NBER WORKING PAPER SERIES

WHEN DO ENVIRONMENTAL EXTERNALITIES HAVE ELECTORAL CONSEQUENCES?
EVIDENCE FROM FRACKING

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Working Paper 28857
<http://www.nber.org/papers/w28857>

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
May 2021

I am grateful to workshop participants at the NBER Summer Institute, Yale University, Duke University, North Carolina State University, UC Davis, Stanford University, the AERE Summer Conference, the Workshop in Environmental Economics and Data Science (TWEEDS), and the ASSA Annual Meeting; as well as Edson Severnini, Mark Jacobsen, Julie Cullen, Richard Carson, Teevrat Garg, and Megan Mullin. Wesley Howden provided excellent research assistance. The views expressed herein are those of the author and do not necessarily reflect the views of the National Bureau of Economic Research.

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When Do Environmental Externalities Have Electoral Consequences? Evidence from Fracking
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NBER Working Paper No. 28857
May 2021
JEL No. D72,H11,Q35,Q58

ABSTRACT

The electoral salience of some issues may diminish when one politician has authority over many policy areas. This study measures the role of environmental regulation in concurrent elections for governors and specialized energy regulators in two U.S. states. I first show that while both offices can influence environmental and energy policies, quantitative analysis of campaign news coverage reveals clear differences in the importance of these issues in the two races. Next, I use geologic variation in earthquakes caused by oil and gas production to measure the electoral consequences of a costly environmental externality. There are measurable effects only in the energy regulator race. These results are consistent with theories of issue bundling. Finally, the unbundling effects that I measure appear to be themselves limited by voter attentiveness and partisanship.

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In principle, the regulation of externalities in a democracy is subject to electoral discipline. Yet the degree to which voters actually hold elected officials accountable for the perceived quality of environmental regulation is an open question. Do theories of retrospective voting advanced by Key (1966), Fiorina (1981), and Ferejohn (1986) extend to environmental issues or do voters focus scarce attention on other issues? Does exposure to costly environmental externalities affect voters' choices in partisan races, or do party labels continue to dominate other factors? Such questions are central to the political economy of environmental regulation.

Various theories have been proposed for how imperfect information, limited attention, cognitive biases among voters, and other factors may soften electoral accountability.¹ One well-known case arises when voters choose one politician to represent their interests in many policy areas (“issue bundling”). Besley and Coate (2003, 2008) propose a model where generalist politicians face limited electoral consequences for their handling of “secondary” issues, while these topics play a larger role in elections for more specialized offices with fewer competing issues. More recent work considers how the accountability benefits of unbundling electoral decisions into multiple specialized races may depend on voter attentiveness, partisan polarization, and other factors (Berry and Gersen 2009, 2011; Augenblick and Nicholson 2015; Lim and Snyder 2015). Several empirical studies provide indirect tests of these theories by comparing policy outcomes (such as the stringency of utility rate regulation) across jurisdictions with different degrees of specialization among elected officials (Besley and Coate 2003; Mullin 2008; Hauge, Jamison, and Prieger 2012).² But there is little direct evidence from actual voting behavior on how bundling affects the electoral salience of particular issues.

This study approaches these questions through the lens of energy regulation

1. See Kramer (1971), Barro (1973), Fair (1978), Ferejohn (1986), and additional studies reviewed in Healy and Malhotra (2013).

2. A separate literature compares policy outcomes in systems with elected politicians vs. non-elected bureaucrats, holding constant the degree of functional specialization (Maskin and Tirole 2004; Lim 2013; Whalley 2013; Hessami 2018).

in the U.S. states of Oklahoma and Texas. Statewide elections in both states include a specialized energy regulator race alongside the races for governor and other generalist offices. This setting allows me to observe the role of energy and environmental issues in concurrent races with differing numbers of competing issues. In addition to providing descriptive evidence of the role of environmental issues in general, the empirical analysis focuses on the response to a new externality: earthquakes caused by underground disposal of wastewater from oil and gas production. As I show using data on insurance takeup, the emergence of this new externality has imposed meaningful costs in the most-affected areas. These costs are further substantiated by hedonic studies that find fracking-related earthquakes decrease house prices by several percentage points or more (Koster and van Ommeren 2015; Metz, Roach, and Williams 2017; Cheung, Wetherell, and Whitaker 2018; Ferreira, Liu, and Brewer 2018; Gibbons, Heblich, and Timmins 2021; Burnett and Mothorpe 2021).

Fracking-related earthquake risk provides an unusually good opportunity for empirical analysis. First, governors and elected energy regulators both have authority to affect the stringency of earthquake regulation. The energy regulators – the Oklahoma Corporation Commission (OCC) and Texas Railroad Commission (TRC) – can directly regulate wastewater disposal. Governors can exercise influence through appointments such as the Oklahoma Secretary of Energy and the Environment and the Texas Commission on Environmental Quality, and by exercising their broader convening power.³ Second, unlike typical pollution externalities, induced seismicity is unlikely to be endogenously determined with respect to local political and economic factors. While oil and gas drilling happens throughout Oklahoma and Texas, susceptibility to fracking-related earthquakes depends on local geological factors that were essentially unknown prior to about 2013. This reduces the importance of omitted variables concerns that arise when considering the electoral effects of $\text{PM}_{2.5}$, NO_x , or other commonly-considered air and water pollutants.

3. For example, former Oklahoma governor Mary Fallin established a Coordinating Council on Seismic Activity that included the Secretary of Energy and the Environment, the Oklahoma Geologic Survey, the OCC, state legislators, and industry representatives.

From a geographic perspective, Oklahoma and Texas are inherently interesting places to examine the electoral significance of energy and environmental issues. They are representative of the Republican-dominated states that control a disproportionate share of the United States' energy production, as well as electoral votes and U.S. Senate seats. The fracking boom has generated tremendous wealth in these states at the same time that it has introduced large local disamenities (Muehlenbachs, Spiller, and Timmins 2015; Currie, Greenstone, and Meckel 2017; Bartik et al. 2019). Because most onshore oil and gas reserves in the United States are on private land, state-level regulations are of primary importance in controlling production and trading off these economic benefits and local externalities.

The paper combines text analysis of campaign news coverage with traditional regression analysis of election outcomes. The first part of the paper analyzes the role of environmental issues in the 2018 campaigns for governor and energy regulator. I apply methods for quantitative text analysis to a collection of local newspaper articles. This exercise reveals the relative prominence of various issues in the race for each office. The gubernatorial campaigns focused on education, budget balance, healthcare, and the economy. There is no indication that either candidate for governor believed environmental issues or earthquake regulation to be important to voters in that race. In contrast, the energy regulator races focused heavily on oil and gas regulation, including induced seismicity. In Oklahoma, phrases related to earthquakes, other environmental issues, and the oil and gas industry were 110, 18, and 12 times more common in coverage of the OCC race than the governor race. Moreover, the candidates for energy regulator had clearly differentiated positions. The Democratic OCC candidate focused more heavily on earthquake regulation while the Republican incumbent instead emphasized economic messages.

The second part of the paper measures voters' responses to fracking-related earthquakes using elections data. Whether this new externality would have led self-interested voters to prefer stricter regulation is *ex ante* ambiguous, since that decision depends on the perceived costs of regulation as well as its

benefits. I do not impose any assumption about which candidates would have best served voters' interests. Instead, I let the data reveal whether the issue affected election outcomes in either direction in each race.

The analysis of election outcomes first considers the energy regulator races (OCC and TRC). The empirical design here takes advantage of the electoral institutions in these two states by measuring how the difference in outcomes between energy regulator and other downballot executive races (e.g., Labor Commissioner, Agriculture Commissioner) varies along the earthquake exposure gradient. This differencing design aids identification and substantially improves precision by purging unobserved heterogeneity across precincts. I find small but clearly measurable effects of induced seismicity on candidate vote share and undervote (the share of ballots left blank for energy regulator). These effects are limited to Oklahoma, where earthquake experience was particularly acute. In the precincts with the most severe shaking, induced seismicity appears to have reduced the vote share for the Republican OCC candidate by about 1.5 percentage points and reduced undervote about one-fourth of one percentage point (a 15% reduction).

These effects may appear modest given the costs of the externality revealed in hedonic studies and the narrow policy portfolio of Corporation Commissioner. Such muted effects may reflect limitations on issue unbundling in partisan races. Given attention constraints, adding many low-information races to the ballot can lead voters to rely even more heavily than usual on party labels in these races. Lim and Snyder (2015) document this effect in partisan judicial races in the United States.⁴ My data show that precinct-level party vote shares for OCC or TRC are almost perfectly predicted by vote shares in other downballot executive races unrelated to earthquakes and the environment. A simple bivariate regression of Republican vote share for OCC or TRC on vote shares in these other low-information races has an R-squared of 0.98.

Lastly, I consider the effect of exposure to induced seismicity on overall turnout

4. See also the recent review piece by the same authors describing additional studies on this question (Lim and Snyder 2021).

and party vote shares for governor. The differencing estimator used for the downballot energy regulator offices is not applicable here because of the lack of a contemporaneous comparison group for these top-level outcomes. I present estimates from three other approaches: a regression-adjusted cross-sectional gradient with respect to earthquake exposure; matching estimates that compare observationally similar voters in more- and less-affected areas; and county-level panel estimates that compare outcomes across historical elections. Across these various designs, there is no evidence of effects on participation in the election or on candidate choice for governor. Thus, but for the unusual inclusion of a specialized energy regulator race in these states, there would have been scant evidence that voters cared about earthquakes at all, either in news coverage of the campaigns or in election outcomes.

This study is related to an economic and political science literature on voting and the environment. Many of these studies have considered environmentally-oriented ballot initiatives, which often address land preservation, infrastructure, and other public goods (Deacon and Shapiro 1975; Kahn and Matsusaka 1997; Kotchen and Powers 2006; Burkhardt and Chan 2017; Anderson, Marinescu, and Shor 2019; Hazlett and Mildenberger 2020). This paper, in contrast, is one of a small number of studies examining partisan races for elected office. List and Sturm (2006) consider the role of environmental policy in U.S. gubernatorial elections using state-level data on environment and natural resources spending. The authors propose that governors facing close re-election races may adjust environmental spending to win over small numbers of “single issue voters” who disproportionately prioritize environment, while these issues remain inconsequential to most voters. Stokes (2016) documents voter backlash against renewable energy infrastructure in Canada.⁵

This paper makes several contributions. It presents the first evidence of the

5. Another strand of work uses natural disasters as an empirical tool to understand whether voters irrationally punish politicians for acts of nature and/or reward them for providing generous post-disaster aid (Healy and Malhotra 2009; Bechtel and Hainmueller 2011; Gasper and Reeves 2011; Cole, Healy, and Werker 2012; Chen 2013). While earthquakes also feature in the present study, these are human-caused events related to industrial activity, as opposed to random natural disasters.

importance of environmental issues in elections for generalist and functionally-specialized offices in the same election. The results add to our limited understanding of the electoral salience of environmental policy. More broadly, they extend an empirical literature that seeks to resolve competing theoretical predictions about issue bundling. From a methodological perspective, the paper applies emerging empirical tools for text analysis. Finally, it is one of a small number of studies that apply quasi-experimental methods to develop casually-identified estimates of the electoral effects of pollution exposure.

The paper proceeds as follows. Section 1 describes state-level oil and gas regulation and the problem of induced seismicity. Section 2 describes the data and Section 3 describes the empirical strategy. Section 4 presents and discusses the results and Section 5 concludes.

1 Background

This section describes oil and gas regulation in Oklahoma and Texas (Section 1.1) and the issue of manmade earthquakes due to oil and gas wastewater disposal (Section 1.2).

1.1 State-level Oil and Gas Regulation

The large majority of oil and natural gas production in the United States – 76% of crude oil and 87% of natural gas in 2017 – occurs on private or state lands and is thus governed by state-level regulatory commissions.⁶ These commissions manage most aspects of drilling and production. They play key roles in determining environmental and safety rules, enforcing those rules through site inspections and penalty hearings, resolving common pool externalities, and permitting new drilling. Given this important role, there is a surprisingly

6. Production totals are from Congressional Research Service, “U.S. Crude Oil and Natural Gas Production in Federal and Nonfederal Areas”, CRS Report R42432, Updated October 23, 2018.

limited amount of research on the political economy of state-level oil and gas regulation.

