Give Me A Break, Oil Companies Don't Need Them:
A Case Study of Drilling Incentives in Louisiana Oil & Gas

by

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ABSTRACT

On July 31, 1994, Louisiana halted all taxes on hydrocarbon production from new wells in the state for the initial 23 months post-completion or until well cost payout, whichever occurred first, in efforts to stimulate oil & gas activity and promote economic growth. To evaluate the impact of the new severance tax provision, I gathered county-level panel data on all the new wells in Texas and Louisiana parsed by county—and parish—before and after the policy change. Using Texas as a control group, pre and post-treatment comparisons of the growth in wells in each state provide estimates of the effect of the tax break on Louisiana's energy industry. I specifically study changes in the same outcome variable, new wells, by five distinct geographical regions within both states as robustness checks to provide supporting evidence of the causal effect of the law: 1. localities within the Haynesville Shale, 2. all localities of Texas and Louisiana as a whole, 3. localities along the Texas-Louisiana border, 4. comparable localities in specific regions of each state, and 5. and specific localities within Louisiana. Contrary to the intent of the law, I find no indication that the new tax break increased growth in Louisiana.

INTRODUCTION

TAXES

The debate of whether, and to what extent, taxes alter production is so old it might predate the inception of taxation itself. Ronald Reagan, reflecting on his Hollywood days, humorously remarked, "When I was in the movies, each year after the second film, I'd hit the 90% tax bracket, so I wouldn't make any more movies that year."[1] Nobel Laureate Milton Friedman often concurred, cautioning against taxing work, as it could lead to increased unemployment. Even President John F. Kennedy advocated for lower tax rates, asserting that they stimulate economic activity.

Indeed, one of the fundamental principles in economics is that taxation diminishes production, while subsidies yield the opposite effect. A tax increases production costs, and when the cost of producing a good rises, simple economic theory implies that its production naturally decreases. Thus, if you want less of something, tax it. And if you want more, subsidize it. This model explains the efficacy of tobacco taxes in reducing adult smoking (McLeod and DeCicca, 2007) and the popularity of carbon taxes to curb CO2 emissions for climate change mitigation (OECD, 2021).

However, recent evidence challenges the traditional belief that new tax policies significantly alter behavior. Contrary to the widespread assumption that cigarette taxes decrease smoking, Callison and Kaestner (2013) assert that adult smoking remains largely unaffected by taxes. Other studies, such as Chetty, Looney, and Kroft's (2009) paper *Salience and Taxation* argue that a tax's saliency has a significant impact on the behavioral response towards such a tax, presenting possible implications in the taxation of natural resources given that the effects of changing tax rates might be inhibited due to this saliency, versus regular changing commodity prices which are highly visible to oil and gas producers. These various arguments have been tested in subsequent studies that look at the effect of taxes on production in other markets, but nowhere in economics has this shift in taxation's paradigm in economic theory been more pronounced than in the branch of exhaustible resources economics.

LITERATURE

Predictions by economists specializing in nonrenewable resources regarding the impact of severance taxes have been unequivocal since the inception of this field. The imposition of such

[1] Taken from the popular magazine *Washington Examiner*, quote can be retrieved at: https://www.washingtonexaminer.com/news/business/marginal-benefit

taxes, *ceteris paribus*, is anticipated to result in a decline in production. The theoretical and practical foundation of this assertion can be directly traced to mathematician Harold Hotelling's seminal work, *The Economics of Exhaustible Resources* (1931), which was the first to incorporate

a severance tax in a model, examining its long-term effects on mine extraction by factoring in the tax's burden on production as a project's profitability-decreasing variable, outlining the intricate relationship between severance taxes and the economic viability of mining projects.

Subsequent studies aimed to elucidate the causal relationship between severance taxes and production, consistently affirming Hotelling's initial findings. But early assessments often relied on basic supply and demand models or simple correlative measures of taxation and production, as seen in Millsaps, Spann, and Erickson (1974). While descriptive case studies abound, statistical econometric analyses specific to the *ceteris paribus* introduction of taxes were notably absent. Eck (1983), for example, attributed the oil and gas industry's weakening conditions in the early 80s to the growing tax burden in the nation. However, this period coincided with a sharp recession and subsequent economic fluctuations, complicating the isolation of tax effects (Investopedia, 2023). Despite favorable economic conditions later in the decade, a full industry recovery was hindered by plummeting commodity prices, particularly a significant drop in oil prices from $30 per barrel in 1982.[2] Put more strongly, Brannon (1975) even argued that tax incentives have such a high effect on energy activity that "there is a bias toward overdrilling inherent in a tax law which permits a full deduction."

However, many nonexperimental studies faltered in constructing *ceteris paribus* scenarios to econometrically attribute production decline to taxation. Renowned Resource Economist Margaret Slade (1984) was one of the first ones to provide such a study by investigating Hotelling's profitability framework. Examining case studies of a 10% royalty imposition in metal extraction, she revealed an 8% reduction in metal production, translating to a $78 million deadweight loss for a single mine. Slade affirmed that taxing diminishes the profitability of extraction, aligning with Hotelling's original conclusions. Yet, Slade introduced two considerations often overlooked. First, she highlighted the oversight in focusing predominantly on extraction effects, neglecting potential exploration effects measured not in production but in investment in new fields or future production. Second, the impact of tax changes on mining extraction depends on various factors—tax size, type, placement, effects on input/output prices, and extraction technology. This nuanced perspective underscores the complexity of tax effects in exhaustible resource economics beyond Hotelling's factorial model.

The underexplored interplay and reinforcement of factors shaping the relationship between higher taxation and lower production form a crucial gap in past and current research. Luckily, 21st-century literature has delved into panel data methodologies, examining pre and post-tax imposition on production, state tax revenue, and related outcomes. These contemporary approaches offer credibility advantages over previous methods, particularly in industries heavily reliant on volatile commodity prices. New panel data estimations of production and revenue better capture treatment effects of tax imposition, overcoming estimation challenges posed by fluctuating market conditions. This is exemplified by the observation of gasoline prices during the COVID-19

[2] Taken from the EIA, data can be retrieved at: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=f000000__3&f=m

pandemic, where despite variations across gas stations and states, the universal fall and rise in prices underscored the equalizing impact of market conditions.

