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# Oklahoma Oil and Gas Severance Taxes: A Comparative Analysis

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# Oklahoma Oil and Gas Severance Taxes: A Comparative Analysis[1]

**Abstract.** Oklahoma assesses a production tax of seven percent on the extraction of oil, natural gas, and other minerals. However, since July 2002, it has taxed production from horizontal wells at only one percent for the first 48 months of production. This is a significant tax incentive relative to its neighboring states, Texas and Kansas, particularly considering the limited evidence as to the effectiveness of severance tax incentives for increasing in-state development of immobile resources. This paper empirically examines whether the severance tax incentive has encouraged horizontal development in Oklahoma relative to Texas and Kansas. Our findings indicate that the Oklahoma tax exemption has not had a significant influence on horizontal drilling.

Keywords: Severance Tax, Oil and Natural Gas, Hydraulic Fracturing
JEL Codes: H71, H73, Q32, Q35, Q48

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## I. **Introduction**

The development of horizontal drilling and hydraulic fracturing technologies has triggered a resurgence in oil and natural gas production in the United States. State governments levy different types of production taxes on these unconventional wells, at different rates, with a diverse mix of exemptions, deductions, and incentives. These tax policies are designed to encourage industry activity, development, job creation, and to enhance economic benefits to the state.

The state of Oklahoma has carried one of the lowest effective tax rates on horizontal wells when compared to peer states.[3] The low rate is partly triggered by a four-year production tax holiday that reduces the tax on newly completed horizontal wells from seven to one percent in the first 48 months of production. This tax break has a significant impact on state revenues, but its effect on drilling activity is an open question. This paper empirically examines whether the horizontal wells severance tax incentive has encouraged horizontal drilling activity in Oklahoma relative to Texas and Kansas.

Previous literature has examined the effects of the state's political environment on oil and gas development and found that price rather than politics determined oil and gas development (Maguire 2012). On federal lands, the regulatory environment was a key factor in oil and gas leasing (Maguire 2016).[4] Other work has examined the effects of oil and gas development on regional economic outcomes such as unemployment with mixed results (Lee 2015; Munasib and Rickman 2015; Weinstein 2014; Weber, 2014; Weber 2012; Michaels, 2010).

[3] Throughout the paper, references to horizontal drilling and horizontal wells, refer to those wells that use a combination of horizontal drilling and hydraulically fracturing to access unconventional oil and natural gas resources. These are commonly referred to as fracked or hydraulically fractured wells. See Fitzgerald (2012) for a detailed discussion of the economics of fracking.

[4] Oklahoma, Texas, and Kansas do not have significant federal lands. (BLM, Public Land Statistics)

To our knowledge, our study is the first to examine the effects of Oklahoma horizontal well tax incentives. The subject is of interest as Oklahoma offers a generous exemption on horizontal production while other neighboring states, such as Texas and Kansas, do not. Providing tax incentives would be considered an effective policy for the state if it stimulates development. However, the alternative would suggest that additional natural gas production is profitable to firms regardless of the incentives and extending tax breaks only harms Oklahoma's economy by reducing its tax revenue.

The contemporary Tiebout (1956) tax competition literature devotes much attention to the question of whether or not state tax differentials have an empirical impact on the location of economic activity. Theoretically, when a jurisdiction lowers its tax rate on a mobile capital base, the net of tax return rises above that available elsewhere, and capital flows in until net of tax returns are equalized across all jurisdictions. The resulting incentive is that a lower tax rate on capital relative to surrounding jurisdictions has the potential to encourage economic activity as part of state development policy. Thus, states utilize exemptions, deductions, and other tax incentives in an effort to stimulate economic development.

Most of the empirical work on state tax incentives centers on the effects of state taxation on geographically mobile capital with mixed results. Evidence ranges from a positive influence of incentives on location (Bartik 1985; Helms 1985; Bartik 1989; Papke 1991; Papke 1994; Holmes, 1998; Strauss-Kahn and Vives, 2009) to a small effect or none at all (Schmenner 1982; Plaut and Pluta 1983; Carlton 1983; Schmenner, Huber and Cook 1987; Blair and Premus 1987; Dabney 1991; Tannenwald 1996; Lee 2008). Literature reviews also suggest that the results are somewhat ambiguous (Wasylenko 1999; Buss 2001; and Arauzo-Carod, et al 2010).