Texas and Oklahoma, the first- and fourth-highest oil-producing states, both choose their oil and gas regulators via popular election (as opposed to other states where these are appointed positions). The Texas Railroad Commission (TRC) and the Oklahoma Corporation Commission (OCC) each consist of three members elected to six-year terms. These terms are staggered so that one seat is contested in each November general election. In Texas, the TRC regulates the oil and gas industry, natural gas utilities, pipelines, and coal and uranium mining. In Oklahoma, the OCC regulates oil and gas extraction and serves as the public utilities commission. The governors of both states have parallel responsibility to enforce additional environmental rules affecting the industry (for example, through appointments to the Texas Commission on Environmental Quality or the Oklahoma Secretary of Energy and the Environment).

Despite receiving less attention than gubernatorial races or close Congressional contests, the energy regulator races in both states attract significant campaign effort and money. In Texas, total contributions in the 2018 TRC race were \$6.2 million, compared to \$18.7 million for Attorney General and \$82.3 million for governor. In Oklahoma, contributions were \$1.4 million for OCC, \$6.4 million for Attorney General, and \$23.8 million for governor.⁷

The state governments of Texas and Oklahoma include a number of other directly-elected executive officers.⁸ All of these races are contested in the regular November statewide elections. These are partisan races; candidates' political party affiliations are listed on the ballot and the major party candidates are selected via party-specific primary elections. During the study

7. Campaign contribution data are reported by the National Institute on Money in Politics and are available from www.FollowTheMoney.org.

8. Oklahoma: Governor, Lieutenant Governor, Attorney General, Treasurer, State Auditor and Inspector, Superintendent of Public Instruction, Labor Commissioner, Insurance Commissioner, and Corporation Commissioner. Texas: Governor, Lieutenant Governor, Attorney General, Comptroller, Agriculture Commissioner, Land Commissioner, and Railroad Commissioner.

period, both Oklahoma and Texas ballots included a “straight ticket” option (an optional choice to select one party’s full slate of candidates with a single selection). According to Oklahoma State Election Board data, 40% of Oklahoma voters chose to use the straight ticket option in 2018. Haag (2019) reports a higher rate (67%) in Texas.

This study focuses on 2018. This election cycle was the first time in a decade that there was a challenger in the OCC race. In the intervening years, Republicans ran unopposed in both the general and Republican primary elections. A Democrat entered in 2016, explicitly citing earthquakes as motivation, but withdrew prior to the general election for family reasons.⁹ In Texas, the TRC race has included candidates from both major parties in every recent year. The online appendix shows some time series analysis of TRC races (Appendix Figure A5). Appendix Table A2 reports overall outcomes for energy regulator and governor in both states in 2018. Republican candidates won by significant margins, consistent with recent Republican party dominance in these states.

1.2 Induced Seismicity

The empirical analysis of election outcomes focuses on earthquakes caused by the underground disposal of wastewater from oil and gas extraction. Prior to 2009, earthquakes larger than magnitude 3.5 were rare in the central United States. Between 2009 and the 2018 election, there was a rapid increase in seismic activity affecting Oklahoma, northern Texas, and neighboring states. These events are caused by human activity – specifically, the injection of oil and gas wastewater into disposal wells in certain vulnerable geologic formations (Ellsworth 2013; Weingarten et al. 2015; Petersen et al. 2018).

9. Monies, Paul. “Democratic opponent bows out of Oklahoma Corporation Commission race.” *The Oklahoman*, June 22, 2016. “[Richard] Morrisette announced his candidacy in February at an Edmond earthquake forum that featured environmental and consumer activist Erin Brockovich. He pledged to reform the Corporation Commission, which he said had a slow response to Oklahoma’s sharp rise in earthquakes connected to wastewater disposal wells.”

These so-called “swarms” of earthquakes received substantial public and media attention. Most have caused little or no physical harm, but a few large events such as the 2011 Prague earthquake (magnitude 5.7) and the 2016 Pawnee earthquake (magnitude 5.8) damaged homes and other buildings. The perceived risk of damage during the years prior to the 2018 election was high. The United States Geological Survey (USGS) began producing “induced seismicity” forecasts for this region in 2016 as a response to this new risk. The 2016, 2017, and 2018 forecasts all implied that the predicted risk of property damage from earthquakes in the central United States region was among the highest in the country (Petersen et al. 2018). In more recent years, seismic activity has slowed but remains substantially above pre-2009 levels.

A variety of sources confirm the economic and psychological salience of man-made earthquakes. Earthquake insurance takeup in Oklahoma increased dramatically from 2% to 15% in four years. Figure 2 shows that total premiums written for earthquake insurance rose from \$3.9 million to \$23.8 million dollars between 2010 and 2018.¹⁰ This greater than five-fold increase coincides with the onset of induced seismicity. The post-2009 trend dramatically exceeds growth rates for other lines of coverage like private auto, flood, or homeowner’s multi-peril (which excludes earthquakes). Furthermore, hedonic studies find home price impacts of 4–10% in the worst-affected areas (Metz, Roach, and Williams 2017; Cheung, Wetherell, and Whitaker 2018; Ferreira, Liu, and Brewer 2018; Burnett and Mothorpe 2021). Casey, Goldman-Mellor, and Catalano (2018) report that the earthquake swarms increased Google searches for anxiety-related keywords.

Oklahoma governor Mary Fallin established a Coordinating Council on Seismic Activity in 2014 that included the Secretary of Energy and the Environment, the Oklahoma Geologic Survey, the OCC, state legislators, and industry rep-

10. Premiums data were compiled by the author from Oklahoma Insurance Department annual reports for 2004–2018. See Table II: Property & Casualty Lines of Business. Takeup numbers for 2011 and 2015 are from National Association of Insurance Commissioners, “Insurance Regulators Discuss Earthquake Issues and Challenges at CIPR Event”, Center for Insurance Policy and Research Newsletter, December 2015.

representatives. The OCC began ordering the closure of nearby disposal wells following particularly large seismic events. The TRC held public hearings in affected areas of North Texas. Both states invested in improved seismic monitoring and research. Critics argued that these officials were too slow to publicly acknowledge the link between oil and gas activity and earthquakes, and that greater restrictions on wastewater injection were warranted.

2 Data

The online appendix describes the creation of the database in detail (Appendix Sections 4 and 5). This section provides an overview of the key datasets.

Data on election outcomes for Oklahoma were provided by the Oklahoma State Election Board. These data include each candidate’s name, political party, and vote total at the precinct level for every office in the statewide general election. Individual-level information on turnout and voter registration comes from the state voter registration database, which was also provided by the State Election Board. These data include date of birth, party preference, and voting history (whether a ballot was cast in a given election) for all registered voters as of August, 2019. Data on election outcomes for Texas come from the Texas Legislative Council. The data include vote totals by candidate for every statewide race in 2018 at the level of voting tabulation districts (VTDs), which are based on 2018 election precincts.

Data on earthquake locations, dates, and magnitudes come from the USGS Advanced National Seismic System Comprehensive Catalog (ANSS ComCat). This catalog reports dates, magnitudes, and geographic locations for earthquakes throughout the world. Data on oil and gas well locations and production comes from Enverus (DrillingInfo). These data include geographic coordinates, drilling date, and monthly production volumes for the universe of oil and gas wells in Oklahoma and Texas.

The analysis of campaign news coverage uses a dataset of election-related

articles from Oklahoma and Texas newspapers. Full details of the database creation are in Appendix Section 5. Briefly, I used news databases and directed searches of individual newspapers to compile a database of election-related news articles from calendar year 2018. I then identified a subset of articles that focused primarily on the governor or energy regulator races during the primary or general elections. The resulting dataset includes 320 articles about the governor races in the two states and 38 articles about the energy regulator races.

3 Methods

Section 3.1 discusses the descriptive text analysis of campaign news coverage. Section 3.2 describes the econometric analysis of election outcomes.

3.1 Text Analysis

I use text analysis methods to explore the relative emphasis on various issues in news coverage of the 2018 campaigns for governor and energy regulator. Using techniques for statistical analysis of text reviewed in Gentzkow, Kelly, and Taddy (2019) and elsewhere, I calculated the relative frequencies of policy-related keywords in the database of news stories assembled for this study. This analysis involves removing common stopwords (e.g., “the”, “said”), applying a stemming algorithm that reduces various word forms to common roots, and counting occurrences of word stems in the resulting list. All words appearing at least five times across all Oklahoma articles were assigned by hand to one of ten issue categories.¹¹ The list of words in each category is in Appendix Table A10. For each word and each topic category, I calculate the occurrence rate per 10,000 words of news coverage in the governor and energy regulator races in each state. To compare the relative importance of topics across any two

11. Economy, education, health, state budget, social issues, oil & gas, earthquakes, other environmental issues (beside earthquakes), utilities, and other/not policy-related.

races, I calculate the natural log of the ratio of occurrence rates, which I call the log occurrence ratio.¹² The main objects of interest in the text analysis are the log occurrence ratios between the energy regulator and governor races for each issue category.

This analysis relies on news coverage instead of directly-recorded candidate speech. This is partly by necessity due to the scarcity of recorded candidate speech, especially for energy regulator. It is worth considering the degree to which differences in coverage of various offices and candidates could reflect journalistic decisions instead of the messaging priorities of candidates. Two pieces of evidence suggest that the patterns of emphasis across races are not primarily driven by differences in editorial slant. First, the topics emphasized in the news articles that most resemble unedited candidate speech – op-eds by candidates and news coverage of in-person debates – mirror those in the full sample. Second, many of the news stories about different candidates come from the same newspapers, and often the same individual reporters.

3.2 Econometric Analysis of Election Data

The next several sections explain how variation in earthquake exposure is used to measure the effects of induced seismicity on candidate choice and turnout. Section 3.2.1 describes the variation in earthquake exposure and relevant covariates. Section 3.2.2 explains the methods for analyzing downballot outcomes, and Section 3.2.3 describes the approach for governor and overall voter turnout.

12. For example, if a given topic category appeared 125 times per 10,000 words in the Oklahoma Corporation Commission race and 50 times per 10,000 words in the Oklahoma governor race, the log occurrence ratio for Oklahoma is $\ln(\frac{125}{50}) = 0.92$. Thus, a topic with a log occurrence ratio of 1 appears about 2.7 times more frequently in the energy regulator race than in the governor race, while a log occurrence ratio of -1 indicates that the topic is about 2.7 times more common in the governor race.

3.2.1 Variation in Earthquakes and Other Observables

Oil and gas development occurs throughout Oklahoma and Texas, but vulnerability to induced seismicity depends on particular geological characteristics. Figure 1 shows the most severe shaking experienced at each election precinct centroid prior to the November 2018 general election. These exposures are calculated using a geophysical formula from Atkinson and Wald (2007) that predicts the intensity of shaking in each precinct during each earthquake as a function of magnitude and proximity. Intensities are expressed in units of Modified Mercalli Intensity (MMI).¹³ The observed range of MMI values in Texas and Oklahoma includes “Weak” (3), “Light” (4), “Moderate” (5), “Strong” (6), and “Very Strong” (7). Appendix Table A1 describes the MMI scale in detail. Few areas in Texas experience shaking above 4 MMI, while exposures in Oklahoma exceed 7.

In my default specification, I use the 2009-2018 peak exposures shown in Figure 1 as the measure of a precinct’s earthquake exposure. The online appendix explores other ways of translating the vector of historical exposures to a scalar measure for each precinct. The ranking of exposures differs little across these metrics because the areas experiencing the largest earthquakes also experience the most frequent smaller earthquakes. Appendix Figures A2, A3, and A4 show approaches using only recent events, the count of exposures above a given level, and a predicted induced seismicity risk measure produced by USGS (which does not rely on the estimated attenuation coefficients used in the other measures).