Kunce's (2003) state-level panel data analysis on oil and gas extraction and severance tax incentives revealed that tax incentives "yield moderate to little change in oil drilling and production activity," but "substantially reduce state tax revenue." Contrary to earlier literature, Kunce warns against using tax policy to properly incentive the energy industry, emphasizing the need for states to exercise caution in evaluating "arguments asserting that large swings in oil field activity can be obtained from changes in severance tax rates."

Recent empirical studies have prompted a significant shift in economic theory, challenging the once unambiguous prediction that higher severance taxes lead to a decline in production activities. Gade, Maguire, and Makamu (2016) conducted a case study on Oklahoma's 2002 horizontal drilling severance tax incentive, revealing that the special reduction from seven percent to one percent did not significantly influence horizontal drilling in the state.

Similarly, Reimer, Guettabi, and Tanaka (2017) examined the impact of a tax increase in Alaska's 2007 ACES program, which tripled the tax liability for oil producers. Using aggregate-level panel data and a synthetic control study, they found no discernible differences in outcome variables of interest between Alaska and its synthetic control, challenging the conventional view of tax effects. Other studies, like Brown, Maniloff, and Manning (2020), approached the tax response of oil drilling through conventional regression discontinuity methods. Employing a border regression discontinuity method, they determined that energy firms' investment in U.S. oil projects exhibits inelastic responsiveness to changes in state tax rates. These nuanced findings underscore the need for a reevaluation of the assumed relationship between severance taxes and production activities.

CONTRIBUTION

While prior literature has predominantly focused on production and tax revenue as crucial metrics for assessing economic impacts of tax policy changes, it has often overlooked investigating the primary effects of a tax. This oversight stems from the established economic axiom that higher taxes inherently lead to lower production. This paper introduces new insights into the impact of severance tax incentives on county-level well completion, aiming to either affirm or challenge this foundational premise. The objective is not to determine whether tax policy affects production, as intended by the law, but rather to investigate whether tax policy fosters the creation of new wells—the law's mechanism for increasing production. Extensions of this work will delve into other variables such as production, employment, and actual taxes paid more fully.

LOUISIANA SEVERANCE TAX LAW

In Louisiana, the pursuit of profit has historically entailed the imposition of taxes. According to the Louisiana Department of Natural Resources (2023), the state initiated a severance tax on oil in 1910, a mere decade after the discovery of crude within its borders. Initially, this tax took the form of an occupational license, levied at a rate of $0.004 cents per barrel, during a time when oil prices hovered around a dollar. Over the years, severance taxes expanded both in value and complexity. By 1990, there were no fewer than five distinct severance taxes solely on oil extraction. However, Louisiana has been no stranger to exemptions from these levies. In 1986, the state legislature introduced the LEAP and STEP programs, granting substantial severance tax exemptions to stimulate drilling. Yet, assessments in 1988 revealed that drilling activity did not significantly increase beyond expectations, leading to the expiration of these programs (Troy and McClanahan, 1992).

But in 1994 the state tried again, passing a comprehensive bill that absolved oil and gas companies from tax liabilities—a unique move even at the time of this writing. Central to this legislative change for our analysis is the introduction of the New Discovery Well Exemption. This exemption granted a complete suspension of all severance taxes on oil and gas production from certified new wells, lasting for 24 months or until the well cost payout, whichever came first, at a time when the full tax rate for oil sat at 12.5% of total production value (DNR, 2023).[3] Crucially, the motivation behind this tax break aligned with Louisiana's objective of fostering economic growth and revitalizing the petroleum industry, which had experienced a significant downturn in the preceding year. The following study offers a straightforward method for evaluating the effects of severance tax incentives.

SAMPLE DESIGN AND EVALUATION

DATA

Data are gathered from Enverus, an energy data provider that tracks oil and gas data for energy companies and is often used by energy companies, which make up most of its customers. Enverus obtains information from state agencies, which for purposes of this paper are the DNR, Louisiana's Department of Natural Resources, and the RCC, the Railroad Commission of Texas.

WHY ARE TEXAS AND LOUISIANA GOOD COMPARABLES?

Among U.S. energy states, Texas' energy industry unequivocally stands as the closest relative to Louisiana's for a few reasons. First, their geographical proximity is evident, but more significantly, both states share similar geologic formations critical for oil and gas extraction. Second, their parallel development of oil and gas resources occurred roughly simultaneously. Third, due to their proximity, many companies operate in both states, while still allowing room for small independent operators, constituting a comparable proportion of all active wells over time. Finally, it is noteworthy that both states consistently rank among the top oil and gas producers in the country, whether considering offshore drilling or not. Given the sizable, comparable production capabilities of both states, we anticipate the influence of commodity prices on production levels will exhibit similar pronounced effects at comparable rates, distinguishing them from other states.