Examination of the effects of state severance tax incentives on oil and gas drilling and production activity requires an alternative perspective. Nonrenewable natural resources are geographically immobile. Firms engaged in oil and gas production cannot change location to the extent that their main capital consists of the immobile reserve base. Therefore, state severance tax preferences cannot encourage relocation across jurisdictions. Firms can respond, however, by altering the level and timing of extraction as state tax policy changes.

The introduction of horizontal drilling along with hydraulic fracturing technology has expanded the ability of firms to profitably recover natural gas and oil from unconventional sources.[5] However, horizontal drilling comes with higher costs relative to conventional drilling. A horizontal well can cost between 25 to 300 percent more to drill and complete. Due to the difference in cost structure, horizontal drilling is restricted to geological plays with low permeability where vertical wells would not be considered economically viable (Helms, 2008).

There have been few empirical studies that look at how firms in nonrenewable resource industries respond to state tax incentives. They have included simulation and/or econometric studies of the relationship between a specific tax policy and natural resource exploration and production. For example, Kunce, et al (2003) simulate the effects of state tax policy changes in Wyoming on both the level and timing of exploration and output in the state. The simulation is based on the standard model of natural resource supply from Pindyck (1978) and estimates exploration costs, production of reserve additions, and extraction costs for Wyoming while incorporating the specific tax parameters that are of interest to the industry. In contrast, Leighty and Lin (2012) estimate field-specific cost functions based on cost and production data from

[5] INTEK, Inc., 2011, Review of emerging resources: U.S. shale gas and shale oil plays, Energy Information Administration, DOE. Web accessed 05 August 2015. http://www.eia.gov/analysis/studies/usshalegas/pdf/usshaleplays.pdf

Alaska's North Slope and use those estimated equations to model production decisions and simulate the impact of tax policy on the production rate.

The conclusions drawn from these studies and others suggest that the volume of oil and natural gas production and drilling activity is insensitive to severance tax rate changes (see also Helmski-Oskou, et al 1992, Kunce 2003, Chakravorty, et al 2010, Kaiser 2012).

In this paper, we build on this existing literature by examining whether Oklahoma's severance tax reduction has led to disparate effects for horizontal versus conventional drilling as compared with its neighboring states. These states, particularly Texas, share a similar oil and gas resource potential, which we will use in this paper in order to isolate the effect of the tax policy on development from differences in development due to resource disparities. Our findings suggest that the Oklahoma tax exemption has not increased horizontal drilling activity.

## II. Background

### 11.1 Oil and Natural Gas Resources

Oklahoma, Texas and Kansas are not only among the states to apply the lowest oil and gas production taxes in the nation, but are also among the major contributors of oil and gas in the country. These states are selected in this study for their regional proximity as well as their long history of oil and gas production. For the period 1982 to 2013, Texas had the highest production (onshore) of natural gas, Oklahoma comes in third position and Kansas is seventh.[6] The Hugoton gas field which contains one of the largest producing natural gas fields in the U.S. is located in southwestern Kansas and includes parts of the Texas and Oklahoma panhandles. In 2013, Texas accounted for 29 percent of the country's marketed gas production, well above any other state.

[6] U.S. Energy Information Administration. 2015. Natural gas gross withdrawals and production. Authors' calculations. http://www.eia.gov/dnav/ng/ng_prod_sum_a_epg0_fpd_mmcf_a.htm

Oklahoma accounted for 7.1 percent of the U.S. natural gas production and 8.4 percent of the U.S. marketed production in 2013. Oklahoma is one of the leading states in terms of the number of gas wells drilled, only behind Ohio, Pennsylvania, West Virginia and Texas. From 1995 to 2013, Kansas ranked ninth in the number of producing gas wells. Texas is also the leading oil producing state with production levels sometimes exceeding the federal offshore areas. In 2013, Kansas ranked tenth in crude oil production among the 50 states, while Oklahoma ranked fifth in crude oil production in the nation in 2014.[7]

