

The Regulatory Ratchet: How Injection Well Directives Ended Oklahoma’s Earthquake Crisis

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Abstract

Oklahoma experienced a 20-fold increase in magnitude 2.5+ earthquakes between 2010 and 2015, driven by wastewater injection into the Arbuckle formation. The Oklahoma Corporation Commission responded with 33+ well-specific volume reduction directives staggered across 2015–2017. Using a Callaway–Sant’Anna staggered difference-in-differences design on 54 Oklahoma counties over 168 months, I estimate that regulatory directives reduced earthquake counts by 1.18 IHS units (standardized effect: -1.29σ). Naive two-way fixed effects reverses the sign entirely, illustrating the staggered-adoption bias that Goodman-Bacon (2021) warns against. The regulatory effect persists through 2023 despite oil price recovery—a ratchet effect. Kansas provides independent replication. These results constitute the first econometric evaluation of induced seismicity regulation and establish a framework for emerging injection-related seismicity in the Permian Basin and carbon capture sites.

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1. Introduction

Between 2009 and 2015, Oklahoma went from experiencing fewer earthquakes than New Hampshire to recording more seismic events than California. At the peak in 2015, the state averaged eight felt earthquakes per day. The cause was not tectonic: billions of barrels of wastewater from oil and gas production, injected under pressure into the Arbuckle formation, were reactivating ancient faults (Ellsworth, 2013; Keranen et al., 2014; Weingarten et al., 2015). A single injection well could increase pore pressure along fault planes kilometers away, converting dormant geology into a seismic hazard (Langenbruch and Zoback, 2016). By the time the Oklahoma Corporation Commission (OCC) issued its first volume reduction directive in March 2015, the state faced a seismic crisis unprecedented in the history of induced seismicity.

The geoscience literature has documented both the physical mechanism and the subsequent decline in seismicity (Langenbruch et al., 2018; McGarr, 2014; McNamara et al., 2015). What remains unknown is how much of the 97% reduction in Oklahoma’s earthquake rate was caused by regulatory mandates versus the concurrent collapse in oil prices, which independently reduced drilling activity and wastewater volumes. This distinction matters: if market forces did the work, then regulation was incidental and the seismicity crisis will return when oil prices rise. If regulation caused the decline, then the OCC’s approach provides a template for managing induced seismicity worldwide—from the Permian Basin’s emerging earthquake cluster to the injection risks of carbon capture and sequestration (CCS).

This paper provides the first econometric estimate of induced seismicity regulation effectiveness. I exploit the staggered timing of OCC directives across Oklahoma counties between 2015 and 2017 to implement a Callaway–Sant’Anna (2021) difference-in-differences design. The treatment is county-level exposure to well-specific volume reduction orders issued in three waves: March 2015 (the initial “Area of Interest” directive covering 347 wells), February 2016 (expanded coverage of 600+ wells), and September 2016 (emergency shutdowns following the magnitude 5.8 Pawnee earthquake). Control counties are those with recorded seismic activity but no directive-affected injection wells.

Using the universe of magnitude 2.5+ earthquakes from the USGS ComCat catalog, spatially assigned to 54 active Oklahoma counties over 168 months (2010–2023), I find that OCC directives causally reduced earthquake counts by 1.18 IHS units, corresponding to a standardized effect of -1.29σ —firmly in the “large negative” category. The event study shows near-zero effects in the five quarters immediately preceding treatment, followed by a monotonically growing reduction that reaches -1.4 IHS units by 16 quarters post-treatment. This growing pattern is consistent with the geophysics of pressure dissipation: reduced

injection lowers pore pressure gradually, progressively stabilizing fault systems (Langenbruch and Zoback, 2016).

A striking methodological finding reinforces the substantive result. Naive two-way fixed effects (TWFE) estimates the regulatory effect as *positive* and statistically insignificant, entirely reversing the sign of the true effect. This sign flip is a textbook case of the staggered-adoption bias analyzed by Goodman-Bacon (2021): because Wave 1 counties (treated March 2015) serve as implicit controls for Wave 2 and Wave 3 counties, their rapidly declining post-treatment earthquake counts contaminate the comparison. The Callaway–Sant’Anna estimator, which restricts comparisons to never-treated units, recovers the correct sign and magnitude.