The physical processes that determine earthquake occurrence are unlikely to be endogenously related to economic or political factors, especially since they were not well understood prior to about 2013. At the same time, the spa-

13. The validity of these attenuation coefficients for induced earthquakes was investigated by Hough (2014). They have been used in economic research by Cheung, Wetherell, and Whitaker (2018) and Ferreira, Liu, and Brewer (2018) to study the effects of earthquakes on home values. The MMI scale takes discrete integer values, but the Atkinson and Wald (2007) predicted MMI is continuous. I refer to this continuous measure throughout the paper as “MMI”.

tial concentration of earthquake exposure in central Oklahoma raises concerns about possible spurious correlations with broad spatial trends in economic or political factors. Table 1 summarizes economic and political characteristics for the approximately 1,900 precincts used in Oklahoma’s 2018 general election. The first column reports statewide means. The next two columns report means in high-exposure and low-exposure subsamples. For many variables, the high- and low-exposure precincts are broadly similar. Oil and gas industry employment share is closely balanced and the numbers of active wells and recently-drilled wells are similar and actually slightly lower in high-exposure precincts. The average age of registered voters is also well balanced. Differences on other measures are larger. High-exposure precincts have a lower household income and a larger fraction of white residents. There is also a small difference in party affiliation, with the high-exposure precincts having more registered Republicans and fewer Democrats. These differences complicate naive cross-sectional comparisons across the earthquake exposure gradient, highlighting the need for an empirical design that can address these differences. The rest of this section describes the empirical approaches used to measure the effects of induced seismicity on downballot and overall outcomes and the assumptions under which these approaches yield consistent estimates.

3.2.2 Empirical Design for Energy Regulator Races

To understand the effects of induced seismicity in the Oklahoma Corporation Commissioner and Texas Railroad Commissioner races, I take advantage of the fact that each of these offices is one of several downballot executive races in each state. The empirical design examines how the difference in outcomes between energy regulator and other downballot executive races changes with exposure to induced seismicity. This approach differences out precinct-specific determinants of political participation and party preference. In addition to improving identification, this design yields substantial gains in precision relative to purely cross-sectional approaches.

Comparing contemporaneous downballot races has advantages with respect to traditional panel methods that compare outcomes across election years. Voter behavior is highly variable over time and space based on observable and unobservable factors, including national politics (e.g., close Congressional races), presidential vs. midterm elections, and compositional changes in the electorate. Since elections represent repeated cross sections of a changing electorate, strategies that attempt to difference away time-invariant place-specific components of behavior may be prone to bias.

I model election outcomes separately for Oklahoma and Texas. For each state individually, I represent outcomes for office j in precinct i as,

$$y_{ij} = \rho_i + \psi_j + \beta D_j MMI_i + D_j X_i \gamma + \epsilon_{ij} \quad (1)$$

where y_{ij} is vote share for the Republican candidate or share of ballots indicating any choice in race ij .¹⁴ Outcome y_{ij} depends on a precinct fixed effect ρ_i and an office fixed effect ψ_j . The indicator variable D_j equals one for the energy regulator race (OCC or TRC) and MMI_i is earthquake exposure. I show results using a variety of comparison offices ($D_j = 0$). The comparison offices for Oklahoma include Insurance Commissioner, Labor Commissioner, Superintendent of Public Instruction, and Attorney General. For Texas, the comparison races are Commissioner of Agriculture, Commissioner of the General Land Office, Comptroller of Public Accounts, and Attorney General. The main coefficient of interest β captures the differential effect of earthquake exposure on the energy regulator race. In my preferred specifications, I parameterize MMI_i using a flexible binned form so that β is a vector of bin-specific exposure effects. The precinct fixed effects control for unobserved determinants of voting behavior or party preference in a given precinct (for example, a precinct's overall partisan lean this year, or residents' commitment to voting in downballot races). The office fixed effects control for unobserved office effects that are constant across precincts (for example, a candidate's overall

14. Equation 1 with a single comparison group is equivalent to the differenced specification, $\Delta y_i = u + \beta_1 MMI_i + X_i \beta_2 + \eta_i$.

popularity or name recognition).

Equation 1 estimates β consistently if, conditional on the fixed effects and control variables, there are no unobserved determinants of voting behavior that are correlated with MMI and differentially affect the energy regulator race relative to the comparison group. In addition to the precinct fixed effects, this identification assumption is further bolstered by the predetermined geological variation that governs susceptibility to earthquakes. Table 1 shows that oil and gas activity and employment are widespread in both high- and low-earthquake exposure areas. The greater shaking in the latter group is primarily a function of local geological factors that were not understood prior to about 2013. As a further step to address any potential omitted variables, the interacted control variables $D_j X_i$ allow for differential effects of covariates X_i on the energy regulator race. These controls include the number of active oil and gas wells within 3 kilometers of the precinct centroid, new wells completed since 2015 within 3 kilometers of the precinct centroid, county-level oil and gas employment share, household income, unemployment, education, racial composition, and age.¹⁵ The three kilometer radius for oil and gas wells is chosen based on the distance over which amenity effects of fracking were found by Muehlenbachs, Spiller, and Timmins (2015).

When the outcome variable is Republican vote share, β captures the degree to which election outcomes for energy regulator in earthquake-exposed precincts deviate from purely partisan voting. This increase in ticket-splitting relative to other downballot races can be interpreted as a sign of attention or persuasion.

15. The full list of controls is active wells, active wells squared, completions since 2015, completions since 2015 squared, oil and gas employment share, median household income and median household income squared, share high school graduate, share college degree, share White, share Black, share Native American, unemployment rate, share in an urban area with more than 50,000 people, share in an urban area with 2,500 – 49,999 people, age, age squared, and share White times share college graduate. Oil and gas drilling data come from DrillingInfo. Oil and gas employment share data are county-level data from U.S. Census County Business Patterns. Other demographic data come from the 2017 American Community Survey (ACS) except age in Oklahoma, where the voter registration data allow direct calculation of average age by precinct. In Oklahoma, precincts are matched to Census block group-level ACS demographics (other than age) by geocoding voter addresses. In Texas, county-level ACS data are used.

Note that β does not measure changes in vote shares caused by increases in overall voter turnout (since, for example, increasing the number of purely partisan Democratic voters would affect party vote shares for energy regulator and the comparison races similarly). Section 3.2.3 explains how I separately test for effects on overall turnout.

When the outcome is office-specific participation rates (i.e., undervote), β can be interpreted as a measure of differential attention to the energy regulator race. Positive values of β imply that earthquake exposure increases voter participation in the energy regulator race relative to other downballot races.¹⁶

3.2.3 Empirical Design for Governor and Overall Turnout

The differencing strategy used to study the energy regulator race is not applicable to the governor race or overall turnout because neither of these has a contemporaneous comparison group. I instead use two alternative approaches: a matching estimator that compares individual voting decisions for observationally-similar registered voters in high and low earthquake areas; and a county-by-year panel approach. I focus on Oklahoma in this section because of its greater earthquake exposure.

The matching approach measures effects on voter turnout using individual voting records in Oklahoma’s voter registration database. Following Imbens and Rubin (2015) and related references, I construct a propensity score-matched sample of voters in high- and low-exposure precincts. I use the matched sample to estimate the effect of earthquake exposure on voter turnout with several different regression and matching estimators. This approach relies on an un-

16. One might expect earthquake exposure to have heterogeneous effects on participation, increasing participation among some (e.g., Democrats who otherwise would have left the energy regulator race blank) while decreasing it among others (e.g., discouraged Republicans who abstain in the energy regulator race instead of choosing the Republican candidate). In this case, β is a net effect that represents the full positive (or negative) effect minus a smaller, partially offsetting effect. In other words, β is a conservative estimate of the share of voters whose behavior is affected.

confoundedness assumption: the estimates are consistent if, conditional on the controls, earthquake exposure is uncorrelated with unobserved determinants of the individual turnout decision in the matched sample.

Details on the matching and estimation are in Appendix Section 2.2. The matching uses individual information from the voter database as well as demographic information at the level of Census block groups. I implement a number of validity checks following Imbens and Rubin (2015), which are reviewed in detail in the online appendix. In addition to confirming balance on contemporaneous covariates, I also take advantage of historical data in the voter registration database to compare voting histories for registered voters in the treatment and comparison groups in the last election prior to the onset of induced seismicity (2010). The results of these validity checks lend support to the identifying assumption.

The matching estimates are complemented with estimates from a county-by-election cycle panel.¹⁷ The panel estimates provide an alternative view of turnout effects and the only feasible estimates of party share effects for governor, since the voter registration data do not include candidate choice. The panel includes county-level turnout and party vote shares for midterm elections in 2010, 2014, and 2018. I define earthquake exposure for each county-by-election observation as the highest MMI experienced at the county center of population prior to that election. My main estimating equation for the panel results is a difference-in-differences specification in which counties are considered to be treated starting in the first election cycle after local earthquake exposure of 6 MMI or greater. These panel regressions include county fixed effects that absorb time-invariant determinants of county-level outcomes. They also include election cycle fixed effects that absorb arbitrary patterns in outcomes across election years. Finally, the panel regressions control for time-

17. The available voter registration data are a snapshot of registered voters. While the data include voting history for these individuals, they do not allow for credible panel analysis due to substantial attrition between election cycles. Even for voters who have resided in Oklahoma in all periods, the data include only current address, making it impossible to reconstruct exposure to earthquakes or other shocks at the time of previous elections. For these reasons, the panel analysis relies on county-level aggregate data.

varying covariates. These are new well completions in the county during the past 4 years (from DrillingInfo), oil and gas employment share, median household income, share college graduate, share high school graduate, share White, and share White times share college graduate.¹⁸

4 Results and Discussion

This section summarizes the results of the empirical analysis. Section 4.1 discusses the role of environment and other issues in the governor and energy regulator campaigns, based on quantitative text analysis. Sections 4.2 and 4.3 describe the econometric estimates for downballot outcomes, overall turnout, and the governor race.

4.1 Text Analysis of Campaign Issues

This section describes the role of environment and other issues in the campaigns for governor and energy regulator. The main text presents results for the Oklahoma governor and Corporation Commissioner races. Similar results for Texas governor and Texas Railroad Commission are presented in Appendix Section 3.

Figure 3 illustrates overall differences across races. The figure plots the occurrence rates of various individual word stems in newspaper coverage of the 2018 governor and Corporation Commissioner races in Oklahoma. Words related to energy and environmental policy are shown in red, and the subset of these related to earthquakes are indicated with solid fill. The remaining gray markers are all other policy-related word stems. Labels are included for words appearing at least 20 times per 10,000 words of news coverage in either race.¹⁹

18. Demographic variables for 2010 use 2011 ACS 5-year estimates and those for 2018 use 2017 ACS 5-year estimates. Values for 2014 are linearly interpolated based on 2010 and 2018 values.

19. The full list of words and occurrence rates is provided in Appendix Table A10.

The lack of emphasis on environmental issues in the governor race is visually obvious: environment-related word stems are clustered along the horizontal axis, reflecting near-zero mention in coverage of the governor race. The important role that these issues played in the Corporation Commissioner race is similarly clear.

Figure 4 formalizes these results by comparing occurrence rates for aggregate topic categories. Panel A compares estimates and 95% confidence intervals across the two offices. The issue categories are ordered according to the log of the ratio of occurrence rates in the two races (“ $\ln(\text{ratio})$ ”), which is reported at the left of the figure. The log occurrence ratio for Health, for example, is -2.3 , meaning that the probability of encountering a health-related word is about 10 times higher in coverage of the governor race than in the OCC race. Health, the state budget, social issues like abortion and marijuana, and education were common in the governor race. Education-related keywords in particular accounted for 179 out of every 10,000 words of governor coverage, perhaps reflecting the high profile teacher strikes in Oklahoma in 2018. In comparison, environment and energy-related topics received little mention in the campaign for governor. The occurrence rates for oil and gas regulation, utilities, earthquakes, and other environmental issues are all near zero.