**II.2 Horizontal drilling and Hydraulic fracturing**

Horizontal drilling combined with hydraulic fracturing technology allows producers to develop deposits of oil and natural gas that are trapped in deep shale and tight sands formations often one mile below the surface. To access the resources, producers drill vertically until they reach the reservoir, the kickoff point, and then the wellbore starts curving horizontally. The drill pipe is removed and replaced by a steel casing pipe through which cement is pumped in order to isolate the wellbore from any freshwater source. Hydraulic fracturing consists of pumping a mixture of water, sand and chemicals under controlled conditions into deep underground shale or tight sands formations. The injected sand and fluid remain in the rock to leave cracks open so that when the pump pressure is released the oil or natural gas can flow into the horizontal casing and then up to the wellbore.[8]

The concept of hydraulic fracturing was developed in 1891, and implemented for the first time in Texas around 1929, but it only become commercially viable in the 1980s. The cost of horizontal drilling is generally higher than the conventional vertical drilling, up to 300 percent.

[7] http://www.eia.gov/state/

[8] American Petroleum Institute. 2009. Hydraulic fracturing operations, well construction and integrity guidelines. API Guidance document HF1. Web accessed 09 September 2015. http://www.shalegas.energy.gov/resources/HF1.pdf

However, when financially viable a horizontal drill can produce 2.5 to 7 times the rate and reserves of conventional wells and allow producers to access once economically infeasible resources (King, 1993). Since the early 2000s the price of natural gas and other fuels have been steadily rising making more expensive and complicated methods like hydraulic fracturing more attractive.[9] It should be noted that gas prices have declined since 2008 and oil prices have fallen significantly recently, leading to a reduction in oil and gas development activity, but this decline occurred largely after our sample period, which ends in 2013. (Arezki and Blanchard, 2014; Asche, Oglend and Osmundsen, 2012; Baffes et al., 2015).

### II.3 State Severance Tax Structures: Oklahoma, Texas, Kansas

Tax structures are not easy to compare as they vary across states and at different levels of government authority, i.e. federal, state, and local jurisdictions. To address this problem, the literature often makes use of the effective tax rates, taxes divided by production value, in order to account for various form of tax incentives granted by states. For example, including severance, property, income and sale taxes, Oklahoma, Texas and Kansas have in FY 2010-2011 effective tax rates between 7.4 and 8.4 percent.[10] Although their effective tax rates are similar, there are major differences in their tax structures. For example, Kansas levies high property taxes while Oklahoma does not, and Texas does not levy a corporate income tax while Oklahoma does. In addition, counties can impose property taxes on drilling companies, which are independent of the well economic value, but the revenue from taxation on structures and equipment are generally not as large as the revenue obtained from the severance tax (Kunce & Morgan, 2005). Also, state and federal corporate income taxes are levied on the firm profit and have very little effect on the

[9] U.S. Energy Information Administration. 2015. U.S Natural Gas Prices. Wellhead price from 1922 to 2012.
[10] Carey, M. May 11, 2014. Effective severance tax rates [Memorandum]. Colorado Legislative Council. Denver, CO.

firm's decision to explore and produce. They are more likely to affect future drilling investments and output, rather than the actual number of drilling permits issued (Deacon, 1993).

States grant numerous exemptions and credits to oil and gas producers (Kunce, 2003). For example, Oklahoma, Texas and Kansas offer exemptions for inactive wells for at least a certain period after the date of certification of two or three years of inactivity. Their tax structures also differ on other features. The Oklahoma gross severance tax rate on gas is 7 percent when the price of gas exceeds $2.10 per thousand cubic feet (Mcf). The state offers exemptions on severance tax for recovery projects, inactive wells (reestablished production), horizontally drilled wells, new discovery wells, and seismic exploration. Since 2002, Oklahoma has exempted gas production from horizontal drilling to claim only 1 percent for the first four years of production.[11] It is the most generous exemption provided by the state which can be claimed by drilling companies for unlimited production for the first forty-eight months regardless of the current market price.

Like Oklahoma, Texas has taxed oil and gas production at a rate of 7.5 percent of the market value of gas produced and 4.6 percent of the market value of oil produced.[12] (See Appendix: Table 2A for detailed information on state tax incentives for Kansas, Oklahoma, and Texas.) The state has provided natural gas tax incentives since 1989 in the form of an exemption for production of gas with higher drilling costs ("high cost gas") and inactive wells, both for a period of ten years. The tax benefits have been extended several times and made permanent in 2003. More important to our identification, the tax code does not include production tax exemptions for horizontally drilled wells in oil and gas production.[13]

[11] Oklahoma Statutes. Chapter 68 §1001 (E).
[12] Texas Tax Code. Chapter 201 section 52 (A).
[13] Other exemptions comprise gas production from low producing wells on and after 2005 and gas production in association with geothermal energy production after 2009.