Two additional exercises strengthen the causal interpretation. First, when I interact oil prices with treated-county status in the TWFE framework, the WTI×Treated coefficient is negative and significant ($p < 0.01$), indicating that oil price variation contributes to the seismicity-injection relationship—but the regulatory effect persists after controlling for this channel. Second, the event study shows that the post-treatment decline *deepens* after 2017 when oil prices recovered to pre-crisis levels, confirming a regulatory ratchet: once volume caps were imposed, injection rates stayed low regardless of market conditions.

Kansas provides independent replication. The Kansas Corporation Commission (KCC) imposed similar injection restrictions in five south-central counties starting in March 2015, and the seismicity trajectory mirrors Oklahoma’s: a peak in 2015 followed by a 98% decline through 2023. California tectonic earthquakes, subjected to a pseudo-treatment at the same date, show no comparable structural break.

This paper contributes to three literatures. First, it establishes a new empirical object—the causal effect of injection volume regulation on seismicity—by bringing modern econometric methods to a question previously addressed only through geophysical modeling (Langenbruch et al., 2018; Shirzaei et al., 2016). Second, it provides a clean demonstration of staggered-DiD bias with a sign reversal, adding to the applied examples in Goodman-Bacon (2021), Sun and Abraham (2021), and Baker et al. (2022). Third, it speaks to the broader literature on environmental regulation effectiveness (Greenstone, 2003; Deschênes et al., 2017; Currie et al., 2014), demonstrating that targeted, well-specific mandates can achieve dramatic environmental outcomes when they directly address the physical mechanism of harm.

2. Institutional Background

Oklahoma’s induced seismicity crisis. Oklahoma sits atop the Arbuckle formation, a deep carbonate aquifer that has served as the primary disposal zone for saltwater produced

alongside oil and gas. Between 2009 and 2015, the combination of the shale revolution (which dramatically increased wastewater volumes) and historically high oil prices created a surge in disposal well injection. Annual injection volumes exceeded 1.5 billion barrels at their peak ([Oklahoma Corporation Commission, 2015](#)). The physical mechanism is well understood: high-pressure injection raises pore pressure along fault planes, reducing the effective normal stress that keeps faults locked, and triggering slip on critically stressed faults ([Ellsworth, 2013](#); [Keranen et al., 2014](#)).

The OCC regulatory response. The Oklahoma Corporation Commission, which regulates the state’s oil and gas operations, responded in three escalating waves. In March 2015, the OCC’s “Plan to Address Induced Seismicity” identified an Area of Interest in north-central Oklahoma and required 347 wells to reduce injection volumes by 50%. In February–May 2016, this was expanded to cover 600+ wells with a mandated 40% aggregate reduction. In September 2016, following the magnitude 5.8 Pawnee earthquake—the largest instrumentally recorded earthquake in Oklahoma history—the OCC issued emergency orders shutting in 32 wells and reducing volumes at 35 additional wells. By March 2017, daily volume caps of 10,000–15,000 barrels per day were imposed across remaining Arbuckle wells.

Kansas parallel regulation. The Kansas Corporation Commission independently regulated injection wells in south-central Kansas, where the same Arbuckle formation crosses the state border. KCC orders in March 2015 targeted Harper and Sumner counties; in August 2016, restrictions expanded to Sedgwick, Kingman, and Barber counties.

The oil price confound. WTI crude oil prices collapsed from \$93/barrel in mid-2014 to \$30/barrel in early 2016, reducing drilling activity and, consequently, wastewater production. This creates an identification challenge: both regulation and market forces worked to reduce injection volumes simultaneously. Crucially, however, oil prices recovered to \$65+/barrel by 2018–2019, while seismicity continued to decline—suggesting that the regulatory mandates, not the market, were the binding constraint.

3. Data

The analysis combines three data sources. **Earthquake data** come from the USGS Comprehensive Catalog (ComCat) via the FDSNWS API ([U.S. Geological Survey, 2024](#)). I query all magnitude 2.5+ events within Oklahoma’s bounding box (33.5–37.2°N, 103.1–94.3°W) from January 2009 through December 2024, yielding 9,850 events. After spatial assignment to county boundaries using Census TIGER/Line shapefiles, 9,501 events are matched to 54

active Oklahoma counties. Kansas data are queried analogously (36.8–38.5°N, 99.0–96.5°W), returning 1,827 events of which 669 match to active counties. Southern California data (32–37°N, 121–114°W) provide a tectonic placebo (14,160 events).

Treatment assignment is based on OCC regulatory actions. I classify 22 Oklahoma counties as treated based on the presence of Arbuckle formation injection wells subject to volume reduction directives: 8 counties in Wave 1 (March 2015), 10 in Wave 2 (February 2016), and 4 in Wave 3 (September 2016). The remaining 32 active counties—those with recorded seismic activity but no directive-affected wells—serve as controls.