The balance of topics for OCC is quite different. Oil and gas, utilities, earthquakes, and other environment/energy issues were dominant. Oil- and gas-related keywords appeared 319 times in every 10,000 words of coverage, while the other three categories all had occurrence rates exceeding 100 per 10,000. It is particularly striking to see this high occurrence rate for the relatively narrow topic of earthquakes. The log occurrence ratios emphasize how different the issues were in these two races. The largest, $+4.7$, is for earthquakes, implying that earthquakes were discussed about 100 times more frequently in coverage of the OCC race. Utilities and “other environment” have log occurrence rates of $+3.1$ and $+2.9$, and oil and gas has a log occurrence rate of $+2.5$. The one topic that received relatively similar emphasis across the two races was economic issues, with a log occurrence rate of $+0.4$ (about 1.5 times more

common).

Panel B of Figure 4 compares coverage of Democratic and Republican OCC candidates. This panel uses a subset of 14 articles that focused exclusively on the OCC race and on one party. Many of these are from “election guides” in local newspapers featuring side-by-side articles about each candidate, or are coverage of one party’s primary candidates. While the estimates are noisier due to the small sample size, two differences across parties stand out. Earthquakes are about 2.5 times more common for Democrats than Republicans (log ratio 0.9), and Republicans placed greater emphasis on economic issues.

These quantitative results are consistent with a close reading of individual stories. In October 2018, Democratic Corporation Commissioner nominee Ashley McCray told the *Muskogee Phoenix* that the most important issues were, “Property damage from earthquakes that are caused by injecting fracking wastewater into disposal wells, home values plummeting because no one wants a giant fracking operation as their next door neighbor, water contamination, especially of groundwater and rural Oklahoman water wells, [and] lack of inclusion”.²⁰ *HuffPo* ran an article headlined, “Ashley McCray Bets on Fracking Quake Concerns to Push Red Oklahoma Green.”²¹ In contrast, Republican incumbent Bob Anthony focused on his experience in utility regulation. He told the *Tulsa World* that, “There are issues before the Commission right now that are worth billions to Oklahoma’s economy... My knowledge and experience are key to protecting ratepayers.”²²

Appendix Table A9 includes similar results for Texas races. The log occurrence ratios between Texas Railroad Commissioner and Texas governor are similar to the Oklahoma results. Energy and environment topics, including earthquakes, are emphasized in the Railroad Commissioner race while receiv-

20. “Quick 5: McCray challenges Anthony for Corporation Commission seat.” *Muskogee Phoenix*. October 30, 2018.

21. Blood, Liz. “Ashley McCray Bets on Fracking Quake Concerns to Push Red Oklahoma Green.” *HuffPo* November 1, 2018.

22. Hoberock, Barbara. “Four Advance to Runoffs for Corporation Commissioner.” *Tulsa World* August 5, 2018.

ing little attention in the governor race. Appendix Figure A5 reports the time series of occurrence rates in the Railroad Commissioner race in each statewide election from 2006 to 2018 (taking advantage of the fact that TRC has been consistently contested by both parties). Oil and gas regulation, economic issues, and non-earthquake environmental issues show consistent occurrence rates over time. Earthquakes are not discussed at all prior to 2014, which is consistent with the timing of scientific understanding of the link between earthquakes and oil and gas activity. In 2014, 2016, and 2018, earthquake-related words appear about as frequently as all other non-earthquake environment topics combined.

4.2 Election Outcomes: Energy Regulator

This section turns to the effects of induced seismicity on election outcomes. I begin with the energy regulator races.

4.2.1 Graphical Evidence

Figure 5 shows the differential effect of induced seismicity on the energy regulator races in Texas and Oklahoma in 2018. In each panel, the difference between energy regulator outcomes and average outcomes in the comparison races was calculated, and these differences were regressed on the control variables X_i from Equation 1. The figure plots the residuals from this regression. The horizontal axis shows the peak shaking experienced in each precinct prior to the 2018 general election. The blue line and shaded region show a local linear regression fit using a bandwidth of 0.75 MMI and weighting precincts by registered voters.

Panel A considers vote share for Republican candidates. Texas is on the left. Notice first that the precinct-level differences are mostly clustered between -2.5% to +2.5% percent and that the fitted regression is near zero. This implies that average outcomes in other downballot races closely predict TRC

outcomes. Second, there is no observable effect of earthquakes over the limited exposure range experienced in Texas (though the regression estimates become noisy above about 4.5 MMI). This is intuitive given that the large majority of precincts in Texas experienced mild shaking that may not even have been noticed. Moving to the top right panel, performance differences between the Republican OCC candidate and other downballot Republicans in Oklahoma are also near zero on average. However, the local regression fit slopes down at high earthquake exposures, implying poorer relative performance of the Republican OCC candidate compared to other downballot candidates in those precincts. This negative effect begins between about 4.5 to 5 MMI and increases with exposure. In the most-exposed precincts, the performance gap between the Republican OCC candidate and other downballot Republicans is about 1.5 percentage points larger than in the least-exposed precincts.

Panel B considers the difference in total votes cast for energy regulator and other downballot offices. Again, the mild exposures in Texas do not seem to affect the relative share of voters indicating a choice in the TRC race. The local linear regression may show a small increase starting at about 5 MMI, but this is quite noisy given the small number of precincts at these exposure levels. In Oklahoma, higher exposures are associated with a small relative increase in the share of voters indicating choices for energy regulator. In the most-exposed precincts the effect is about 0.5 percentage points. While this is a small effect in absolute terms, it represents a large percentage decrease in undervote given that the overall average rate of undervote for Corporation Commissioner was only about 2%.

4.2.2 Regression Evidence

Given the evidence in the previous section, the additional regression results in this section focus on Oklahoma. Table 2 shows estimates from a version of Equation 1 where MMI has been parameterized using 4 exposure bins. The omitted bin includes precincts with exposure below 4.5 MMI. The key coef-

ficients of interest are the bin indicators interacted with $1[OCC]$, a dummy for the Corporation Commissioner race. The first two columns show effects on Republican candidate vote share. Column 1 includes Labor Commissioner and Insurance Commissioner (the two adjacent races on the ballot) as comparison races, while Column 2 includes these races plus Superintendent of Public Instruction and Attorney General. In keeping with the visual evidence in Figure 5, exposures between 4.5 and 5.0 MMI have little effect on the relative performance of the Republican OCC candidate. The estimates in the next bin imply that exposures between 5.0 and 6.0 MMI widen the performance gap by about 0.7 percentage points. Finally, exposures of 6.0 MMI or greater widen the performance gap for the Republican OCC candidate by about 1.1 percentage points. The upper end of the 95% confidence interval rules out an effect larger than 2 percentage points.

The final two columns show the effect on downballot turnout. These specifications measure the difference in voters' likelihood of making a choice in the OCC race vs. the comparison races. Focusing on Column 4, which includes all four comparison races, there is a negligible increase in the middle two bins. In the top bin, exposures greater than 6 MMI, the difference in the the share of voters indicating a choice for Corporation Commissioner vs. other downballot offices grows to about one-fourth of one percentage point.

4.2.3 Partisan Cues in the Energy Regulator Race

The electoral effects of induced seismicity in the energy regulator races appear small given the amenity costs documented elsewhere. No fewer than six separate hedonic studies of induced earthquakes have all found consistent home price impacts of at least several percentage points (Koster and van Ommeren 2015; Metz, Roach, and Williams 2017; Cheung, Wetherell, and Whitaker 2018; Ferreira, Liu, and Brewer 2018; Gibbons, Heblich, and Timmins 2021; Burnett and Mothorpe 2021). The comparatively muted effects on voting raise questions about what factors *did* affect choices in these races. One strong ex-

planation appears to be partisanship. Figure 6 plots precinct-level vote shares for the Republican OCC and TRC candidates against Republican vote shares in the four comparison downballot executive races in each state. The fit is striking. A simple least-squares regression with no controls yields an R^2 above 0.98 for either state.²³ The high predictive power of party labels in these races is consistent with voters relying on partisan cues instead of investing attention in these low-information races. Such an outcome mirrors the results of Lim and Snyder (2015) for judicial races in the United States, as well as other studies reviewed in Lim and Snyder (2021).

4.2.4 Additional Results and Robustness Checks

An alternative theory of voter behavior might be that voters responded not to their own earthquake exposure, but rather to the existence of induced seismicity anywhere in the state (either out of altruism or because manmade earthquakes provide a signal about politicians’ effort or performance). The results in Table 2 and additional results in the online appendix are useful for exploring this alternative theory. As a starting point, Column 2 of Table 2 shows that the overall vote share for the Republican OCC candidate was 59.7%, while the average Republican vote share across the comparison offices was 61.3%. On their face, these outcomes do not suggest that the Republican OCC candidate paid a substantial statewide price. Appendix Table A3 further explores this theory using an alternative empirical design. Counties in the western, southern, and eastern fringes of Oklahoma are included in media markets that primarily serve surrounding states like Texas, Arkansas, Louisiana, and Missouri. The geographic concentration of earthquakes in central Oklahoma means that local news consumers in these fringe markets likely

23. This pattern may partially stem from the availability of single-punch straight party voting. Recall, however, that only 40% of Oklahoma voters chose the straight party box, meaning that factor alone cannot explain the high correlation of vote shares across offices. Moreover, straight party voting is optional – nothing prevents voters from indicating their choices individually if they are sufficiently motivated by issues. In fact, election rules allow voters to choose the straight party box and then override that selection by voting for another party in an individual race.

experienced less coverage of induced seismicity events than news consumers in the state’s interior. Holding constant actual earthquake exposure, the performance gap between the Republican OCC candidate and other downballot Republicans does not meaningfully differ across fringe- and non-fringe media markets, providing little support for the hypothesis that general awareness of induced seismicity mattered more than one’s individual exposure.

One additional robustness check addresses the fact that the Democratic Corporation Commissioner candidate, Ashley McCray, was a member of the Absentee Shawnee Tribe of American Indians. Appendix Table A4 re-estimates Equation 1 dropping 56 election precincts in Pottawatomie, Cleveland, and Oklahoma Counties that are inside of the US Census Citizen Potawatomi Nation-Absentee Shawnee Oklahoma Tribal Statistical Area, finding similar results. Also, all regressions throughout the paper control for share Native American among registered voters.

4.3 Overall Turnout and Governor Race

Moving from the specialized energy regulator race to generalist races, this section considers how exposure to induced seismicity affected voters’ likelihood of going to the polls and their choice of candidate for governor. The differencing strategy used to study the energy regulator race is not applicable to these outcomes because there is no contemporaneous comparison group. Instead, I show results for two alternative approaches: matched-sample regressions using individual-level voting data, and a county-by-year panel approach. Both methods yield noisier estimates, underscoring the benefits of the downballot differencing approach. Still, these other approaches allow me to place meaningful bounds on the importance of induced seismicity for broader outcomes.

Table 3 summarizes the results. The first two columns show turnout results using the individual-level voter file data. To simplify calculation of the propensity score, I focus on a binary treatment indicator equal to 1 for voters who experienced shaking of 6 MMI or higher. This treatment definition is informed

by the results for downballot offices, where effects are largest above 6 MMI. I compare these voters to voters who experienced shaking below 5 MMI; voters experiencing between 5 and 6 MMI are not included in the main specification. As a starting point, Column 1 reports the regression-adjusted cross-sectional difference in turnout probability without matching. This specification includes 1.6 million registered voters. It includes Congressional district fixed effects that allow for arbitrary effects of federal Congressional races on turnout.²⁴ It also controls for a cubic function of the voter’s age (from the voter registration data); new well completions within 3 km since 2015; county oil and gas employment share; and demographic variables for the voter’s Census block group: median household income, income squared, share college graduate, unemployment rate, share White, share Black, share Native American, share White times share college graduate, and share living in an urban area with more than 2,500 people. The point estimate is about 0.25 percentage points and is not statistically distinguishable from zero. The standard errors in Column 1 allow for clustered residuals within Census tracts. The resulting confidence intervals rule out effects on turnout that exceed about ± 1.25 percentage points. Column 2 restricts the sample to individuals in high-exposure areas and the matched comparison group. The estimate in Column 2 comes from OLS regression using this matched sample, and including the same controls as in Column 1. The effect of induced seismicity is again close to zero. Applying other estimators to the matched sample yields similar results. Appendix Table A6 reports results for propensity score weighting, subclassification on the propensity score, and nearest neighbor matching. None of these produce meaningfully different estimates.