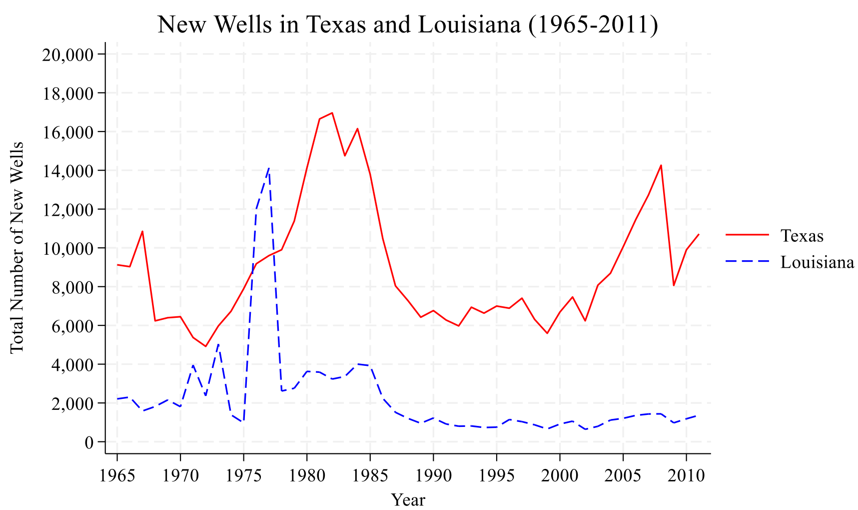
[3] According to the DNR, 12.5% was the "full" oil rate, meaning that is the rate at which an operator pays for their production of oil, which is given by the price at which a barrel of oil is sold times the quantity of oil barrels produced from the well. Other rates include an incapable (for wells that produce extremely little oil) at 6.25%, and other rates. Since the "full" oil rate accounts for the vast majority of production, and because new wells drilled are expected to pertain to this "full" rate, consideration is not given to these lesser rates. Gas production follows a volumetric tax, which is trickier to quantify in the confinement of this brief tax rate discussion. Nevertheless, for practical matters, it is estimated by the Center for Energy Studies that this rate is around 4%. DNR discussion can be retrieved at: https://www.dnr.louisiana.gov/assets/TAD/data/severance/la_severance_tax_rates.pdf while CES discussion can be retrieved at: https://house.louisiana.gov/wm/Docs/2022/NOV/Dr.%20Upton%20LSU%20-%20Overview%20of%20Mineral%20Revenues.pdf. Information about Texas's own tax regimen can be found at: https://comptroller.texas.gov/taxes/natural-gas/cong-rate-history.php

Oil & Gas Production by State and Square Mile Basis, 2022.

State	Square Miles	Oil (Million BBLs)	Rank	Per Square Mile (Total BBLs)	Rank	Natural Gas (Million MCFs)	Rank	Per Square Mile (Total MCFs)	Rank
Texas	261,232	1,842	1	7,050	1	11,325	1	43,352	5
Pennsylvania	44,743	5	15	110	15	7,483	2	167,248	1
Louisiana	43,204	36	10	843	7	4,025	3	93,166	3
Alaska	570,641	160	4	280	13	3,587	4	6,286	12
West Virginia	24,038	16	14	678	9	2,921	5	121,501	2
Oklahoma	68,595	152	6	2,210	4	2,744	6	40,009	6
New Mexico	121,298	574	2	4,735	3	2,727	7	22,478	7
Ohio	40,861	22	12	538	11	2,273	8	55,628	4
Colorado	103,642	158	5	1,520	5	1,821	9	17,571	8
Wyoming	97,093	91	8	937	6	1,229	10	12,659	10

This table presents the rankings of the top producers in the country. Some producing states, like North Dakota and California, are omitted from the table to save space, but their rankings are still reflected in the data. Texas holds the top spot in total land production of crude oil, with Louisiana ranking 10th. When offshore oil is considered, Louisiana secures the 2nd position, trailing just behind Texas. In the realm of natural gas, Texas maintains its 1st rank, while Louisiana holds the 3rd position.

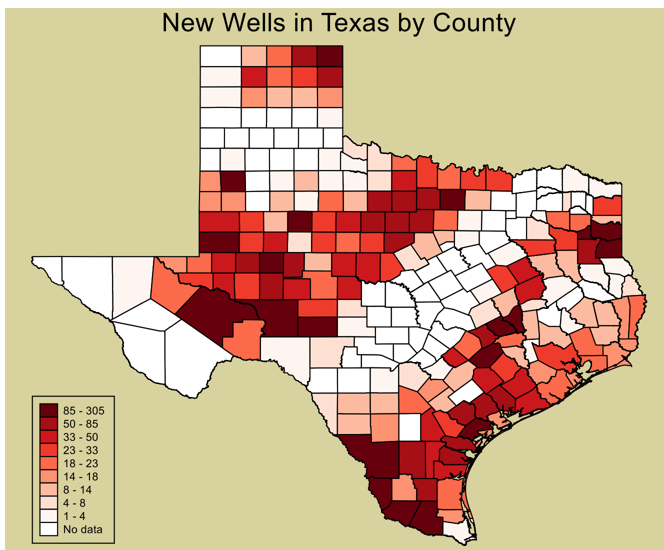
Examining the historical data of both states serves as a valuable gauge for assessing similarity, a crucial aspect of the differences-in-differences estimator, discussed later in this paper. Utilizing the original outcome variable data, I plot the new wells in Texas and Louisiana from 1965 to 2011, covering the entire time span of the dataset.



This graph illustrates the trajectory of new wells in Texas and Louisiana over the entire dataset.

Notably, a fixed gap emerges, largely attributed to Texas being approximately six times larger than Louisiana, with access to diverse hydrocarbon-rich basins. This fixed gap aligns with the inherent influence of a state's geology on hydrocarbon production. While the line graph reveals a generally close alignment between Texas and Louisiana over time, disparities in the volatility of the outcome variable are evident. Although both states exhibit concurrent movement in new wells, the pace differs. This variance is attributed to each state's distinct reaction to exogenous variables, primarily driven by fluctuations in commodity prices—crucial for hydrocarbon production profitability. However, the dissimilar volatility between Texas and Louisiana extends beyond commodity prices. It arises from a combination of factors, including each state's unique response to commodity price changes. Texas, for instance, with its diverse basins, experiences varied impacts based on the characteristics of each basin, contributing to the observed differences in volatility.