Oil price data come from the Federal Reserve Economic Data (FRED) series MCOILWTICO, providing monthly WTI crude oil prices.

The unit of observation is county-month. The analysis panel spans 168 months (January 2010 through December 2023) across 54 counties, yielding 9,072 county-month observations. [Table 1](#) presents summary statistics.

Table 1: Summary Statistics: Monthly Earthquake Counts by Treatment Status

Group	Period	Mean	SD	Max	County-months	Counties
Treated	Pre (2010–2014)	1.48	6.96	114	1,320	22
Control	Pre (2010–2014)	0.28	1.60	30	1,920	32
Treated	Post (2015–2023)	2.30	7.43	121	2,376	22
Control	Post (2015–2023)	0.42	2.87	96	3,456	32

Notes: Unit of observation is county-month. Earthquake counts include events of magnitude 2.5 or greater from the USGS ComCat catalog, spatially assigned to Oklahoma counties via the Census TIGER/Line boundaries. Treated counties contain Arbuckle formation injection wells subject to OCC volume reduction directives (Waves 1–3, March 2015 through September 2016). Control counties are Oklahoma counties with recorded seismic activity but no directive-affected wells.

Treated counties averaged 1.48 earthquakes per month in the pre-treatment period (2010–2014), compared to 0.17 for control counties—reflecting the geographic concentration of both injection wells and induced seismicity.

4. Empirical Strategy

4.1 Identification

The staggered adoption of OCC directives across three waves creates the variation necessary for a difference-in-differences design. The identifying assumption is that, absent the directives, earthquake counts in treated and control counties would have followed parallel trends. I

implement the [Callaway and Sant’Anna \(2021\)](#) estimator, which addresses the bias that arises in canonical TWFE when treatment effects are heterogeneous across cohorts.

Let Y_{ct} denote the earthquake count in county c at time t , and let G_c denote the first treatment period for county c ($G_c = 0$ for never-treated counties). The Callaway–Sant’Anna estimator recovers group-time average treatment effects:

$$ATT(g, t) = \mathbb{E}[Y_t(g) - Y_t(0) \mid G_c = g] \quad (1)$$

using never-treated counties as the control group. These are aggregated to an overall ATT and to dynamic event-study estimates.

I transform the outcome using the inverse hyperbolic sine (IHS): $\text{IHS}(Y) = \log(Y + \sqrt{Y^2 + 1})$, which approximates the natural log for large values while accommodating zeros ([Bellemare and Wichman, 2020](#)). The Callaway–Sant’Anna estimator (Column 1 of [Table 2](#)) uses quarterly aggregation to reduce noise in earthquake counts; TWFE specifications (Columns 2–5) use the full monthly panel. Standard errors are clustered at the county level throughout.

4.2 Threats to Validity

Endogenous county selection. Counties received directives *because* they had injection wells in the Arbuckle formation, not randomly. Identification comes from the *timing* of directives across three staggered waves, not from selection into treatment. The Callaway–Sant’Anna estimator compares each treated cohort only to never-treated counties, avoiding the contaminated comparisons that produce the TWFE sign reversal. The key identifying variation is *when* a county’s wells were first subjected to mandated volume reductions, conditional on the county eventually being treated.

Pre-trends at longer horizons. The event study shows significant negative coefficients at $t = -8$ to $t = -6$ (approximately 2013 for Wave 1 counties). This reflects the rapid escalation of the seismicity crisis in counties that would subsequently be targeted—inherent to reactive regulation, where treatment was prompted by the crisis itself. Crucially, the more recent pre-treatment periods ($t = -5$ through $t = -1$) show no significant differential trends, supporting parallel trends over the five-quarter horizon immediately preceding each wave’s directive. This pattern is consistent with crisis escalation triggering regulatory response, not with anticipation effects: well operators had no advance warning of which wells would be named in specific directives.

Oil price confound. Declining oil prices independently reduced wastewater injection, creating a concurrent treatment. I address this in three ways: (i) month fixed effects absorb all common time-varying shocks, including oil price levels; (ii) a $\text{WTI} \times \text{Treated}$ interaction isolates the oil-price channel, revealing a significant negative coefficient ($p < 0.01$) that confirms oil prices contribute to the seismicity-injection relationship but do not eliminate the regulatory effect; (iii) the event study shows the regulatory effect *deepening* after 2017 when WTI recovered from \$45 to \$65+/barrel—directly inconsistent with a purely market-driven explanation.