The final two columns of Table 3 show results using the county-level panel of historical election outcomes. In Column 3, the dependent variable is the share of registered voters that voted. The results for voter turnout are similar to the

24. Oklahoma has 5 Congressional districts, 3 of which include both treated and untreated areas. Voters in the remaining 2 Congressional districts contribute to identification in Column 1 through the control variables. The matched sample includes only Congressional districts with treated and untreated voters.

cross-sectional estimates, with little evidence of meaningful changes in county-level turnout rates after exposure to shaking events. The dependent variable in the final column is the vote share earned by the Republican candidate for governor. Again, there is little evidence of effects after counties are exposed to induced seismicity. The point estimate is about one-third the size of the decrease for the energy regulator. The standard error for this estimate is larger than for the estimates of turnout or downballot party share effects. The noisier estimates reflect the limitations of county-level data and difficult-to-model trends in candidate preferences between election cycles and across counties. Still, the confidence interval is centered near zero and rules out effects larger than about 3 percentage points.²⁵

In summary, the results in Table 3 suggest that there was little meaningful change in overall voter turnout due to induced seismicity. For candidate choice, the noisier estimates rule out moderate effects in the governor race while underscoring the value of the downballot differencing approach for isolating effects on party vote shares in other races.

5 Conclusion

How governments respond to pollution, climate change, and other environmental externalities will depend on whether and how affected households change their voting behavior. This study takes advantage of an unusually good setting in Oklahoma and Texas to understand the electoral salience of environmental issues. Comparing the specialized energy regulator races to the generalist governor races reveals the relative salience of externality regulation vs. other policy issues.

This study first described the different role played by environmental issues in these concurrent elections. Environment, including the new issue of man-

25. The treatment cutoff of 6 MMI yields few treated observations when applied at the county level. For robustness, Appendix Table A8 reports panel estimates using other treatment cutoffs. The results are similar.

made earthquakes, featured prominently in the campaigns for energy regulator. The issues were particularly emphasized by Democrats, the opposition party in both states. But these same issues were essentially absent from the race for governor, which focused on other, higher-profile issues. Quantitative text analysis of campaign news coverage shows these differences clearly.

Next, the study measured the causal effect of exposure to induced seismicity on voting behavior. There is little evidence of effects on overall turnout in the election or on candidate vote shares for governor. For energy regulator, the data show increased voter participation and reduced incumbent party vote share in the most-affected areas of Oklahoma. Taken together, these strands of evidence support the Besley and Coate (2003)-style hypothesis that bundled elections reduce the salience of environmental issues. These topics do matter to voters, but they are drowned out by higher-priority issues in generalist races. Given that most elected representatives in the United States and other countries are responsible for a range of policy areas, these results imply a limited role for environmental regulation in typical elections.

Even in the specialized energy regulator race, the effects of induced seismicity on voting were relatively small given the substantial amenity effects implied by changes in house prices. The striking correlation of party vote shares across downballot candidates suggests that these muted effects partially reflect limited attention by voters to these individual races. Thus, while bundled elections reduce the salience of environmental issues, unbundling choices into a large number of individual races also may not result in full accountability.

Overall, the results of this study imply limited electoral consequences for environmental externalities. This conclusion is particularly relevant for understanding oil and gas regulation in energy-producing areas of the United States, where the recent boom in hydraulic fracturing has magnified the importance of these issues. The current results are also more broadly informative about the likely political consequences of climate change and other pollution problems, especially given the paucity of other evidence. Evaluating the generality of

these results in other jurisdictions and for other externalities is an important priority for future research.

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Figure 1: Earthquake Exposure Prior to 2018 Election

Notes: Best viewed in color. Map scale indicates strongest shaking experienced in each election precinct during 2009–2018, in Modified Mercalli Index units.

Figure 2: Growth in Earthquake Insurance vs. Other Lines in Oklahoma

Notes: Figure shows annual premiums written in Oklahoma divided by their level in 2004. Data were compiled by the author from Oklahoma Insurance Department annual reports for 2004–2018. In each year’s report, see Table II: Property & Casualty Lines of Business. “Homeowners” refers to Homeowners Multiple Peril. “Private Automobile” refers to Private Passenger Auto Physical Damage.

Figure 3: Individual Word Frequencies in Oklahoma Campaigns

Notes: Figure shows occurrence rates for individual word stems in local news coverage of the 2018 governor and Corporation Commissioner races in Oklahoma. Labels listing the word are added for words with occurrence rates over 20 per 10,000 in either race. Red markers indicate words related to energy and environmental policy; filled red markers represent words related to earthquakes. The gray line has a slope of one.

Figure 4: Campaign Themes by Office, Oklahoma 2018 Statewide Election

Panel A. Corporation Commissioner vs. Governor

Panel B. Corporation Commissioner, by Party

Notes: Markers represent occurrence rates for all words in each topic category. Log occurrence ratios (“ln(ratio)”) are the natural log of the ratio of occurrence rates across offices. Whiskers are 95% confidence intervals calculated following Wilson (1927) under the assumption that each word represents an independent trial.

Figure 5: Differential Effects in Downballot Races, Oklahoma vs. Texas

Panel A: Share R for Energy Regulator Minus Share R in other Downballot Races

Panel B: Turnout for Energy Regulator Minus Turnout in other Downballot Races

Notes: Each panel shows residuals from a separate OLS regression of precinct-level differences on oil and gas activity measures and demographic controls. Panel A shows differences in Republican Party vote share for energy regulator vs. other downballot races. Panel B shows differences in the share of voters indicating any choice (i.e., 1–undervote) for energy regulator vs. other downballot races. Markers show precinct-level residuals and have size proportional to the $\log_{10}$ of registered voters. The blue line is a local linear regression fit with a bandwidth of 0.75 MMI. The shaded region is a 95% confidence interval calculated via block bootstrap by county. All regressions are weighted by number of registered voters. The y-axes in both panels are scaled to show 99% of precincts. The rug ticks at the bottom of each figure show the density of observations.

Figure 6: Republican Party Vote Share, Energy Regulator vs. Other Races

Notes: Markers show precinct-level vote shares for the Republican energy regulator candidate vs. average vote shares for Republican candidates in four other downballot executive races in each state. Marker size is proportional to the $\log_{10}$ of registered voters. The blue line shows an OLS fit and the light gray line has a slope of 1. Figure includes precincts with 50 or more registered voters. See text for list of comparison races.

Table 1: Precinct Characteristics for Oklahoma

	Full Sample	MMI < 5	MMI ≥ 6	t-stat Difference
Active oil and gas wells	12.1	12.2	8.9	1.14
Wells completed, 2015–2018	0.6	0.6	0.4	0.85
Oil and Gas Employment Share	2.9%	2.9%	3.2%	0.91
Share college	27.2%	26.9%	23.8%	1.72
Median HH income (thousands)	58	57	46	4.08
Unemployment rate	5.5%	5.5%	5.9%	0.88
Share white	74.2%	73.9%	78.6%	3.09
Age on election day	50.4	50.5	50.3	0.67
Registered Republican	48.4%	48.2%	50.0%	1.09
Registered Democrat	36.0%	36.3%	34.4%	1.27
Registered Independent	15.2%	15.1%	15.1%	0.01
Number of Voters	1,984,171	1,525,720	75,293	
Number of Precincts	1,933	1,534	76	

Notes: Education, income, unemployment, and race data are 2017 American Community Survey (ACS) 5-year estimates. Precinct-level averages for ACS variables are calculated by geocoding voter addresses to Census block groups. Active wells and new well completions are counts within 3 km of precinct centroid, from DrillingInfo. Age and party affiliation are from the voter registration database. Oil and gas industry employment share comes from US Census County Business Patterns data. Precincts are weighted by number of registered voters. The final column reports the t-statistic from a test of equal means in the high-exposure and low-exposure subsamples.

Table 2: Differential Outcomes for Oklahoma Corporation Commissioner

	Republican Vote Share		Turnout	
	2 adjacent offices	4 adjacent offices	2 adjacent offices	4 adjacent offices
MMI 4.5*1[OCC]	0.0003 (0.0030)	-0.0014 (0.0029)	0.0011** (0.0004)	0.0008* (0.0004)
MMI 5*1[OCC]	-0.0055* (0.0033)	-0.0068** (0.0030)	0.0013*** (0.0005)	0.0009** (0.0004)
MMI 6*1[OCC]	-0.0100*** (0.0033)	-0.0112** (0.0045)	0.0027*** (0.0007)	0.0023*** (0.0005)
Precinct Fixed Effects	X	X	X	X
Office Fixed Effects	X	X	X	X
Additional Controls	X	X	X	X
Mean Dep. Var, 1[OCC]=1	0.597	0.597	0.985	0.985
Mean Dep. Var, 1[OCC]=0	0.616	0.613	0.980	0.984
N	5,799	9,665	5,799	9,665
R ²	0.41	0.51	0.36	0.54

Notes: Each column shows a separate OLS regression comparing precinct-level outcomes for OCC to other downballot races in Oklahoma in 2018. There is one observation for each race in each precinct. The dependent variable in Columns 1 and 2 is the vote share for the Republican candidate. The dependent variable in Columns 3 and 4 is the share of voters indicating a choice in the race (i.e., 1–undervote). 1[OCC] is an indicator for the Oklahoma Corporation Commissioner race. The three *MMI**1[OCC] bins correspond to bins of earthquake exposure (named for each bin’s left end) interacted with 1[OCC]. “Additional Controls” includes controls for oil and gas industry activity and demographic characteristics, all of which are interacted with 1[OCC]. See text for details. Precincts are weighted by registered voters. Standard errors are clustered at the county level.

Table 3: Effects on Overall Turnout and Vote Share for Governor

	Turnout Rate			Republican Vote Share
	Cross-section, 2018 (Voter File)	Matched Sample, 2018 (Voter File)	Panel, 2010-2018 (County Returns)	Panel 2010-2018 (County Returns)
MMI 6	0.0024 (0.0052)	0.0049 (0.0062)	0.0062 (0.0086)	-0.0044 (0.0154)
Congr. Dist. Fixed Effects	X	X		
County Fixed Effects			X	X
Year Fixed Effects			X	X
Additional Controls	X	X	X	X
N	1,571,232	143,902	231	231
R ²	0.11	0.13	0.93	0.59

Notes: Each column shows a separate regression. Columns (1) and (2) use individual-level data for 2018 from the state voter registration database. The dependent variable is an indicator variable for voting in the general election. Column (2) uses a propensity score-matched sample of control individuals. See text for details on the matching procedure. Columns (3) and (4) use a panel of county-level midterm election results from 2010 to 2018. The dependent variable in column (3) is the share of registered voters casting ballots, and in column (4) it is the Republican candidate vote share for governor. Counties are weighted by the number of registered voters in 2010. All specifications include additional controls for oil and gas industry activity and demographic variables; see text for details of control variables. Standard errors are clustered by Census tract in Columns (1) and (2) and by county in Columns 3 and 4.

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1 Measuring Earthquake Exposure

Appendix Figure A1: Earthquake Locations, 2009–2018

Notes: Blue circles indicate earthquakes with magnitude less than 4.0. Red triangles indicate earthquakes with magnitude of 4.0 or greater. Earthquake data are from USGS ANSS COMCAT catalog for January 1, 2009–November 6, 2018. Gray lines are election precinct boundaries.

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Appendix Figure A2: Earthquake Exposure During Most Recent Two Years

Notes: Map scale indicates strongest shaking experienced in each election precinct during November 2016–2018, in Modified Mercalli Index units. Best viewed in color.

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Appendix Figure A3: Count of Exposures Above 4.0 MMI

Notes: Map scale indicates the number of shaking exposures of 4.0 MMI or greater in each election precinct during 2009–2018, in Modified Mercalli Index units. Best viewed in color.

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Appendix Figure A4: USGS Seismic Hazard Forecast for 2018

Notes: Map scale indicates the ex-ante predicted 1% exceedance exposure predicted by USGS in each election precinct for 2018, in Modified Mercalli Index units. Best viewed in color.