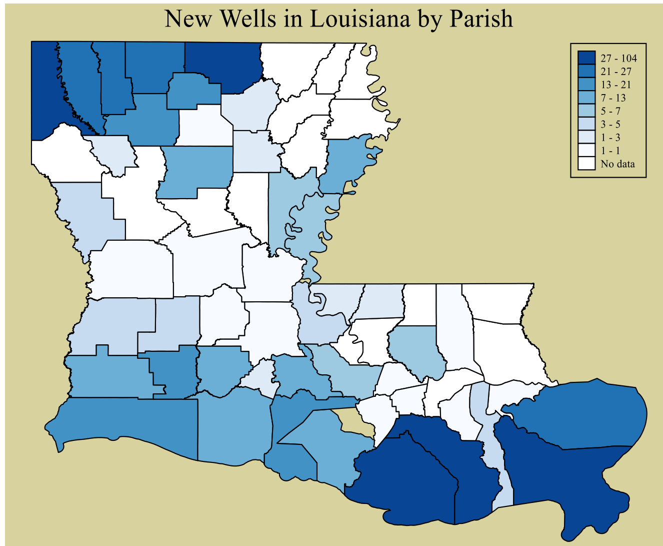
Utilizing geocoded data of all Texas counties in 1993, I map all the new wells to enhance the comparative analysis of Texas and Louisiana. The map visually depicts the distribution of new wells with a fixed range, revealing the crucial role of natural resources in estimating a county's hydrocarbon production. Notably, the intensity of new wells in 1993 varies significantly across the state, with heightened concentrations in the five basin regions: *Barnett Shale* (north, Dallas area), *Eagle Ford Shale* (spanning over 26 counties from the Mexican border through a 400-mile arc northeast of Texas), *Granite Wash* (Texas Panhandle), *Permian Basin* (northwest Texas extending into New Mexico), and *Haynesville Shale* (northeast Texas extending towards northwest Louisiana). These regions exhibit exceptionally high levels of oil and gas activity, owing to the distinctive geology of each basin, providing extensive reservoirs of hydrocarbons.



This map shows the varying intensity of new wells in Texas in 1993.

Interestingly, although the geology itself varies greatly from one basin to another, it leads to relatively similar activity levels—as measured by the number of new wells in each county. The *Permian Basin*, rich in oil, stands out as the most active basin in the country. The *Granite Wash*, characterized by a thick and fine-grained rock under pressure, represents a tight sand play. Conversely, the *Eagle Ford*, with significantly higher permeability, requires much less natural fracturing (fracking) and operates with a "more planar and less complex" system, as noted in The American Oil & Gas Reporter (King, 2011).

The following map similarly highlights the relationship between natural resource presence and 1993 new well intensity in Louisiana. The Haynesville contributes to above-average activity in northwestern parishes, while coastal parishes benefit from rich hydrocarbon deposits in nearby offshore locations, with extraction activities linked to the specific parish closest to these resources.



This map shows the varying intensity of new wells in Louisiana in 1993.

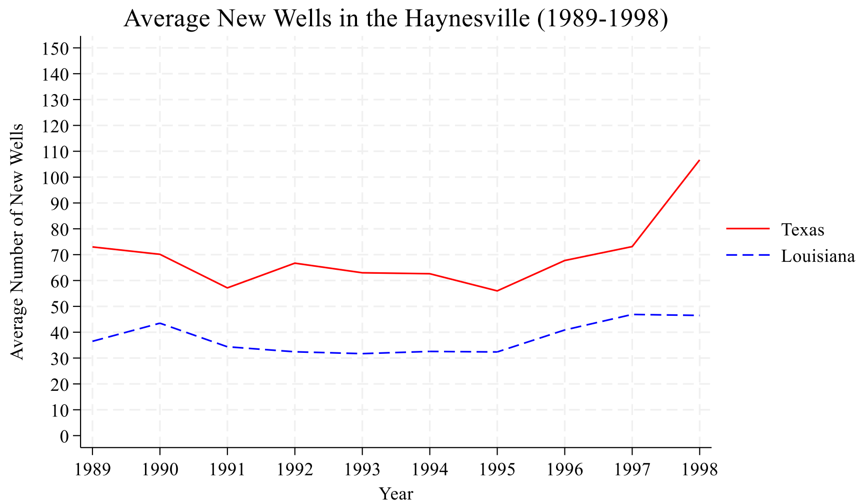
Conducting a straightforward state-to-state analysis encounters an empirical challenge due to the geological distinctions across basins, which diminishes the comparability between the states. To address this hurdle and achieve an apples-to-apples comparison of untreated and treated groups, a baseline model is crafted. This model specifically outlines new well completions within counties situated in the Haynesville Shale. Renowned for its unique formation of sedimentary rock over 10,000 feet below the surface, the Haynesville Shale stands as the third-largest natural gas field in the country, owing to its extensive reserves of tight gas.[4]

This map shows the Texas (left) counties and the Louisiana (right) parishes that are part of the Haynesville Shale.

The proximity of Texas and Louisiana renders them a highly comparable sample compared to other states. However, for a more precise examination of the causal impacts of tax law, I focus

[4] Map taken from the Natchitoches Parish Journal, map can be retrieved at: https://natchitochesparishjournal.com/2017/05/20/the-re-emergence-of-the-haynesville-shale/

on comparisons within the Haynesville Shale counties, which share identical geology, allowing for a more accurate comparison. The following graph illustrates this assumption.



This graph shows the parallel trends of the averaged outcome variable, new wells, in the Haynesville Shale 1989-1998.

Visualizing the trend helps understand the comparability between Haynesville counties. The graph shows that, for the most part, the trends in average new wells in the Haynesville of both states move tandem over the specified period. Following, I create a table that outlines the sample design of this visualization for the baseline Differences-in-Differences (DiD) model.

Table 1 - Sample Design And Response Rates

		Counties in:	
	All	TX	LA
Haynesville Comparisons, December 31, 1993			
Number of counties in state	320	255	65
Number of counties with new wells	286	224	62
Number of counties in sample frame	16	8	8
Percentage of all counties surveyed	5.0%	3.1%	12.3%

This table shows a sample design that specifies the counties in Texas and Louisiana in the Haynesville Shale.

The sample measures the number of new well completions pre-1994, which is carried throughout a period of interest from 1989 to 1998. There are a total of 160 observations in this sample frame. To study the composition of this sample further, I create a basic summary statistics table.

Table 2 - Summary Statistics of Key Variable

	Counties in:	
	TX	LA
Haynesville Comparisons, December 31, 1993		
Number of New Wells	504	222
Mean	63	27.75
SD	79.12	34.43
Var	6260.57	1141.64
Median	31.5	23
Maximum	227	104
Minimum	3	0
Maximum County	Panola	Caddo
Minimum County	Shelby	Natchitoches
Haynesville Comparisons, December 31, 1994		
Number of New Wells	501	228
Mean	62.63	28.50
SD	81.73	36.00
Var	6679.98	1296.29
Median	34	20.5
Maximum	245	109
Minimum	5	0
Maximum County	Panola	Caddo
Minimum County	San Augustine	Red River

This table shows summary statistics of interest for both 1993 and 1994, to picture the change in the outcome variable before and after treatment.