Kansas has a severance tax rate of 8 percent on the gross value of oil and gas, implemented on April 1983.[14] The state provides two years of severance tax exemption for oil and gas extracted from new pool and fifteen years tax exemption for inactive wells. Gas production for enhancement recovery projects, new discovery wells, and seismic exploration are exempt for seven years but subject to the market price of gas. Like Texas, Kansas does not provide any specific tax incentives for horizontal drilling.

Overall, and essential to our identification strategy, unlike Oklahoma, Texas and Kansas do not provide tax incentives that specifically target horizontal drilling. Also, these neighboring states have not enacted a major change in their tax code for other types of production. Texas has not revised chapter 201, its administrative code on tax exemption for natural gas, since 1997, except for minor modifications in 2005 and 2009 (House Bill 2161 and Senate Bill 997). Similarly, Kansas has not introduced new exemptions since 1998 (Kansas statutes 79-4217). There are myriad of minor regulatory changes, but we didn't find any major regulatory changes that would confound our findings.[15]

While it is clear that increases in gas production lead to increases in tax revenue, it is not clear that the reduction in Oklahoma's severance tax rate for horizontal wells will lead to additional development. This paper focuses on the empirical question of whether the tax credit on horizontal drilling in Oklahoma led to increased drilling permits relative to Texas and Kansas.

## III. Data

[14] Kansas Statutes. Chapter 79 Article 42 § 17(B).
[15] Oklahoma Corporation Commission: Chapter 10 - Oil and Gas conservation (OAC 165:10-3-10) in http://www.occeweb.com/rules/rulestxt.htm. Railroad Commission of Texas: Chapter 3 – Oil and Gas Division (TAC 16:1.3) in http://www.rrc.state.tx.us/legal/rules/current-rules/; Kansas Corporation Commission – General rules and regulations for the conservation of crude oil and natural gas (KAR 82:3) in http://kcc.state.ks.us/conservation/cons_rr_091615.pdf

For our analysis, the number of oil and natural gas permits issued serves as our measure of oil and gas development. The steps in the development process include permitting, drilling, completion, and production. In each step after the initial drilling permit is issued, firms face additional costs and resource constraints in order to complete the well development process. For this reason, the number of permits issued provides the best measure of the influence of a tax policy on a firm's initial oil and gas development decision without the confounding effects of subsequent changes in development costs and other constraints facing these firms. The permit provides the firm with authorization to drill in the designated location abiding by any state restrictions regarding drilling methods.[16] Therefore, the measure provides a complete set of oil and gas development activity; for each oil or natural gas well drilled in a state, the state's oil and gas commission requires a permit.

The drilling permit data for the analysis were collected from the relevant state oil and gas and or geologic agency (The Oil and Gas Division of The Oklahoma Corporation Commission, The Railroad Commission of Texas, and The Kansas Geologic Survey).[17] Each drilling permit is categorized by the relevant agency as conventional or horizontal. In addition, permits are designated as oil, natural gas, or simply oil and gas.[18] Data are collected for the sample period 1995-2013 and aggregated to the month-county level for each county during the sample period. In addition to permit data, we also collected data on monthly oil and natural gas prices by state

[16] The permits typically require that drilling begin within 6 months to a year from the issue date and expire if not used. The number of permits issued and the number applied for are essentially the same. For example in Oklahoma over the sample period only 20 permits were rejected. In order to eliminate those few cases where permits were denied, we used only approved permits in the measure.

[17] Permits for oil and gas drilling and recompletion were considered. Permits for other wells such as injection wells are excluded from the analysis. For Texas, only onshore permits are analyzed.

[18] For permits for oil and gas drilling that were not categorized separately as oil or natural gas, we defaulted to a joint oil and gas category.

from the Energy Information Association (EIA).[19] Data on population and personal income at the county-year level were collected from the Bureau of Economic Analysis (BEA). Lastly, information on whether a county is a metro or non-metro and whether the counties were consistent oil and gas producing counties were collected from the Economic Research Service of the United States Department of Agriculture (ERS-USDA).