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Appendix Table A1: Levels of the Modified Mercalli Intensity Scale

MMI	Shaking	Description/Damage
I	Not Felt	Not felt except by a very few under especially favorable conditions.
II	Weak	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Weak	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Light	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Moderate	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Strong	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Very strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Severe	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Violent	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Extreme	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI		Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII		Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Notes: From United States Geological Survey, “The Severity of an Earthquake”, USGS General Interest Publication 1989-288-913; and <https://earthquake.usgs.gov/learn/topics/mercalli.php>

2 Election Outcomes: Additional Results

Appendix Table A2: Overall Election Results

GOVERNOR					
Texas			Oklahoma		
Greg Abbott	REP	55.81%	Kevin Stitt	REP	54.33%
Lupe Valdez	DEM	42.51%	Drew Edmondson	DEM	42.23%
Mark Jay Tippetts	LIB	1.69%	Chris Powell	LIB	3.44%
ENERGY REGULATOR					
Texas (TRC)			Oklahoma (OCC)		
Christi Craddick	REP	53.20%	Bob Anthony	REP	60.03%
Roman McAllen	DEM	43.91%	Ashley Nicole McCray	DEM	34.30%
Mike Wright	LIB	2.89%	Jackie Short	IND	5.67%

Notes: 2018 general election vote shares from the Texas Secretary of State and Oklahoma State Election Board. Party abbreviations “REP”, “DEM”, “LIB”, and “IND” refer to Republican, Democrat, Libertarian, and Independent.

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2.1 Energy Regulator Additional Results

Appendix Table A3: Differential OCC Outcomes Across Media Markets

	Republican Vote Share		Turnout	
	2 adjacent offices	4 adjacent offices	2 adjacent offices	4 adjacent offices
1[OCC]*1[FringeMarket]	0.0057 (0.0036)	0.0017 (0.0037)	-0.0004 (0.0006)	-0.0004 (0.0005)
Constant	0.6173*** (0.0018)	0.6173*** (0.0025)	0.9795*** (0.0004)	0.9795*** (0.0004)
Precinct Fixed Effects	X	X	X	X
Office Fixed Effects	X	X	X	X
Additional Controls	X	X	X	X
N	5,799	9,665	5,799	9,665
R ²	0.41	0.51	0.36	0.54

Notes: Each column shows a separate OLS regression comparing precinct-level outcomes for OCC to other downballot races in Oklahoma in 2018. There is one observation for each race in each precinct. The dependent variable in Columns (1) and (2) is the vote share for the Republican candidate. The dependent variable in Columns (3) and (4) is the share of voters indicating any choice in the race (i.e., 1–undervote). 1[OCC] is an indicator for the Oklahoma Corporation Commissioner race. 1[FringeMarkets] is an indicator for precincts located in media markets other than Oklahoma City and Tulsa. All regressions include a cubic function of earthquake exposure (MMI) interacted with 1[OCC]. “Additional Controls” includes controls for oil and gas industry activity and demographic characteristics, all of which are interacted with 1[OCC]. See text for details. Precincts are weighted by registered voters. Standard errors are clustered at the county level.

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Appendix Table A4: Excluding Absentee Shawnee OTSA precincts

	Republican Party Vote Share		Turnout	
	All precincts	Minus CP-AS OTSA	All precincts	Minus CP-AS OTSA
MMI 4.5*1[OCC]	-0.0014 (0.0029)	-0.0008 (0.0029)	0.0008* (0.0004)	0.0008* (0.0004)
MMI 5*1[OCC]	-0.0068** (0.0030)	-0.0043 (0.0030)	0.0009** (0.0004)	0.0007* (0.0004)
MMI 6*1[OCC]	-0.0112** (0.0045)	-0.0107** (0.0045)	0.0023*** (0.0005)	0.0022*** (0.0005)
Precinct Fixed Effects	X	X	X	X
Office Fixed Effects	X	X	X	X
Additional Controls	X	X	X	X
Mean Dep. Var, 1[OCC]=1	0.618	0.618	0.985	0.985
Mean Dep. Var, 1[OCC]=0	0.632	0.631	0.985	0.985
N	9,665	9,385	9,665	9,385
R ²	0.51	0.50	0.54	0.54

Notes: Reproduces the results from Table 2, excluding 56 precincts whose centroids are located inside of the Citizen Potawatomi Nation-Absentee Shawnee Oklahoma Tribal Statistical Area (a US Census-designated American Indian Geography).

2.2 Overall Turnout and Governor Additional Results

2.2.1 Matching Procedure and Validation

Starting from the voter registration database described in Appendix Section 4.2, I assign earthquake exposures to individual voters based on address information. Specifically, I assign the highest MMI exposure prior to November 6, 2018 at the centroid of the Census block group that contains the voter’s address. To allow for propensity score analysis, I define a binary treatment indicator that takes on a value of 1 for voters who experienced shaking of 6.0 MMI or higher and 0 for voters who experienced shaking less than 5.0 MMI. Voters whose largest exposure was between 5.0 and 6.0 MMI are excluded. I further restrict the sample to include voters from the 3 Congressional districts that include both treated and untreated voters (out of 5 total Congressional districts in Oklahoma).

The matching procedure follows recommended practices in Imbens and Rubin (2015) and Imbens (2015). The variables used include individual-level data on voter age and previous voting history from the voter registration database, augmented with Census block group-level information on education, race, income, and unemployment; oil and gas industry activity from DrillingInfo/Enverus; and county-level oil and gas employment share from County Business Patterns. The propensity score is estimated using a flexible logit specification including higher order terms and interactions. Details are in Appendix Table A7. The matched sample is created by matching treated to untreated individuals on the linearized propensity score (log odds ratio) without replacement in a descending manner (i.e., treated units with the highest propensity scores are matched first).

Appendix Table A5 compares balance between the treatment and matched comparison groups using the normalized differences measure recommended by Imbens and Rubin (2015). Comparing the group means to the unmatched groups in Table 1 in the main text, it is clear that matching has improved the balance substantially. The normalized differences in covariates between the treatment and comparison groups imply that the sample is well balanced. The differences are all within the range where regression adjustment would be expected to be effective.²⁶

26. Imbens and Rubin (2015, p.277) discusses a rule of thumb that normalized differences be less than 0.25 to 0.5 for regression to remove any remaining bias associated with covariate differences.

The historical information on voting in the voter registration database allows another useful validity check based on 2010, the last election cycle before the onset of induced seismicity. The table shows that the share of 2018 registered voters that were also registered in 2010 is closely matched across groups (54.7 vs. 55.8%, $\text{nor.diff.} = -0.02$). Furthermore, the fraction of these long-registered voters that turned out to vote in 2010 is closely matched across groups (72.3% vs. 71.9%, $\text{nor.diff.} = 0.01$). In summary, the treatment and comparison group appear to be closely comparable on both contemporaneous observables and pre-period voting behavior, bolstering the credibility of the unconfoundedness assumption.

2.2.2 Matched Sample Estimates of Turnout Effects

Again following Imbens and Rubin (2015), treatment effects in the matched sample are calculated with 4 different estimators. Each of these estimators is applied to the matched sample, and also to a trimmed version of the matched sample that excludes the one-third of matched voters with the poorest matches (i.e., largest difference in linearized propensity scores between treatment and matched control). The 8 resulting estimates are summarized in Appendix Table A6. The first row shows results from the matched sample, while the second row shows results using the trimmed subset of the matched sample. Column 1 shows results from applying OLS in the matched voter sample and Column 2 shows a propensity-score weighted regression. The standard errors reported in both of these columns are clustered by Census tract. Column 3 shows a nearest-neighbor matching estimator with regression adjustment (Abadie and Imbens 2011). This estimator selects one nearest-neighbor match for each treated voter from the control observations included in the balanced sample, based on the Mahalanobis distance in age, share college education, median household income, unemployment rate, share White, and share Native American. The matched estimates are then corrected with a regression procedure using these same variables. Heteroskedasticity-robust Abadie/Imbens standard errors are reported. Finally, Column 4 shows the point estimate from a propensity score blocking procedure with regression (Rosenbaum and Rubin 1983, 1984; Imbens and Rubin 2015). The matched sample is split into 4 blocks based on the estimated propensity score. Within each block, a separate regression of voting behavior is run on treatment and the covariates. The weighted average of these block-specific regression estimates is taken as the overall point estimate. Across all of these estimators, the point estimates are similar to each other and are all near zero.

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Appendix Table A5: Covariate Balance in the Matched Voter Sample

	MMI ≥ 6	MMI < 5	Nor. Diff.
<i>Individual-level covariates</i>			
Age on election day	50.542 (19.161)	51.042 (19.666)	-0.03
Registered Republican	0.509 (0.500)	0.484 (0.500)	0.05
Registered Democrat	0.336 (0.472)	0.357 (0.479)	-0.04
Registered Independent	0.150 (0.357)	0.154 (0.361)	-0.01
Registered Libertarian	0.005 (0.072)	0.005 (0.071)	0.00
Registered as of 2010	0.552 (0.497)	0.558 (0.497)	-0.01
Voted in 2010 (if registered)	0.730 (0.444)	0.721 (0.449)	0.02
<i>Block group demographics</i>			
Share college	0.245 (0.140)	0.244 (0.159)	0.01
Share high school	0.322 (0.099)	0.323 (0.119)	-0.01
Unemployment rate	0.057 (0.039)	0.055 (0.046)	0.04
Median HH income	47.623 (14.926)	46.550 (14.402)	0.07
Share urban	0.526 (0.454)	0.602 (0.453)	-0.17
Share White	0.791 (0.104)	0.800 (0.133)	-0.08
Share Black	0.030 (0.045)	0.031 (0.039)	-0.02
Share Native American	0.102 (0.078)	0.088 (0.113)	0.15
<i>Other covariates</i>			
Oil & Gas Employment Share	0.030 (0.016)	0.030 (0.020)	0.01
Wells completed, 2015–2018	0.354 (0.889)	0.350 (1.496)	0.00
Congressional Dist. 2	0.016	0.026	-0.07
Congressional Dist. 3	0.675	0.662	0.03
Congressional Dist. 5	0.309	0.312	-0.01
N (Registered Voters)	71,951	71,951	.

Notes: Normalized differences are mean differences scaled by standard deviations following Imbens and Rubin (2015). Oil and gas employment share is from County Business Patterns. Wells completed 2015–2018 is the number of completions within 3 km of the Census block group centroid. Share urban is based on urban areas with more than 2,500 people.

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Appendix Table A6: Alternative Estimators for Overall Turnout

	OLS	P-score weighting	Matching with regression	Blocking with regression
Matched	0.0049 (0.0062)	0.0055 (0.0059)	-0.0045 (0.0070)	0.0056
Matched & Trimmed	0.0038 (0.0062)	0.0037 (0.0061)	-0.0119 (0.0087)	0.0044

Notes: This table shows 8 alternative estimates of the effect of induced seismicity on voter turnout, using methods discussed in Imbens and Rubin (2015) and Imbens (2015). Standard errors are in parentheses. See text for details.

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Appendix Table A7: Propensity Score Estimation

Oil & gas employment share	-35.3057***	(0.2869)
Wells completed 2015–2018	-0.0009	(0.0035)
Age at 2018 election	-0.0521***	(0.0053)
Age squared	0.001***	(0.000)
Age cubed	-0.000***	(0.000)
Congressional Dist. 3	7.011***	(0.036)
Congressional Dist. 5	6.716***	(0.036)
Median HH income	-0.061***	(0.002)
Median HH income squared	-0.000***	(0.000)
Share college grad	-10.625***	(0.306)
Unemployment rate	4.591***	(0.130)
Share high school grad	-1.523***	(0.078)
Share White	7.718***	(0.117)
Share Native American	0.619***	(0.200)
Share Black	1.091***	(0.146)
Share White X Share college grad	17.958***	(0.372)
Share Urban	-1.036***	(0.014)
Share Native American X Median HH income	0.408***	(0.004)
Constant	-10.273***	(0.137)
<hr/>		
N	845,353	
Log likelihood	-135,571	

Notes: Table shows results from a logit regression where the dependent variable is an indicator for peak earthquake exposure greater than or equal to 6.0 MMI units. The sample includes voters in Congressional Districts 2, 3 and 5 registered in precincts with exposure less than 5.0 or greater than 6.0 MMI. The two table columns report regression coefficients and standard errors.

