. We supplement FracFocus with well-level data from Enverus (previously Drillinginfo). Specifically, we use production data from Enverus.

Historical Railroad Land Grants Since 1860s, railroad companies in the US were given land grants in exchange for building rail lines. Grants of land to railroads were done on a *checkerboard pattern*. In most oil and gas producing states, the Public Land Survey System (PLSS) splits the territory into 6-by-6-square-mile units. Each unit is further split into 36 sections. The US government granted the railroad every odd-numbered section within a 20-mile distance form the line, while keeingt the even-numbered sections, thus creating a checkboard pattern.

[1] Other papers using this dataset include Fetter et al. (2018), Bellon (2022) and Jiang (2024). Our approach to toxicity score differs from Fetter et al. (2018) and Bellon (2022) as we discuss next.

[2] https://unece.org/about-ghs

[3] We exclude silica (or sand) from the list of toxic chemicals. Although silica is toxic, because it causes damage to organs through prolonged or repeated exposure, it typically constitutes up to 10% of the fracturing fluid. If we keep sand in our calculations, our measure would be entirely driven by the amount of sand used.

Three transatlantic roads passed through oil-rich counties in multiple states: Northern Pacific line passed through North Dakota and Montana; Union Pacific line passed through Wyoming; and Atchison, Topeka, and Santa Fe Railway passed though Colorado (and also New Mexico, but in this state it was built far away from oil-rich counties of Eddy and Lea). In our analysis, we compare odd- and even-numbered sections in *treatment* states: Colorado, Wyoming, North Dakota, and Montana. In contrast, railroads did not pass through oil-rich counties Oklahoma and New Mexico, thus we consider these states as a *control* group.

We drop Texas form this exercise. A railroad line crossed oil-extracting counties in Texas making it a treatment state[4], however Texas does not use the PLSS system, so we cannot conduct our analysis.

We make two important observations. First, most of the land grants occurred in 19th century and long before oil discoveries. For example, in North Dakota, the first oil was found only in 1951. Second, although over time railroad companies sold out parts of their land, however, they often retained mineral rights. Moreover, Smith (2024) shows that land concentration driven by railroad land grants has been very persistent.

3 Results

3.1 Market Concentration and Toxicity

The main results are presented in Table 1. We use both county-level and section-level measures of market concentration. The first two specifications use the county-level HHI index as a measure of market concentration. The next two specifications use the largest market share across all operators defined also at the county level for each year. Finally, the last two specifications use the section-level (1-by-1 square mile unit) measure equal to 1 if multiple operators are active in this section on average, and 0 otherwise. Because of granularity of this measure, we take the average over years as most sections are typically active only for 1 or 2 years anyways. A large part of the sample is lost,

[4]Texas Pacific Land Trust was once the largest landowner in Texas with 3.5 million acres of land. It now owns 888,333 acres of land in West Texas. Source: https://www.oilandgaslawyerblog.com/texas-pacific-railway-texas-pacific-land-trust-history-railroads-texas/

because we have to drop Texas which does not use the PLSS system (which splits the territory into 6-by-6 townships, each divided into 36 sections).

In all specifications, we find that in counties with more concentrated oil market, firms use less toxic chemicals. Specifically, counties with larger HHI index and counties with larger market share of the largest operator tend to have less chemicals used. Similarly, sections in which more than one operator actively drills, tend to use more toxic chemicals.