Analyzing sample summary statistics unveils two anticipated factors. First, the activity in Texas significantly surpasses that in Louisiana, more than doubling in both 1993 and 1994, albeit with a marginal reduction in the gap between these figures in 1994. This outcome aligns with expectations, considering the inherently larger scale of the energy industry in Texas. Throughout the industry's history in both states, Texas has consistently exhibited higher new wells per year than Louisiana within the Haynesville. The second expected factor pertains to substantial disparities in the number of new wells across counties, evident in the standard deviation, variance, and notably, the contrast between the maximum and minimum number of new wells in each state's counties. This straightforward observation underscores the significant variations in oil and gas activity even within the Haynesville.

NAIVE DiD

Finally, we observe the anticipated outcome of the treatment under consideration. A preliminary examination of an naive DiD model allows us to visually assess the disparities in new well counts in Texas and Louisiana before and after the treatment. In an naive DiD approach, pre-treatment differences in the outcome variable for each group (control or treatment) are contrasted with post-treatment differences in the same variable for each group, and subtract one from the other.

Let Y_{st} denote the number of new wells in state *s* in year *t*, where the subscript *s* indicates whether the data pertains to Texas or Louisiana, and subscript *t* indicates whether the data corresponds to 1993 (prior to the 1994 severance tax law amendment) or 1994 (following such an amendment). The DiD estimate, δ_{DiD} signifies the effect of tax incentives in Louisiana:

$$\delta_{DiD} = \left(Y_{TX,1993} - Y_{LA,1993}\right) - \left(Y_{TX,1994} - Y_{LA,1994}\right)$$

Using Table 2's information yields:

$$\delta_{DiD} = (504 - 222) - (501 - 228)$$

$$\delta_{DiD} = 9$$

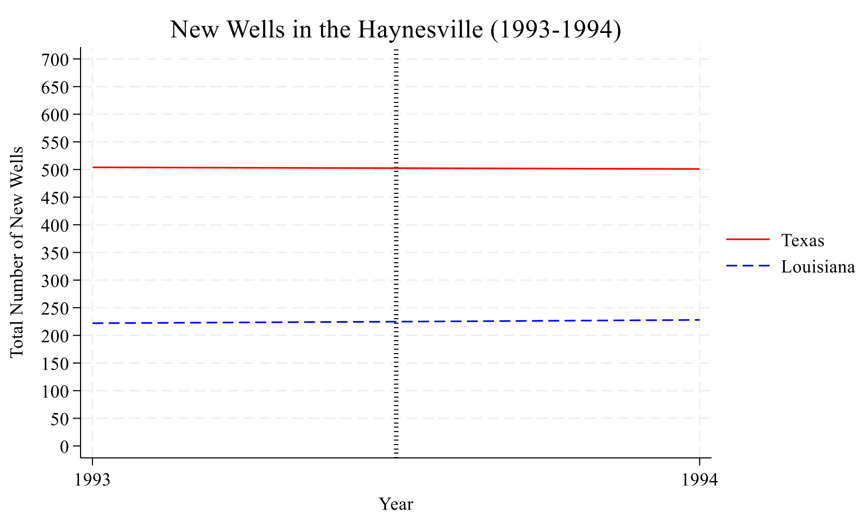
The result is that we find the *gap* between Texas and Louisiana shrunk by 9 new wells with the implementation of the treatment. Inherently, the same scenario can be represented in table form as:

Intuitive DiD			
	Pre	Post	Difference
Control	B_C	A_C	A_C-B_C
Treatment	B_T	A_T	A_T-B_T
Difference	B_C-B_T	A_C-A_T	(B_C-B_T)-(A_C-A_T)

Plugging in Table 2's information in the Naive DiD table yields:

Naive DiD (contd.)			
	1993	1994	Difference
Texas	504	501	-3
Louisiana	222	228	6
Difference	282	273	9

An alternative method to preview DiD treatment effects before engaging in regression analysis involves the use of another line graph, where I plot the number of new wells immediately before treatment (1993) and immediately after treatment (1994).



This graph illustrates the number of new wells in Texas and Louisiana before and after treatment, with a dotted, black vertical line tracing where "treatment" affected the samples empirically.

This illustration exposes the treatment's outcome of introducing 9 new wells. Ironically, this method, despite yielding the same numerical result, adds complexity to the visualization due to how marginal the overall treatment effect is.

BASELINE REGRESSION

Standard DiD regression employs three distinct independent variables to estimate effects on the outcome variable y_{it}, which represents the effects of such a regression. In this context, the treatment group, Louisiana, receives a dummy variable written $TREAT_s$, where subscript *s* explains that this varies across states; then, $TREAT_s$ controls for fixed differences between new wells in Texas and Louisiana pre-treatment, which are the fixed differences between the two. A dummy for post-treatment periods, $POST_t$, where subscript *t* indicates that this varies over time, is incorporated; then, $POST_t$ controls for the fact that conditions change over time for both treatment and control group, which is the trend. Lastly, an interaction term $TREAT_s * POST_t$ is added, indicating the causal DiD effect of treatment through the coefficient of this variable. The resulting DiD regression is generated as:

$$y_{it} = \alpha + \beta_0\, TREAT_s + \beta_1 POST_t + \beta_3 (TREAT_s * POST_t) + \varepsilon_{st}$$

$$TREAT = \begin{cases} 1\ if\ s = LA \\ 0\ if\ s = TX \end{cases} \quad POST = \begin{cases} 1\ if\ t \geq 1994 \\ 0\ if\ t < 1994 \end{cases}$$