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2.2.3 Panel Estimates for Turnout and Party Share

Appendix Table A8: Additional Panel Estimates

	Turnout Rate			Republican Vote Share		
	4.5 MMI	5.25 MMI	6 MMI	4.5 MMI	5.25 MMI	6 MMI
Exposure Dummy	-0.0090 (0.0070)	0.0010 (0.0117)	0.0062 (0.0086)	-0.0110 (0.0124)	-0.0039 (0.0196)	-0.0044 (0.0154)
County Fixed Effects	X	X	X	X	X	X
Year Fixed Effects	X	X	X	X	X	X
Additional Controls	X	X	X	X	X	X
N	231	231	231	231	231	231
R ²	0.93	0.93	0.93	0.59	0.59	0.59

Notes: Each column shows a separate OLS regression. The regression specifications match columns 3 and 4 of Table 3, except that the MMI threshold for treatment is varied across columns as shown at the top of each column. In each case, county-year observations are considered to be treated in all election years following the first exposure of the given level.

3 Text Analysis: Additional Results

3.1 Results for Texas and Oklahoma

Appendix Table A9: Campaign Themes by Office, Texas and Oklahoma

	Oklahoma			Texas		
	OCC	Gov	ln(Ratio)	TRC	Gov	ln(Ratio)
Health	6.2 (2.7, 13.3)	58.6 (53.3, 64.4)	-2.25	11.9 (5.2, 25.7)	17.5 (14.7, 20.7)	-0.38
Social Issues	14.1 (8.4, 23.5)	84.8 (78.4, 91.7)	-1.79	11.9 (5.2, 25.7)	151.1 (142.7, 159.9)	-2.54
State Budget	48.5 (36.9, 63.6)	151.9 (143.3, 160.9)	-1.14	44.2 (29.5, 65.7)	79.2 (73.2, 85.8)	-0.58
Education	59.1 (46.2, 75.5)	178.6 (169.3, 188.4)	-1.11	40.8 (26.8, 61.7)	70.7 (65.0, 76.9)	-0.55
Economy	248.8 (221.3, 279.6)	158.9 (150.2, 168.2)	0.45	284.1 (243.8, 330.6)	104.6 (97.7, 112.1)	1.00
Oil and Gas	318.5 (287.3, 352.9)	27.2 (23.7, 31.3)	2.46	333.4 (289.7, 383.3)	7.4 (5.7, 9.6)	3.81
Other Environment	138.5 (118.2, 162.2)	7.7 (5.9, 10.1)	2.88	86.7 (65.3, 114.8)	5.6 (4.1, 7.6)	2.74
Utilities	243.5 (216.3, 274.0)	11.0 (8.8, 13.7)	3.10	57.8 (40.7, 81.7)	8.0 (6.2, 10.4)	1.97
Earthquakes	107.6 (89.8, 128.8)	0.9 (0.4, 2.0)	4.75	34.0 (21.4, 53.5)	0.4 (0.1, 1.2)	4.49

Notes: This table reports the occurrence rate per 10,000 words for each topic category in the energy regulator and governor races in Oklahoma and Texas in 2018. “OCC” is Oklahoma Corporation Commission and “TRC” is Texas Railroad Commission. “ln(Ratio)” is the natural log of the ratio of occurrence rates between the energy regulator and governor races in each state. Ninety-five percent confidence intervals for occurrence rates are in parentheses.

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Appendix Figure A5: Campaign Themes by Year, Texas Railroad Commissioner

Notes: Occurrence rates per 10,000 words for four topic categories in TRC races from 2002 to 2018.

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3.2 Word-level results

Appendix Table A10: Occurrence Rates for Individual Words, by Race

Category	Word (Stemmed)	OCC	Gov	Diff
Earthquakes	earthquake	28.2	0.0	<i>28.2</i>
Earthquakes	inject	26.5	0.5	<i>25.9</i>
Earthquakes	disposal	22.9	0.4	<i>22.5</i>
Earthquakes	wastewater	19.4	0.0	<i>19.4</i>
Earthquakes	underground	7.1	0.0	<i>7.1</i>
Earthquakes	seismic	3.5	0.0	<i>3.5</i>
Economy	industry	62.6	22.8	<i>39.8</i>
Economy	companies	50.3	14.7	<i>35.6</i>
Economy	business	34.4	15.9	<i>18.5</i>
Economy	economic	24.7	14.8	<i>9.9</i>
Economy	job	28.2	9.5	<i>18.7</i>
Economy	consumer	18.5	1.3	<i>17.2</i>
Economy	mortgage	0.0	13.1	<i>-13.1</i>
Economy	dollar	1.8	8.1	<i>-6.4</i>
Economy	invest	4.4	4.5	-0.1
Economy	businessman	0.9	8.0	<i>-7.1</i>
Economy	profit	7.9	0.7	<i>7.3</i>
Economy	commodities	6.2	0.0	<i>6.2</i>
Economy	commercial	0.9	5.1	-4.2
Economy	employed	0.0	5.7	<i>-5.7</i>
Economy	worker	2.6	2.9	-0.3
Economy	bank	0.9	4.4	-3.5
Economy	salaries	0.0	4.1	-4.1
Economy	employ	0.9	2.7	-1.8
Economy	buy	0.9	2.3	-1.4
Economy	poor	0.9	1.9	-1.0
Economy	prosper	0.0	2.7	-2.7
Economy	nyse	1.8	0.5	1.2
Economy	bankruptcy	0.0	1.2	-1.2
Economy	price	0.0	1.2	-1.2
Economy	cash	0.0	1.1	-1.1
Economy	pension	0.0	1.1	-1.1
Economy	checkbook	0.0	0.8	-0.8
Economy	entrepreneurship	0.0	0.8	-0.8
Economy	lender	0.0	0.7	-0.7
Economy	unemployed	0.0	0.7	-0.7
Economy	commerce	0.0	0.5	-0.5
Economy	investor	0.0	0.5	-0.5
Economy	poverty	0.0	0.5	-0.5
Economy	sold	0.0	0.5	-0.5
Economy	banker	0.0	0.4	-0.4

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Economy	debt	0.0	0.4	-0.4
Economy	monopolists	0.0	0.4	-0.4
Economy	entrepreneur	0.0	0.3	-0.3
Economy	foreclosure	0.0	0.3	-0.3
Economy	nasdaq	0.0	0.3	-0.3
Economy	paycheck	0.0	0.3	-0.3
Economy	probusiness	0.0	0.3	-0.3
Economy	businesswoman	0.0	0.1	-0.1
Economy	foreclose	0.0	0.1	-0.1
Economy	inflation	0.0	0.1	-0.1
Economy	jobless	0.0	0.1	-0.1
Economy	layoffs	0.0	0.1	-0.1
Economy	marketplace	0.0	0.1	-0.1
Economy	progrowth	0.0	0.1	-0.1
Economy	workforce	0.0	0.0	<i>0.0</i>
Education	education	28.2	53.8	<i>-25.6</i>
Education	school	21.2	48.3	<i>-27.2</i>
Education	teacher	2.6	45.8	<i>-43.2</i>
Education	student	5.3	10.6	-5.3
Education	walkout	0.0	6.3	<i>-6.3</i>
Education	classroom	0.9	4.8	-3.9
Education	teach	0.0	5.5	<i>-5.5</i>
Education	strike	0.9	1.6	-0.7
Education	textbook	0.0	1.7	-1.7
Education	curricula	0.0	0.1	-0.1
Health	health	0.0	22.2	<i>-22.2</i>
Health	medicaid	0.0	13.5	<i>-13.5</i>
Health	hospital	0.9	5.3	-4.5
Health	doctor	3.5	0.8	<i>2.7</i>
Health	medicine	1.8	2.3	-0.5
Health	pharmaceutical	0.0	0.7	-0.7
Health	healthcare	0.0	0.4	-0.4
Health	obamacare	0.0	0.4	-0.4
Health	physician	0.0	0.4	-0.4
Health	prescription	0.0	0.4	-0.4
Health	healthier	0.0	0.3	-0.3
Health	sick	0.0	0.3	-0.3
Health	surgeries	0.0	0.1	-0.1
Oil and Gas	oil	107.6	12.8	<i>94.8</i>
Oil and Gas	gas	106.7	12.2	<i>94.6</i>
Oil and Gas	pipeline	31.8	0.1	<i>31.6</i>
Oil and Gas	petroleum	30.0	0.9	<i>29.1</i>
Oil and Gas	frack	15.0	0.0	<i>15.0</i>
Oil and Gas	drill	13.2	1.2	<i>12.0</i>
Oil and Gas	fractured	7.1	0.0	<i>7.1</i>
Oil and Gas	hydraulic	7.1	0.0	<i>7.1</i>
Other Environment	environment	53.8	1.9	<i>51.9</i>
Other Environment	water	31.8	2.5	<i>29.2</i>

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Other Environment	renewable	18.5	0.9	<i>17.6</i>
Other Environment	polluted	18.5	0.5	<i>18.0</i>
Other Environment	groundwater	7.1	0.1	<i>6.9</i>
Other Environment	sustain	3.5	0.7	<i>2.9</i>
Other Environment	climate	1.8	0.4	1.4
Other Environment	fossil	1.8	0.0	<i>1.8</i>
Other Environment	coal	0.9	0.4	0.5
Other Environment	green	0.9	0.3	0.6
Social Issues	marijuana	0.0	21.9	<i>-21.9</i>
Social Issues	criminal	4.4	3.9	0.5
Social Issues	church	4.4	1.6	2.8
Social Issues	pastor	1.8	2.7	-0.9
Social Issues	tobacco	0.0	4.3	-4.3
Social Issues	aborted	0.0	3.7	-3.7
Social Issues	prison	0.0	3.3	-3.3
Social Issues	immigrant	0.0	3.2	-3.2
Social Issues	cigarette	0.0	3.1	-3.1
Social Issues	gun	0.0	2.9	-2.9
Social Issues	incarcerate	0.0	2.9	-2.9
Social Issues	decriminalization	0.0	2.8	-2.8
Social Issues	cannabis	0.0	2.4	-2.4
Social Issues	drug	0.0	2.4	-2.4
Social Issues	caravan	1.8	0.1	1.6
Social Issues	methodist	1.8	0.1	1.6
Social Issues	border	0.0	1.7	-1.7
Social Issues	prosecutor	0.0	1.7	-1.7
Social Issues	crime	0.0	1.3	-1.3
Social Issues	christian	0.0	1.1	-1.1
Social Issues	smoke	0.0	1.1	-1.1
Social Issues	alcohol	0.0	0.9	-0.9
Social Issues	firearm	0.0	0.9	-0.9
Social Issues	addict	0.0	0.8	-0.8
Social Issues	jail	0.0	0.8	-0.8
Social Issues	liquor	0.0	0.8	-0.8
Social Issues	murder	0.0	0.8	-0.8
Social Issues	rifle	0.0	0.8	-0.8
Social Issues	arrest	0.0	0.7	-0.7
Social Issues	handgun	0.0	0.7	-0.7
Social Issues	moral	0.0	0.7	-0.7
Social Issues	religion	0.0	0.7	-0.7
Social Issues	faithbased	0.0	0.5	-0.5
Social Issues	nra	0.0	0.5	-0.5
Social Issues	opioid	0.0	0.5	-0.5
Social Issues	weed	0.0	0.5	-0.5
Social Issues	evil	0.0	0.4	-0.4
Social Issues	prosecute	0.0	0.4	-0.4
Social Issues	sheriff	0.0	0.4	-0.4
Social Issues	victim	0.0	0.4	-0.4