Table 1: Operator Concentration and Toxicity

	Toxicity					
	(1)	(2)	(3)	(4)	(5)	(6)
Operator Concentr. - HHI	-0.426***	-0.267**				
	(0.113)	(0.111)				
Operator Concentr. - Max Share			-0.412***	-0.250**		
			(0.122)	(0.114)		
Multiple Operators in Section					0.190***	0.123**
					(0.068)	(0.062)
Log Production, T = 12m	-0.120***	-0.071***	-0.121***	-0.071***	-0.140***	-0.083***
	(0.024)	(0.022)	(0.024)	(0.022)	(0.030)	(0.031)
Log Trade Secret PP	2.186***	2.090***	2.183***	2.090***	1.433***	1.464***
	(0.373)	(0.355)	(0.376)	(0.356)	(0.435)	(0.464)
Log Horizontal Length	-0.087	0.152***	-0.084	0.155***	0.073	0.147***
	(0.068)	(0.048)	(0.068)	(0.048)	(0.057)	(0.055)
Log True Vertical Depth	0.093	-0.334*	0.088	-0.339*	-0.304*	-0.588***
	(0.210)	(0.188)	(0.208)	(0.186)	(0.181)	(0.184)
Log Ground Elevation	-0.250	-0.198	-0.251	-0.200	-0.250	-0.104
	(0.176)	(0.175)	(0.174)	(0.174)	(0.389)	(0.386)
Log Water Volume	-0.440***	-0.272***	-0.439***	-0.271***	-0.433***	-0.290***
	(0.046)	(0.039)	(0.046)	(0.039)	(0.044)	(0.048)
Federal Well	0.094	0.210	0.097	0.214	0.119	0.214
	(0.162)	(0.158)	(0.162)	(0.159)	(0.172)	(0.176)
Mean Dep.Var.	-2.178	-2.178	-2.178	-2.178	-2.169	-2.169
Obs.	69821	69821	69821	69821	32479	32479
R^2	0.233	0.307	0.231	0.306	0.279	0.334
Year FE	Y	Y	Y	Y	Y	Y
Geo FE		Y		Y		Y

Our results show that more concentrated oil drilling locations are associated with lower toxicity.

However, market concentration is endogenous. To identify the effect of market concentration on toxicity, we leverage the unique feature of historical land distribution to railroad companies in the US in the next section.

3.2 Odd Sections

Table 2 compares toxicity outcomes in odd and even sections in treated states of Colorado, Wyoming, North Dakota, and Montana, where the railroad passed through oil-rich counties. The results show, that wells drilled in odd-numbered sections - some of which were associated with larger historical land concentration - tend to be fracked with less toxic chemicals. As odd and even sections are otherwise similar, this results provides a strong confirmation for our hypothesis that market concentration is associated with lower toxicity.

As a Placebo exercise, to provide further support for our identification strategy, Table 3 performs a similar exercise as Table 2, but for control states of New Mexico and Oklahoma. In control states, we find no differences in toxicity between odd and even sections.

Table 2: Odd Sections and Toxicity, Treatment States (Colorado, Wyoming, North Dakota, Montana)

	Toxicity				
	(1)	(2)	(3)	(4)	(5)
Odd Section	-0.04894**	-0.05661***	-0.04173*	-0.03628*	-0.05556***
	(0.02260)	(0.01754)	(0.02112)	(0.01843)	(0.01628)
Public Status			-0.37569*	-0.35932**	-0.29236**
			(0.19326)	(0.14664)	(0.14111)
Log Production, T = 12m			0.03682	0.00173	0.02605
			(0.06628)	(0.04756)	(0.04575)
Log Trade Secret PP			0.64114	0.52270	0.74296*
			(0.44669)	(0.36525)	(0.40238)
Log Horizontal Length			0.09436	0.15941*	0.10344
			(0.10027)	(0.09401)	(0.08609)
Log True Vertical Depth			0.01839	-0.53916	-0.44479
			(0.33482)	(0.41313)	(0.35642)
Log Ground Elevation			-0.45668***	0.82620	0.54037
			(0.17180)	(0.67122)	(0.61567)
Log Water Volume			-0.24374***	-0.26242***	-0.26120***
			(0.05929)	(0.06380)	(0.06615)
Federal Well			0.13789	0.10159	0.07682
			(0.10670)	(0.11370)	(0.08698)
Mean Dep.Var.	-2.089	-2.090	-2.059	-2.059	-2.060
Obs.	20408	20379	19485	19479	19464
R^2	0.225	0.386	0.290	0.348	0.418
Year FE	Y	Y	Y	Y	
Geo FE		Y		Y	
Geo-Year FE					Y