Executing this type of DiD regression requires a final transformation. Tax policy changes of this nature are more likely to yield multiplicative effects rather than direct impacts on the absolute count of new wells in a treated area. To illustrate, consider the previous example highlighting the difference in industry size between Texas and Louisiana. Evaluating a tax policy implemented in one state versus the other is more accurately accomplished by calculating a percentage change in the number of new wells in a state, not the total count of new wells. Therefore, the DiD regression involves taking the logarithm of the number of new wells in both states before conducting the regression. Subsequently, the coefficient of the interaction term can be interpreted as the net percentage change in the number of new wells, serving as the causal outcome of the 1994 tax break. For mathematical ease, the actual transformation will depend on using an *asinh* function since it's necessary to overcome any zero measurements. *Asinh* is defined as an inverse hyperbolic sine transformation similar to performing a *log(x+1)* transformation to get rid of zeroes, strictly reliant on positive outcome variables which new wells do suffice.[5]

[5] For a more detailed discussion on using the *asinh* function versus taking the actual logarithm of a variable, see the following discussion in the World Bank Blogs' website: https://blogs.worldbank.org/impactevaluations/interpreting-treatment-effects-inverse-hyperbolic-sine-outcome-variable-and

BASELINE REGRESSION RESULTS

Baseline DiD Model	
treat	-0.081
	(0.84)
post	0.236
	(0.158)
change1994	-0.231
	(0.277)
cons	3.547***
	(0.667)

Results from a baseline, standard DiD regression in which we regress *treat*, *post*, and the interaction term, *change 1994*, on *logged new wells* yields non-statistical results of the interaction term, which econometrically provides empirical evidence that the amendment to Louisiana's severance tax law, i.e., the tax break, did not lead to statistically significant new wells in the state of Louisiana. Furthermore, it is surprising, though not substantially so, that the regression produced a negative coefficient for the interaction term, which would suggest negative effects of a tax break. Nonetheless, this is not evidence of support of such a claim, given the statistically insignificance of the coefficient. What it does confirm is that, for all matters, the tax break definitely did not have positive effects.

FULL DiD REGRESSION

The most accurate causal estimates of DiD require more sophisticated regression analysis. Sophisticated regression DiD, for example, incorporates narrower data to be regressed. In addition, this full DiD regression will include more accurate estimates of time-effects over the study's horizon, which helps incorporate trends and will facilitate statistical inference. This new regression replaces *treat*, which looks at state fixed effects, with county fixed effects. Similarly, it replaces *post* with time fixed effects, by establishing dummies throughout the period of interest. In other words, this regression can be defined as:

$$y_{it} = \alpha + \beta change1994_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

where y_{it} represents the percent change in new wells due to treatment, $change1994_{it}$ represents is a dummy variable that takes value 1 if county i is in both the Haynesville and in Louisiana in year t, μ_i represents county fixed effects, and λ_t represents time fixed effects. Controlling for county fixed effects allows for more granular analysis of the impact of the 1994 severance tax amendment versus data analysis on state-wide basis. Similarly, controlling for time fixed effects allows control on commodity price volatility.

FULL DiD REGRESSION RESULTS

Full DiD Model	
change1994	-0.231 (0.299)
cons	4.438*** (0.218)

Full DiD regression yields similar results. In fact, the coefficient of the interaction term, *change1994*, is the same, with a slight increase in its corresponding error term. In conclusion, adding county and time fixed effects gives more accurate evidence that the 1994 tax break did *not* have a statistically significant effect on the logged number of new wells in Louisiana.

PARALLEL TRENDS

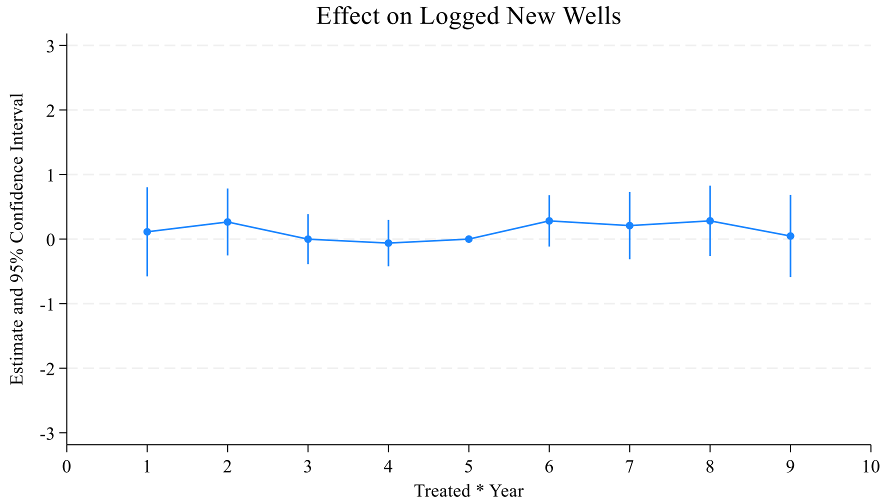
An econometrics study following a DiD approach is not complete without discussion of the parallel trends assumption. In lieu of treatment, it is assumed, as it was shown at earlier sections of this paper, that the trends in the outcome variable for the treatment and control group are parallel to each other. In other words, they move together over time. Then, let Y_0 represent the outcome variable, and *D* be the belonging to the treatment or control group. Then:

$$E(Y_t|D=1) - E(Y_{t-1}|D=1) = E(Y_t|D=0) - E(Y_{t-1}|D=0)$$

where $D = \begin{cases} 1 \; if \; treatment \; group \\ 0 \; if \; control \; group \end{cases}$

In simpler terms, when neither the treatment nor the control group receives treatment, the change in the treatment group is anticipated to mirror the change in the control group. Assessments of Y_t and Y_{t-1} are used to explain the pre-treatment trends in a group's outcome variable. Mathematically, this is the parallel trends. However, while visualizations of the pre-treatment periods are valuable for grasping a variable's parallel trends, it is rarely plausible for pure parallel trends to exist. In essence, the change in the treatment group subtracted from the change in the control group will seldom be zero, depending on how a researcher chooses to analyze the data. To mathematically test parallel trends, event studies are employed. These studies plot a regression's coefficient on the y-axis, with confidence intervals indicating whether the parallel assumption holds. If the upper and lower bounds encapsulate zero on a Cartesian plane, implying that plotted coefficients are near zero, a researcher can reasonably assume parallel trends.

In adherence to the conventional method of constructing an event study, I conduct regressions for all years within the 1989-1998 period and visualize their coefficients on a Cartesian plane. To prevent collinearity, all observations in 1993 are standardized to receive a value of 1. Consequently, when regressed, the coefficient for 1993 (#5) is zero.