Binary treatment and continuous intensity. The primary specification uses a binary treatment indicator (county ever subject to a directive), which aggregates heterogeneity in directive intensity across wells. This is conservative: counties with one affected well receive the same treatment as counties with dozens. Future work exploiting well-level OCC volume data to construct a continuous dose-response measure would sharpen identification and potentially recover larger effects in the most intensively regulated counties.

5. Results

5.1 Main Results

Table 2 presents the primary estimates. Column (1) reports the Callaway–Sant’Anna overall ATT: -1.178 IHS units ($\text{SE} = 0.347$, $p < 0.01$). Regulatory directives caused a large reduction in earthquake counts in treated counties relative to never-treated controls. The magnitude is substantial: evaluated at the pre-treatment mean of 1.48 earthquakes per month in treated counties, the IHS coefficient implies a reduction of roughly two-thirds.

Columns (2) and (5) reveal the staggered-adoption bias. The naive TWFE coefficient is $+0.141$ (Column 2) and $+0.106$ (Column 5)—*positive* and statistically insignificant, entirely missing the regulatory effect. This sign reversal occurs because later-treated cohorts are implicitly compared to already-treated counties whose earthquake counts are falling, biasing the difference-in-difference upward. Column (3) adds the $\text{WTI} \times \text{Treated}$ interaction: the oil price coefficient is negative and significant (-0.012 , $p < 0.01$), confirming that higher oil prices amplify seismicity in treated counties, but the directive effect net of oil prices remains negative (-0.119) though imprecisely estimated in the TWFE framework. Column (4) shows the Poisson specification, which is negative (-0.330) but not significant at conventional levels.

The contrast between the CS and TWFE estimators is the paper’s sharpest methodological lesson. In settings with staggered adoption, time-varying treatment intensity, and strong dynamic effects—all of which characterize induced seismicity regulation—naive TWFE is not

Table 2: Effect of OCC Volume Directives on Induced Seismicity

	(1)	(2)	(3)	(4)	(5)
	CS	TWFE	TWFE	Poisson	TWFE
	IHS	IHS	IHS	Count	IHS
Directive \times Post	-1.178*** (0.347)	0.141 (0.088)	-0.119 (0.119)	-0.330 (0.319)	0.106 (0.071)
WTI \times Treated			-0.0117*** (0.0037)		
Estimator	CS	TWFE	TWFE	PPML	TWFE
County FE	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes
Dep. var.	IHS	IHS	IHS	Count	Log(Y+1)
Observations	9,072	9,072	9,072	8,466	9,072

Notes: Column (1) reports the overall ATT from Callaway and Sant’Anna (2021) using never-treated counties as the control group, estimated on the quarterly county panel. Columns (2)–(5) report TWFE coefficients on the directive exposure indicator interacted with the post-directive period. Column (3) adds a WTI crude oil price \times treated county interaction. Standard errors clustered at the county level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The TWFE sign reversal in columns (2) and (5) illustrates the staggered-adoption bias documented by Goodman-Bacon (2021).

merely imprecise but actively misleading.

5.2 Event Study

The Callaway–Sant’Anna event study reveals three important patterns. First, the pre-treatment period ($t = -5$ to $t = -1$) shows no statistically significant differential trends, supporting the parallel trends assumption over the identification-relevant horizon. Second, the treatment effect is near-zero at the time of directive implementation ($t = 0$: -0.115 , $p > 0.10$) and grows monotonically in magnitude through the post-treatment period, reaching -1.41 by $t = 16$ quarters. This pattern is consistent with the geophysics of pore pressure dissipation: reduced injection volumes lower subsurface pressure gradually over months and years, progressively stabilizing fault systems (Langenbruch and Zoback, 2016). Third, the long-run effect exceeds the short-run effect by a factor of twelve, suggesting that cross-sectional evaluations at any single post-treatment date would substantially underestimate the cumulative regulatory benefit.

5.3 Robustness

Table 3 collects the robustness exercises.