## IV. Empirical Specification

The paper empirically examines whether the severance tax reduction in Oklahoma in 2002 has led to an increase in the amount of horizontal drilling relative to Texas and Kansas. The empirical analysis is focused on measuring the influence of the horizontal drilling severance tax policy in Oklahoma on the number of drilling permits issued and how this may have differentially impacted horizontal and conventional drilling.

The main specification of the fixed effects model is:

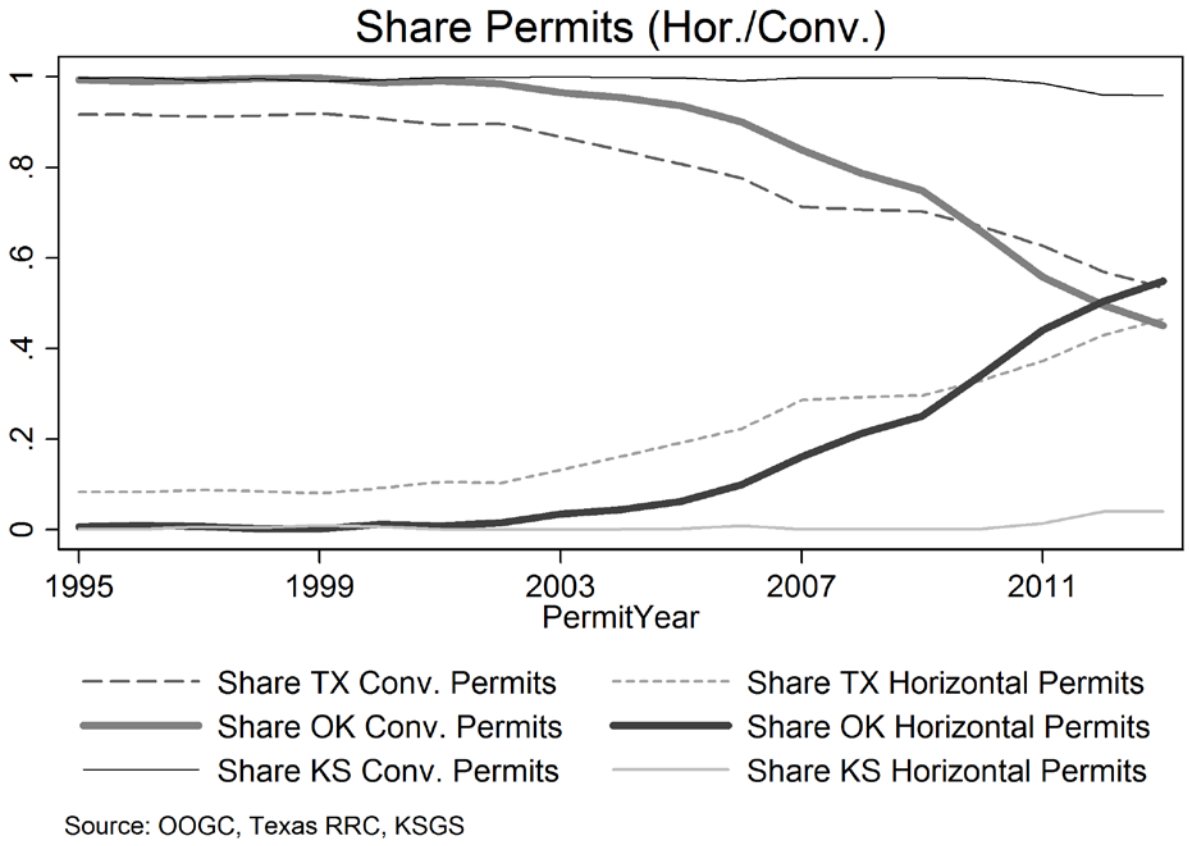
$$Y_{it} = \propto + \beta_1 R_{it} + \beta_2 Price_{jt} + \beta_3 Inc_{iy} + \beta_4 Pop_{iy} + \beta_6 i + \beta_7 t + \varepsilon_{it}$$

*Where* $i$ = county, j = state, $t$ = month, and y = year

*(Y)* represents the monthly county number of permits issued. ($R$) is an indicator of the Oklahoma tax policy of interest. (*Price)* is a state-month real oil or natural gas price. (*Inc)* is county-year real personal income. Lastly, (*Pop)* is the county-year population.