Table 3: Placebo: Odd Sections and Toxicity, Control States (New Mexico and Oklahoma)

	Toxicity				
	(1)	(2)	(3)	(4)	(5)
Odd Section	0.00657	0.01974	0.01417	0.02603	0.03144
	(0.03288)	(0.03129)	(0.02597)	(0.02563)	(0.02398)
Public Status			-0.54958***	-0.52209**	-0.64272***
			(0.20711)	(0.21052)	(0.20799)
Log Production, T = 12m			-0.00933	-0.06080	-0.06154*
			(0.04827)	(0.04051)	(0.03358)
Log Trade Secret PP			2.34994***	2.40336***	2.57512***
			(0.82310)	(0.82709)	(0.82138)
Log Horizontal Length			0.01551	0.09793	0.11407
			(0.09353)	(0.07821)	(0.07150)
Log True Vertical Depth			-0.15250	-0.40722*	-0.33125
			(0.18127)	(0.24142)	(0.24695)
Log Ground Elevation			-0.38196*	-0.54075	-0.36541
			(0.19980)	(0.41465)	(0.37432)
Log Water Volume			-0.41225***	-0.41305***	-0.26751***
			(0.07461)	(0.07257)	(0.07046)
Federal Well			0.31820	0.33152	0.40966*
			(0.25566)	(0.23994)	(0.21879)
Mean Dep.Var.	-2.375	-2.379	-2.360	-2.361	-2.364
Obs.	13158	13115	12394	12390	12353
R^2	0.182	0.390	0.340	0.387	0.490
Year FE	Y	Y	Y	Y	
Geo FE		Y		Y	
Geo-Year FE					Y

Finally, we check if historical land concentration is associated with higher market concentration today. For each year and each active section (at least 5 wells fracked in this year), we count the number of operators who fracked a well in this section in this year and then take the average over the years. Typically a section is active for a few years only. We also need a measure of market concentration at the very granular section level. So we create an indicator variable equal to 1 if more than 1 operator was active in this section on average and 0 otherwise. We call this variable *MultipleOperators*.

Table 4 compares *MultipleOperators* between odd and even sections. The first two specifications correspond to treated states, and the last two to control states. We include either state or county level controls. Comparing the means of the dependent variable, we find that on average market is more concentrated in treated states, as the mean dependent variable is substantially lower in these states. More importantly, in the treated states, we find that odd sections are less likely to have more than 1 active operator. In contrast, in the control states, the coefficient is negligible and insignificant. It should be noted, that in our analysis we simply compare *all odd and even sections in treated states, without identifying precisely the location of the railroads.* Once we focus on the relevant odd and even sections around the actual railroads, our results are likely to become stronger (to be done). Overall, our results imply that historical land concentration survived over time and led to a more concentrated oil market today.

Table 4: Historical Land Concentration and Current Market Concentration

	Multiple operators			
	Treated States		Control States	
	(1)	(2)	(1)	(2)
Odd Section	-0.025*	-0.026*	0.004	0.005
	(0.015)	(0.014)	(0.008)	(0.008)
Mean Dep.Var.	0.653	0.653	0.905	0.905
Obs.	3582	3582	4484	4484
R^2	0.162	0.213	0.108	0.148
State FE	Y		Y	
countyfe		Y		Y

Notes: In this table only:* $p < 0.15$. Source: Authors' calculations based on data from Enverus and FracFocus.

4 Testing the Mechanism

To test the mechanism, we perform two additional exercises. First, we investigate operators' propensity to use toxic chemicals when it becomes more difficult to shift he blame of contamination on other firms. Second, we explore the link between reported harm and filed tort litigation court cases and market concentration.

4.1 Distance to Prior Wells

In this section, we investigate whether operators tend to be more cautious and use less toxic chemicals, if wells of other firms are too far away, in which case it becomes more difficult to "shift the blame". Using the data on the exact location of each well, we calculate the distance in km to the closest previously fracked well of other operators. For comparison, we also calculate the distance to the closest well.