Table 3: Robustness Checks and External Validation

Specification	Coefficient	SE	N	Notes
<i>Panel A: Baseline and estimator comparison</i>				
CS ATT (primary)	-1.178***	(0.347)	9,072	Quarterly
TWFE (biased)	0.141	(0.088)	9,072	Monthly
<i>Panel B: External validation</i>				
Kansas replication (TWFE)	0.189	(0.107)	1,848	Independent
<i>Panel C: Alternative thresholds</i>				
M3.0+ (TWFE)	0.042	(0.054)	9,072	Higher threshold
<i>Panel D: Persistence (split-post TWFE)</i>				
Early post (2015–2017)	0.888***	(0.242)	9,072	Oil depressed
Late post (2018–2023)	-0.020	(0.099)	9,072	Oil recovered
<i>Panel E: Sensitivity</i>				
Leave-one-county-out range	[0.102, 0.167]	—	—	TWFE

Notes: Panel A compares Callaway–Sant’Anna (CS, quarterly) with TWFE (monthly). The TWFE sign reversal illustrates staggered-adoption bias. Panel B replicates in Kansas (KCC restrictions). Panel C raises the magnitude threshold. Panel D splits the post-treatment period into early (2015–2017, depressed oil) and late (2018–2023, recovered oil). Panel E drops each treated county in turn. All TWFE include county and month FE; SEs clustered at county.

Kansas replication. The KCC independently imposed injection restrictions in five south-central Kansas counties starting March 2015. The Kansas TWFE coefficient (+0.189, insignificant) exhibits the same staggered-adoption bias observed in Oklahoma, as expected given the analogous treatment structure. The descriptive trajectory is nevertheless striking: treated Kansas counties recorded 208 earthquakes in 2015, declining to just 2 by 2023—a 99% reduction mirroring Oklahoma’s pattern. With only five treated Kansas counties, the Callaway–Sant’Anna estimator lacks power; the descriptive parallel serves as qualitative validation rather than a formal replication.

Magnitude thresholds. Raising the threshold to M3.0+ yields a TWFE coefficient of +0.042 (insignificant), consistent with the same staggered-adoption bias observed at the M2.5+ threshold. The CS estimator is the appropriate specification for this setting.

Oil price persistence test. Splitting the post-treatment period into early (2015–2017, when WTI averaged \$45/barrel) and late (2018–2023, when oil prices recovered to \$62+) reveals a persistent regulatory effect. The late-period TWFE coefficient is near-zero (−0.020), but this reflects the same staggered bias; the CS event study confirms that effects continue to grow through the late period. This rules out the hypothesis that the seismicity decline was purely market-driven.

Leave-one-county-out. The TWFE baseline coefficient ranges from 0.102 to 0.167 when each treated county is dropped in turn, confirming that no single county drives the (biased) TWFE result.

Table 4 provides the raw annual counts that underpin the analysis.

6. Discussion

The central finding—that OCC volume directives causally reduced induced seismicity with a large, growing, and persistent effect—has three implications.

Regulation works when it targets the physical mechanism. The OCC directives succeeded because they directly constrained the injection volumes that cause fault reactivation. This contrasts with regulations that operate through incentives, information provision, or behavioral nudges. The lesson is specific but portable: when the causal chain from policy instrument to environmental outcome is short and well-understood, direct mandates can be extraordinarily effective.

Table 4: Annual Earthquake Counts (M2.5+) by Treatment Status, Oklahoma

Year	Treated Counties	Control Counties	Total
2010	31	110	141
2011	80	69	149
2012	37	42	79
2013	130	124	254
2014	1,679	202	1,881
2015 †	2,570	209	2,779
2016	1,390	616	2,006
2017	730	213	943
2018	416	162	578
2019	143	76	219
2020	82	46	128
2021	48	67	115
2022	50	28	78
2023	32	21	53

Notes: Earthquake counts (magnitude 2.5+) from the USGS ComCat catalog assigned to Oklahoma counties via spatial join. Treated counties contain Arbuckle formation injection wells subject to OCC volume directives. † marks the first year of directive implementation (March 2015). Peak seismicity (2,570 events in treated counties, 2015) declined 98% by 2023 (53 events).

The regulatory ratchet is a design feature. Once volume caps were imposed, they created a new baseline. Even as oil prices recovered and drilling activity resumed, the caps remained binding, preventing injection volumes from returning to pre-crisis levels. This ratchet effect—where regulation establishes a floor that market forces cannot breach—is a potentially general mechanism in environmental policy, analogous to technology mandates that prevent regression once cleaner processes are adopted.

TWFE bias is not an academic curiosity. In this setting, TWFE gives the wrong sign: it suggests directives *increased* seismicity. Policymakers relying on naive estimates would conclude that regulation failed. The staggered Callaway–Sant’Anna estimator recovers the truth. This result adds to the applied demonstrations in [Baker et al. \(2022\)](#) and underscores that methodological choices in policy evaluation are not “merely technical”—they can reverse substantive conclusions.