This graph depicts the event study, serving as the test to the parallel trends assumptions, as well as visualization of the lack of a statistically-significant treatment event, which would be illustrated by diverging trends post-treatment. Here, the x-axis represents the period of interest (1989-1998), so that #6 is 1994, while the y-axis represents each year's interaction coefficient.

The event study affirms two key findings. First, it validates the parallel assumption, as evidenced by coefficients being remarkably close to zero and confidence intervals encompassing zero. This suggests that Texas and Louisiana counties exhibited parallel trends before treatment. Second, both the pre-treatment period (#1-5) and the post-treatment period (#6-9) include zero. In essence, the trend before treatment is indistinguishable from the trend after treatment, signifying the absence of treatment effects.

ROBUSTNESS CHECKS

Further evidence of no treatment effects is developed through robustness checks. The same DiD regression approach is followed, this time using a larger dataset and parsing county data differently. I separate the data on new wells in Texas and Louisiana in four different blocks according to specified criteria:

Blocks of Data	
Block 1	All counties in TX & LA
Block 2	Counties in TX-LA border
Block 3	Counties outside of a major basins in TX & LA
Block 4	Parishes in LA within and outside the Haynesville

Creating a block's respective sample design table results in:

Table 3 - Sample Design And Response Rates			
		Counties in:	
	All	TX	LA
Block 1, Whole State-And-State Comparisons, December 31, 1993			
Number of counties in sample frame	320	255	65
Number of counties without any new well completions (no data)	70	57	13
Final number of counties taken into consideration	250	198	52
Percentage of all counties surveyed	78.1%	77.6%	80.0%
Block 2, Texas & Louisiana Border Comparisons, December 31, 1993			
Number of counties in sample frame	17	10	7
Number of counties without any new well completions (no data)	1	1	0
Final number of counties taken into consideration	16	9	7
Percentage of all counties surveyed	94.1%	90.0%	100.0%
Block 3, Texas & Louisiana Comparable Counties, December 31, 1993			
Number of counties in sample frame	163	107	56
Number of counties without any new well completions (no data)	33	21	12
Final number of counties taken into consideration	130	86	44
Percentage of all counties surveyed	79.8%	80.4%	78.6%
Block 4, Louisiana More & Less Treated Parish Comparisons, December 31, 1993			
		LT	MT
Number of counties in sample frame	65	9	56
Number of counties without any new well completions (no data)	13	1	12
Final number of counties taken into consideration	52	8	44
Percentage of all counties surveyed	80.0%	88.9%	78.6%

Table 3 defines the sample design for all blocks.

Similarly, studying the composition of the sample further, a basic summary statistics table results in:

Table 4 - Summary Statistics of Key Variable

	Counties in:			
	TX	LA	TX	LA
Block 1, Whole State-And-State Comparisons	December 31, 1993		December 31, 1994	
Number of New Wells	6940	813	6632	734
Mean	35.05	15.63	34.19	14.68
SD	46.20	21.79	43.24	18.83
Var	2134.43	474.75	1869.59	354.63
Median	19	6	20	7
Maximum	305	104	245	109
Minimum	1	0	1	0
Maximum County	Webb	Caddo	Panola	Caddo
Minimum County	Crosby	Evangeline	Angelina	Madison
Block 2, Texas & Louisiana Border Comparisons	December 31, 1993		December 31, 1994	
Number of New Wells	444	186	431	181
Mean	49.33	26.57	47.89	25.86
SD	74.71	36.60	78.99	38.37
Var	5582.25	1339.62	6238.86	1472.48
Median	16	13	13	8
Maximum	227	104	245	109
Minimum	1	0	7	0
Maximum County	Panola	Caddo	Webb	Caddo
Minimum County	Shelby	Vernon	Sabine	Sabine
Block 3, Texas & Louisiana Comparable Counties	December 31, 1993		December 31, 1994	
Number of New Wells	2270	510	2414	474
Mean	22.93	9.62	24.38	8.94
SD	29.05	14.74	31.50	11.86
Var	843.72	217.35	992.18	140.71
Median	15	3	16	3
Maximum	179	68	142	46
Minimum	0	0	0	0
Maximum County	Zapata	La Salle	Zapata	Plaquemines
Minimum County	Hunt	Madison	Franklin	Vernon
Block 4, Louisiana More & Less Treated Parish Comparisons	December 31, 1993		December 31, 1994	
	LT	MT	LT	MT
Number of New Wells	222	510	228	474
Mean	27.75	9.62	28.50	8.94
SD	33.79	14.74	36.00	11.86
Var	1141.64	217.35	1296.29	140.71
Median	23	3	20.5	3
Maximum	104	68	109	46
Minimum	0	0	0	0
Maximum County	Caddo	La Salle	Caddo	Plaquemines
Minimum County	Natchitoches	Madison	Red River	Orleans

Table 4 depicts the sample summary statistics for each block of data, for the period before treatment (1993) and the period after treatment (1994).

Then, each of these blocks is passed through the full DiD regression. I test the statistical significance of the results and the parallel assumptions using both county and time fixed effect, resulting in:

Robustness Checks				
	Block 1	Block 2	Block 3	Block 4
	Robust1	Robust2	Robust3	Robust4
1994change	-0.131	0.362	-0.043	-0.199
	(0.105)	(0.488)	(0.126)	(0.255)
p-value	0.210	0.459	0.732	0.435
Data	224 TX, 62 LA	9 TX, 7 LA	99 TX, 53 LA	8 LT, 53 MT
n	2860	160	1520	610
Types of FE	Year, County	Year, County	Year, County	Year, County
Passes trend?	Yes	Yes	No	No
Sig effects?	No	No	No	No

A concise robustness check table validates the statistically insignificant impact of the treatment. Conducting regressions on all Texas and Louisiana counties, as well as exclusively on border counties, yields consistent findings when tested for parallel trends, ensuring reliability. Notably, the coefficient for the regression in Block 2 is positive. Although not statistically significant, this positive coefficient is noteworthy for interpretation. Previous regressions produced negative coefficients, potentially suggesting evidence that the tax break had adverse effects—a departure from economic theory. The positive coefficient in Block 2 undermines this claim, reinforcing the argument that the tax break did not significantly influence the number of new wells in Louisiana.