The results in Table 5 show that operators use less chemicals, if a new well is located far away from wells of other firms. In constrast, operators use more chemicals for wells that are far away from any wells, and thus likely to represent an experimental well in a new location. Thus, the results in this section are in line with our mechanism.

Table 5: Toxicity and Distance to Prior Wells

	Toxicity			
	(1)	(2)	(3)	(4)
Distance to All Prior Wells	0.03898	0.04630*		
	(0.03339)	(0.02474)		
Distance to Wells of Other Firms			-0.19904***	-0.10648**
			(0.06454)	(0.05016)
Public Status	-0.38956***	-0.40746***	-0.38847***	-0.40763***
	(0.14072)	(0.13448)	(0.14086)	(0.13465)
Log Production, T = 12m	-0.05604***	-0.05013***	-0.05962***	-0.05261***
	(0.01843)	(0.01893)	(0.01880)	(0.01915)
Log Trade Secret PP	1.93719***	2.00581***	1.93631***	2.00646***
	(0.32758)	(0.30779)	(0.32757)	(0.30767)
Log Horizontal Length	0.17226***	0.12814***	0.17222***	0.12893***
	(0.04839)	(0.04501)	(0.04835)	(0.04503)
Log True Vertical Depth	-0.13070	-0.07940	-0.13304	-0.08036
	(0.18281)	(0.18824)	(0.18131)	(0.18800)
Log Ground Elevation	-0.19513	-0.11692	-0.19357	-0.11409
	(0.16111)	(0.16352)	(0.15996)	(0.16274)
Log Water Volume	-0.29745***	-0.25706***	-0.29700***	-0.25696***
	(0.04119)	(0.04052)	(0.04096)	(0.04043)
Federal Well	0.17827	0.20216	0.17541	0.20062
	(0.13148)	(0.12845)	(0.13084)	(0.12827)
Mean Dep.Var.	-2.166	-2.168	-2.166	-2.168
Obs.	71826	71702	71826	71702
R^2	0.324	0.412	0.324	0.412
Year FE	Y		Y	
Geo FE	Y		Y	
Geo-Year FE		Y		Y

4.2 Reported Harm Intensity and Tort Litigation

To further test the mechanism, we explore whether operator's fears of being blamed for contamination in concentrated market are indeed justified. We look at both, self-reported harm by hydraulic fracturing and tort litigation related to hydraulic fracturing.

To measure reported harm by hydraulic fracturing, we use the data collected by the Pennsyl-

vania Alliance for Clean Water and Air (PACWA)[5] . PACWA's mission is to raise awareness of the dangers of hydraulic fracturing on public health and the environment. Although initially focused on Pennsylvania, the alliance collected open data on the individuals and families that have been harmed by fracking in the entire US. The sources of the data range from the self-reported harm cases documented in local media to court cases at various development stages.

Each entry contains a name of the individual or family, location at the county level, exposure type, and experienced symptoms. After deleting missing entries, the dataset contains 1014 cases. When we focus on 14 active oil and gas producing states, we get 916 cases. Importantly, in this section we do not try to separate oil- and gas-related cases, as in many states oil and gas production occurs nearby.

For each county, we calculate the total number of harm cases and normalize it by the total number of fracked wells available in FracFocus since 2014[6]. The normalization is done to control for the overall intensity of drilling. We also calculate the average operator concentration within each county.

Table 6 shows the regression results. The first specification looks at the intensive margin, by only including counties with at least 1 complaint. The second specification includes all counties, and the last specification also includes state fixed effects. We find a strong and positive relationship between market concentration and reported harm intensity.

Table 6: Reported Harm Intensity and Market Concentration

	Reported Harm Intensity		
	(1)	(2)	(3)
Operator Concentr. - HHI	0.04818***	0.02493***	0.01283**
	(0.01286)	(0.00790)	(0.00635)
Mean Dep.Var.	0.020	0.011	0.011
Obs.	142	258	258
R^2	0.146	0.062	0.248
State FE			Y

[5]https://pennsylvaniaallianceforcleanwaterandair.wordpress.com/the-list/

[6]PACWA does not have data on the exact date when the complaint was filed. Although some complaints could have been filed before 2014, the general persistence of drilling intensity still makes our exercise meaningfull.