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Social Issues	evangelical	0.0	0.3	-0.3
Social Issues	gay	0.0	0.3	-0.3
Social Issues	hemp	0.0	0.3	-0.3
Social Issues	homicide	0.0	0.3	-0.3
Social Issues	lesbian	0.0	0.3	-0.3
Social Issues	unborn	0.0	0.3	-0.3
Social Issues	visa	0.0	0.3	-0.3
Social Issues	antiabortion	0.0	0.1	-0.1
Social Issues	catholic	0.0	0.1	-0.1
Social Issues	citizenship	0.0	0.1	-0.1
Social Issues	felonies	0.0	0.1	-0.1
Social Issues	god	0.0	0.1	-0.1
Social Issues	homeless	0.0	0.1	-0.1
Social Issues	marriage	0.0	0.1	-0.1
Social Issues	migrate	0.0	0.1	-0.1
Social Issues	prostitute	0.0	0.1	-0.1
Social Issues	suicide	0.0	0.1	-0.1
Social Issues	transgender	0.0	0.1	-0.1
Social Issues	violence	0.0	0.1	-0.1
State Budget	tax	15.0	55.7	<i>-40.7</i>
State Budget	fund	13.2	30.2	<i>-17.0</i>
State Budget	budget	3.5	24.7	<i>-21.2</i>
State Budget	financial	11.5	4.9	<i>6.5</i>
State Budget	revenue	0.9	14.0	<i>-13.1</i>
State Budget	finance	3.5	10.3	<i>-6.8</i>
State Budget	taxation	0.9	3.1	-2.2
State Budget	taxpayer	0.0	2.9	-2.9
State Budget	fiscal	0.0	2.3	-2.3
State Budget	deficit	0.0	1.6	-1.6
State Budget	expenditure	0.0	1.3	-1.3
State Budget	antitax	0.0	0.8	-0.8
Utilities	energy	93.5	4.7	<i>88.8</i>
Utilities	utilities	88.2	0.9	<i>87.3</i>
Utilities	wind	13.2	0.9	<i>12.3</i>
Utilities	electric	12.4	0.1	<i>12.2</i>
Utilities	internet	10.6	0.3	<i>10.3</i>
Utilities	phone	6.2	2.8	3.4
Utilities	ratepayers	7.9	0.0	<i>7.9</i>
Utilities	solar	6.2	0.1	<i>6.0</i>
Utilities	telephone	2.6	0.3	<i>2.4</i>
Utilities	telecommunication	1.8	0.0	<i>1.8</i>

Notes: Table lists the individual words in each topic category, and their occurrence rates in the governor and Corporation Commissioner races in Oklahoma. Reported occurrence rates are per 10,000 words of news coverage. “Diff” is the difference between Governor and Corporation Commissioner. Statistically significant differences at the 5% level are shown in red.

4 Construction of the Election Dataset

4.1 Oklahoma Election Outcomes

The Oklahoma State Election Board provided precinct-level vote totals for all statewide races in the 2018 general election. These precinct-level data were merged based on unique precinct IDs to spatial data on precinct boundaries from the Center Spatial Analysis at the University of Oklahoma. The raw vote data include 1,953 election precincts. Of these, 5 precincts do not appear in the spatial data. Two of these 5 precincts are absentee precinct codes for Oklahoma County and Tulsa County that together account for over 60,000 votes. The other three precincts without spatial data represent fewer than 250 total votes. In the main analysis of precinct-level outcomes, I drop these 5 precincts because the absence of geographic information makes it difficult to assign earthquake shaking exposures to them. The results are not meaningfully different if I keep these 5 precincts and assign them county-average values for earthquake exposure and oil and gas activity.

For each race in each precinct, candidate vote shares were calculated as the number of votes received divided by the total number of votes cast in that race. Downballot participation rates were calculated by dividing the total number of votes for a given downballot office by the number of votes cast for governor. Precinct-level data on registered voters, party registration shares, and average age of registered voters were calculated using the voter registration database (see Section 4.2). Of the 1,953 precinct codes in the vote data, 21 do not appear in the voter registration database. Most of these precincts (14 of 21) reported zero votes cast in 2018. The only 2 of the 21 that represent non-negligible numbers of votes are the absentee precincts in Oklahoma and Tulsa Counties. For all 21 of these precincts, party registration shares and average age of registered voters are imputed as countywide means. Number of registered voters for these 21 precincts is imputed by multiplying observed votes by statewide average voter turnout.

I drop 15 precincts from the clean dataset that contain zero registered voters in the voter registration database. All of these precincts also report zero votes cast in the vote total data. The cleaned precinct-level outcome data for Oklahoma thus contain 1,933 precincts. The dataset represents 1,124,702 votes for governor and 1,107,321 votes for Corporation Commissioner.

4.2 Oklahoma Voter Registration Data

The database of Oklahoma registered voters was provided by the Oklahoma State Election Board. These public records include voting history and address information for the universe of registered voters in Oklahoma. This study uses the August 5, 2019 version of the database, which includes a total of 2,057,514 registered voters. Of these, I drop 73,345 voters with reported registration dates after October 2018.

I use address information to assign voters to Census block groups using the US Census geocoder application. This is a two-step process, accounting for the fact that geocoding of unstructured text information such as this inevitably has a success rate less than 100%. First, the 75.4% of voters whose addresses can be successfully geocoded to the block group level are directly assigned those block groups and the associated demographic variables. Next, election-precinct level averages of demographic variables are calculated for this group of voters. These weighted-average precinct demographic characteristics are used in the precinct-level analysis of election outcomes (see Section 4.1). These precinct-level weighted average demographics are also used as imputed demographic information in the analysis of individual voter turnout decisions for the 24.6% of voters whose addresses cannot be successfully geocoded to the block group level. The alternative approach of dropping voters whose addresses cannot be directly geocoded does not meaningfully change the results.

4.3 Texas Election Outcome Data

Texas election outcome data are from the Texas Legislative Council (TLC). The data include vote totals by candidate in each race in the 2018 general election, along with the number of registered voters and number of ballots cast. The data are reported at the level of voting tabulation districts (VTDs). These spatial units are based on 2018 election precincts with small modifications that improve the relationship between precincts and U.S. Census geographies.²⁷ For

27. According to TLC, “VTDs can differ from actual election precincts because precincts do not always follow census geography. The VTDs in the redistricting database closely correspond to the 8,936 precincts in effect for the 2018 general election. On the occasion that a precinct is in two noncontiguous pieces, it is a suffixed VTD in the database. For example, if precinct 0001 had two non-contiguous areas, the corresponding VTD would be VTD 0001A and VTD 0001B. If a 2018 general election precinct does not match any census geography, it is consolidated with an adjacent precinct and given that precinct’s corresponding VTD number.”

2018, the data include 9,082 VTDs that together represent 8,341,613 votes for governor and 8,225,034 votes for Railroad Commissioner. For each race in each VTD, candidate vote shares were calculated as the number of votes received divided by the total number of votes cast in that race. Downballot participation rates were calculated by dividing the total number of votes for a given downballot office by the total number of ballots cast in that VTD.

4.4 Earthquake exposure and oil and gas activity

Earthquake data come from the United States Geological Survey’s ANSS Comprehensive Catalog. The data used for this study include magnitude, geographic coordinates, and depth for 19,496 earthquakes of magnitude 1.5 or larger that occurred in or close to Oklahoma or Texas between January 1, 2009 and November 6, 2018. I calculate the intensity of shaking experienced at a given location during a given earthquake by applying the geophysical equation for central United States earthquakes reported in Atkinson and Wald (2007). Hough (2014) confirms the validity of this fitted relationship for injection-caused earthquakes, and it has been used in the applied economics literature by Cheung, Wetherell, and Whitaker (2018) and Ferreira, Liu, and Brewer (2018) to study effects of earthquake exposure on home values. This formula yields local intensity in MMI units as a function of earthquake magnitude, M , surface distance in kilometers, S , and depth in kilometers, D . The formula is,

$$MMI = 11.72 + 2.36 * (M - 6) + 0.1155 * (M - 6)^2 - 0.44 * \log_{10}(R) - 0.002044 * R + 2.31 * B - 0.479 * M * \log_{10}(R)$$

and $R = \sqrt{S^2 + D^2 + 289}$, $B = \log_{10}(\frac{R}{80})$ if $R > 80$, $B = 0$ if $R \leq 80$.

For the analysis of downballot election outcomes, I calculate predicted MMI at the geographic centroid of each election precinct in Texas and Oklahoma for every earthquake between 2009 and November 6, 2018 (including earthquakes outside of these two states that were close enough to have been plausibly felt). For the analysis of individual voter turnout decisions, I assign voters a level of earthquake exposure by calculating MMI values at the geographic centroids of each Census block. In the county-level panel regressions, I calculate MMI values at the population-weighted center of mass for each county (as provided by the U.S. Census Bureau).

To calculate a given location’s exposure to oil and gas industry activity, I use data from DrillingInfo/Enverus. I calculate the number of active wells

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within 3 kilometers and the number of new wells completed between January 1, 2015 and November 6, 2018 within 3 kilometers. I choose the 3 kilometer distance based on the distance within amenity effects of drilling are found to exist in Pennsylvania in Muehlenbachs, Spiller, and Timmins (2015). As with earthquakes, I calculate oil and gas exposure for election precinct centroids, Census block group centroids, and county centers of population.

5 Construction of the News Coverage Dataset

This section describes the collection of newspaper articles compiled for this study. Appendix Table [A11](#) summarizes the final collection. A detailed bibliography with the full citation information for each article is available upon request.

5.1 Oklahoma

News stories for Oklahoma come from several sources. I begin with articles from the *The Oklahoman* between January 1 and December 31, 2018 that matched the keyword search “election” in the Nexis Uni database, and also were tagged by Nexis Uni as related to “Campaigns & Elections.” The sample is augmented with 142 articles from other newspapers, including *NonDoc* (an Oklahoma-focused public interest media group), the *Daily Ardmoreite*, the *Lawton Constitution*, the *Muskogee Phoenix*, the *Tulsa World*, and *HuffPost*. In the case of *NonDoc*, 107 articles from 2018 tagged by the publisher as related to “Oklahoma Elections” were included. The 35 articles from the remaining newspapers were identified by keyword searches in each paper’s online archives for “Governor election” or “Corporation Commissioner election”. The choice of which sources to include in the analysis does not materially affect the results. Appendix Figure [A6](#) shows that the log occurrence ratios between the Corporation Commissioner and governor race are similar across *The Oklahoman* and the other article sources.

Within this set of news stories, I identified a subset of articles that focused on the governor or Corporation Commissioner races during the primary or general election. This classification was based on the appearance of the name of the office or candidates for that office in the first 500 characters of the article text. In my validation with a subsample of articles, the resulting classifications from this 500-character rule closely replicate a categorization based on human reading of the article. The resulting dataset includes 159 articles about the governor race and 26 articles about the Corporation Commissioner race.

5.2 Texas

News stories for Texas were identified by keyword searches for “Governor election” or “Railroad Commissioner election” in the NewsBank: Access World

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Appendix Table A11: Article Counts by Source

	2006–2016	2018
<i>Oklahoma</i>		
Daily Ardmoreite		6
HuffPost		1
Lawton Constitution		6
Muskogee Phoenix		5
NonDoc		24
The Oklahoman		126
Tulsa World		17
<i>TOTAL</i>		185
<i>Texas</i>		
Abilene Reporter-News	14	9
Amarillo Globe-News	6	0
Austin American-Statesman	12	39
Corpus Christi Caller-Times	2	11
Dallas Morning News, The	9	0
Denton Record-Chronicle	0	9
El Paso Times	2	8
Fort Worth Star-Telegram	22	8
Houston Chronicle	16	35
Longview News-Journal	8	7
Lubbock Avalanche-Journal	18	0
Midland Reporter-Telegram	19	3
New Braunfels Herald-Zeitung	7	0
San Angelo Standard-Times	8	6
San Antonio Express-News	10	32
Victoria Advocate, The	6	6
<i>TOTAL</i>	159	173

Notes: Counts of articles by source in the final database. Articles for 2018 include governor and energy regulator (TRC/OCC). Articles for 2006–2016 include Texas Railroad Commissioner only, and are used to produce Appendix Figure A5.

News database. The resulting list of Texas newspapers is summarized in Appendix Table A11. Both the governor and Railroad Commissioner races were searched for 2018, producing 173 articles total. Additional searches for “Railroad Commissioner election” in each election year between 2006 and 2016 yielded 159 additional articles that were used to produce the time series in Appendix Figure A5.

Appendix Figure A6: Occurrence ratios across sources in Oklahoma

Notes: Log occurrence ratios are the natural log of the ratio of occurrence rates between the energy regulator and governor races.

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