Blocks 3 and 4 produce similar outcomes but lack meaningful interpretation due to the absence of parallel trends. This result is somewhat anticipated for several reasons. First, Block 3 involves a subjective classification method for counties, excluding Texas counties outside major basins and Louisiana parishes within major basins. However, this approach raises concerns about comparability as Texas, with numerous basins, contrasts sharply with Louisiana, dominated by the Haynesville Shale. Second, Block 4 encounters analogous challenges. The geological disparities between parishes within and outside the Haynesville Shale hinder the establishment of parallel trends. Unlike Block 1, which effectively averages these differences, a direct comparison of new wells in Louisiana falls short in achieving parallel trends.

POSSIBLE EXPLANATIONS, LIMITATIONS AND FUTURE WORK

Economics is governed by numerous principles, such as the inverse relationship between price and quantity demanded. Yet, exceptions exist, and certain goods, like life-saving drugs, showcase perfectly inelastic demand. Similarly, macroeconomic exogenous factors can modify the expected outcomes, challenging conventional wisdom. This paper uncovers a discrepancy in economic theory regarding the effects of tax breaks on exhaustible resource extraction. By shedding light on such anomalies, it aims to contribute to the ongoing evolution of economic theory.

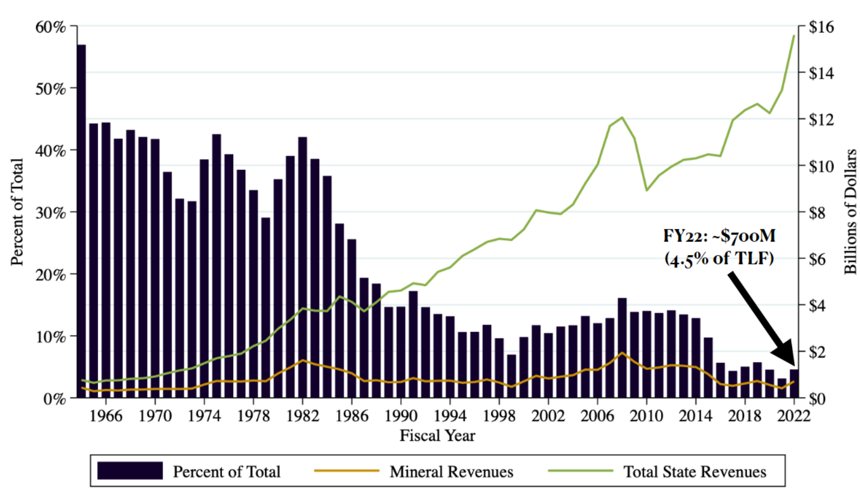
Slade's (1984) comprehensive analysis delves into the nuanced impact of tax breaks on natural resource extraction. She emphasizes that technology plays a pivotal role, yielding varied effects based on regional reliance and access to distinct technologies. In other words, the same tax policy can have different impacts depending on a region's technology. Additionally the high capital costs associated with new well development may also contribute to a muted response to tax policies—an aspect acknowledged in industry discussions but warranting further scholarly exploration. Another potential factor contributing to nonsignificant effects is the presence of time lags in policy impact, an avenue for future research. Despite this, the extensive time horizon (1989-1998) considered in studying the 1994 tax break, encompassing diverse models and datasets, weakens arguments about future causal effects solely due to time lags. Rather, this study reinforces the notion that the abundance of natural resources and their market prices outweigh the influence of severance taxes on stimulating activity.

A suggested avenue for future research involves conducting additional experimental case studies on policy changes across the country, mirroring the methodology employed in this paper. While county-level data was utilized here, leveraging geocoded information could enhance the analysis by allowing for a more granular examination at the census level. Consideration of monthly panel data, as opposed to annual data, may yield more precise results, especially since several tax breaks are implemented at specific points in the year rather than uniformly at the beginning or end of it.

IMPLICATIONS AND REITERATION OF CONCLUSIONS

This study implies that, although the 1994 tax break did not result in new wells, it logically contributed to a decline in tax revenues from new wells in Louisiana. As the tax break cannot be linked to an increase in oil and gas activity, it is anticipated to have caused a reduction in severance taxes from new wells in Louisiana, *ceteris paribus*. The graph below, taken from the Center for Energy Studies at Louisiana State University, illustrates the energy industry's tax contribution to the state and the significant decrease in the share of tax revenue from it throughout history. Given the substantial decline in tax revenue, careful consideration should be given to implementing severance tax breaks and evaluating whether the revenue loss is significant enough to hinder the implementation of such breaks.

Total State Tax Revenue in Louisiana



Source: Mineral Revenues in Louisiana. LSU Center for Energy Studies. Includes update for recent years.

This graph shows the importance of carefully selecting tax policy. While Louisiana's economy has diversified since the late 60s, a contributing factor in the industry's declining share of total tax revenues, it is absolutely indisputable that the emergence of new tax breaks has contributed to this decline.

This paper empirically finds that the 1994 New Discovery Well exemption did not lead to new wells in Louisiana, *ceteris paribus*, compared to its sister state Texas. Study results suggest severance tax breaks act as money transfers, rather than production hurdles which cause deadweight loss. While there are no current studies regarding the tax loss from this drilling incentive, the Louisiana Legislative Auditor reported that the state had loss upwards up $1.1 billion in a four-year period from a similar drilling incentive, indicating that the loss in revenue could be substantial, assuming these incentives had similar effects (Purpera, 2015). Nevertheless, this study does not suggest that higher severance taxes compose a "free lunch," since every penny into a state's tax bucket must come from a company's shareholders, its customers, or its employees. While this study provides evidence of broader implications in tax policy in the energy industry, it is neither my conclusion nor my intention to suggest that all tax incentives have no statistically significant effects, i.e., are useless. Fair conclusions from this paper should be limited to discussions about the tax policy regimen in the state of Louisiana, and more specifically the 1994 tax break.

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