To measure the local intensity of tort litigation involving hydraulic fracturing, we use the data from Watson (2024), who collected information on such cases as of January 2024. Watson (2024) describes 171 cases in total across all years and locations[7]. With few exceptions, plaintiffs need to file a case in the same county where the harm occurred. Given the limited size of the dataset, we perform the analysis at the sate-level and we focus on 14 oil and gas producing states. We find a positive correlation of 0.71 between market concentration and the number of cases filed; the scatter plot is shown on Figure 1.

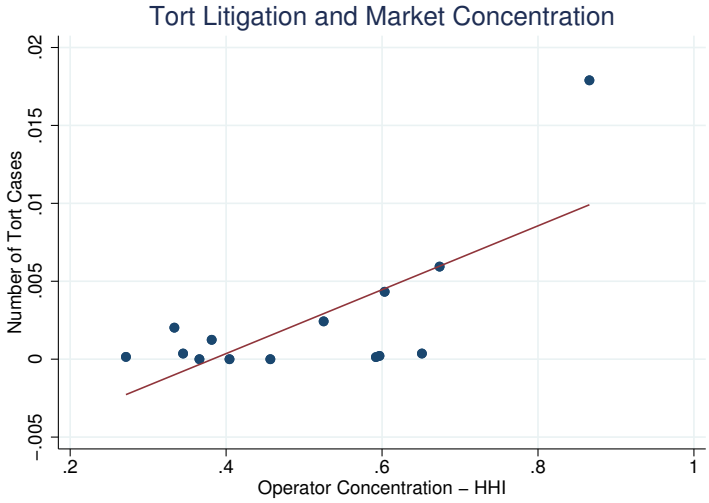
Both the reported harm and tort litigation results provide further support for our mechanism, even though none of these exercises is perfectly identified. We fully acknowledge certain limitations of each test. Self-reported harm produces only a noisy signal of actual damages and might depend on the presence of local media to pick up the story. At the same time, there is no reason to believe that people report harm differently across different states.

In contrast, tort litigation cases represent formal complaints filed in a specific location against specific firms. However, Watson (2024) dataset is likely to be incomplete. More importantly, litigation climate differs substantially across states. Traditional rule in the United States is that plaintiffs have the burden of proving their claims. However, Pennsylvania enacted a statute that if a groundwater supply located within 2,500 feet of a well become contaminated within a year after completion, there is a "rebuttable presumption" that the oil and gas operations caused the contamination. An operator can rebut this presumption, however the burden of proof now lies on the defendant, see Hall (2012). Similarly, while Colorado and Ohio require baseline pre-drilling testing of nearby water supply sources, other states only encourage it. Such differences in rules make the comparison of tort litigation intensity difficult across states.

Moreover, our mechanism implies that operators endogenously become more cautious in concentrated markets, thus making it more difficult to establish a link between market concentration and litigation outcomes.

[7]We treat all cases filed separately as individual cases, regardless of whether they were later combined into one lawsuit or kept separate.

Figure 1: Tort Litigation and Market Concentration



4.3 Additional Discussion

Land concentration by itself may influence litigation risk and affect operators' incentives to use toxic chemicals. With smaller surface land concentration, a larger number of neighbors are exposed to potential harm, increasing the likelihood of complaints and lawsuits. Conversely, greater land concentration limits the number of affected neighbors, reducing the probability of legal action. This mechanism, however, works in the opposite direction of our findings, as larger land concentration would presumably lead to less accountability and fewer incentives to reduce pollution.

5 Conclusion

Over the past few years, the oil exploration industry in the U.S. has experienced significant consolidation through mergers and acquisitions, leading to higher levels of market concentration. In this paper, we show that market concentration has the unintended effect of reducing the use of toxic chemicals in oil production.

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