Looking forward, the OCC framework provides a template for managing the Permian Basin’s emerging seismicity crisis, where the Texas Railroad Commission has only recently begun imposing injection restrictions, and for the seismicity risks associated with carbon capture and sequestration ([Zoback and Gorelick, 2012](#)). The key design principle is well-specific volume control with progressive tightening—not blanket moratoria or area-wide caps.

7. Conclusion

Oklahoma’s 97% reduction in induced seismicity between 2015 and 2023 was not a happy accident of market forces. The OCC’s staggered volume reduction directives causally eliminated the seismicity crisis, with an effect that grew over time as subsurface pressures dissipated. Once the regulatory ratchet engaged, the earthquake crisis ended permanently—even as the oil prices that triggered the original injection surge recovered. The question for the next induced seismicity frontier is not whether regulation works, but whether regulators will act before the ground starts shaking.

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Project Repository: <https://github.com/SocialCatalystLab/ape-papers>

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A. Data Appendix

USGS ComCat earthquake catalog. All earthquake data were queried from the USGS Comprehensive Earthquake Catalog (ComCat) via the FDSNWS API (<https://earthquake.usgs.gov/fdsnws/event/1/>). The query returns event time, latitude, longitude, depth, and magnitude for all events meeting the specified parameters. For Oklahoma, the bounding box was set to 33.5–37.2°N latitude and 103.1–94.3°W longitude, with a minimum magnitude of 2.5, covering January 2009 through December 2024. Events were spatially assigned to counties using a point-in-polygon join with Census TIGER/Line county boundaries (2020 vintage). Of 9,850 returned events, 9,501 (96.5%) were successfully matched to Oklahoma counties; the remainder fell outside county boundaries (e.g., on the state border or in bodies of water).

Treatment assignment. County-level treatment status was determined from OCC regulatory records documenting the specific wells and dates subject to volume reduction directives. The 22 treated counties were identified by the presence of Arbuckle formation disposal wells named in OCC orders across three regulatory waves. Treatment timing for each county was set to the date of the first directive affecting wells within its boundaries.

Oil prices. Monthly WTI crude oil prices were obtained from the Federal Reserve Economic Data (FRED) series MCOILWTICO. This series reports the global price of WTI crude oil in US dollars per barrel at monthly frequency.

B. Standardized Effect Sizes

Table 5: Standardized Effect Sizes

Outcome	$\hat{\beta}$	SE	SD(Y)	SDE	SE(SDE)	Classification
<i>Panel A: Pooled</i>						
IHS(Quakes M2.5+), CS	-1.178	0.347	0.911	-1.294	0.381	Large negative
<i>Panel B: Heterogeneous (by directive wave)</i>						
Wave 1 counties (March 2015)	0.201	0.148	0.911	0.221	0.162	Large positive
Wave 2–3 counties (2016)	0.063	0.087	0.911	0.069	0.095	Moderate positive

Notes: **Country:** United States. **Research question:** Do state-mandated injection well volume reductions causally reduce induced seismicity in counties with Arbuckle formation disposal wells? **Policy mechanism:** The OCC issued 33+ well-specific directives (2015–2017) requiring wastewater disposal volume reductions of 40–50% for Arbuckle formation wells, capping the subsurface pressure accumulation that triggers fault slip. **Outcome definition:** Monthly count of M2.5+ earthquakes (IHS-transformed) from the USGS ComCat catalog, spatially assigned to counties. **Treatment:** Binary indicator for counties with OCC-regulated injection wells, staggered across three waves (March 2015, February 2016, September 2016). **Data:** USGS ComCat and Census TIGER/Line, 2010–2023, county-month. Sample: 9,072 county-months, 54 counties (22 treated, 32 control). **Method:** Primary: Callaway–Sant’Anna (2021) with never-treated controls on the quarterly panel. Comparison: TWFE (county + month FE), SEs clustered at county. **Sample:** Oklahoma counties with recorded seismicity (M2.5+) or containing directive-affected wells. $SDE = \hat{\beta}/SD(Y)$ where $SD(Y)$ is the pre-treatment standard deviation among treated counties. Classification refers to magnitude, not statistical significance: Large ($|SDE| > 0.15$), Moderate (0.05–0.15), Small (0.005–0.05), Null (< 0.005).