[19] For oil prices, we used the EIA first purchase price, while for natural gas prices we used the EIA citygate price; first purchase or wellhead prices for natural gas were discontinued in 2013.

Figure 1: Share of Permits (Horizontal/Conventional) by State



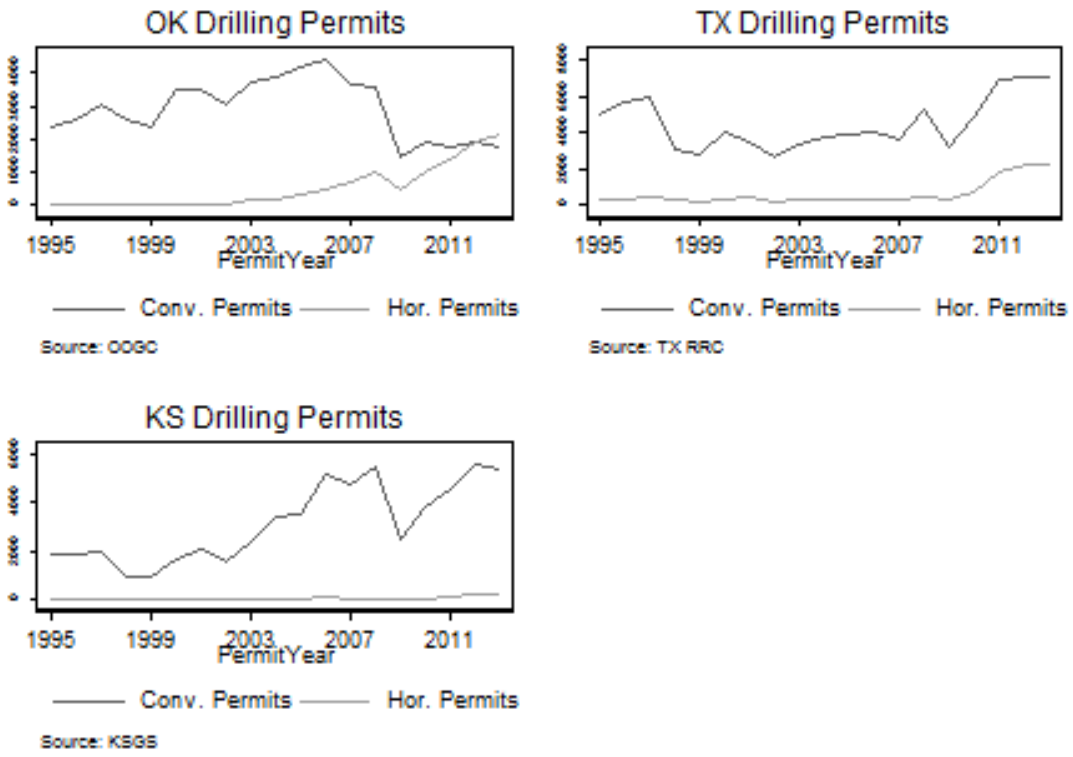

The difference-in-difference (DID) technique that is used relies on the assumption that changes in drilling permits over time would have been the same in both the treatment, Oklahoma, and control states in the absence of the intervention. Figure 1, above, demonstrates that from 1995 through the early 2000s, the share of conventional and horizontal drilling permits approved was constant for all three states. This is due largely to the absence of hydraulic fracturing technology prior to the mid-2000s and its rapid adoption throughout the United States thereafter. The extent to which the rise in horizontal drilling in Oklahoma demonstrated in Figure 1 is due to this technological advancement and the degree to which it was influenced by the tax policy in Oklahoma is therefore an empirical question. By differencing out the availability of hydraulic fracturing technology, which was also available in Kansas and Texas we are focused

on identifying the Oklahoma tax policy impacts. Specifically, the county and month fixed effects specification controls for all time invariant county characteristics, and the effects of seasonal and annual national economic and policy changes that influenced both Oklahoma and the control states in the sample. Still, the possibility of endogeneity exists due to unmeasured county-level heterogeneity in resource potential, which may lead to changes in the number of permits issued and the implementation of the tax policy. In order to control for resource availability, we have used an alternative sample to focus on geologically similar regions across states as designated by the United States Geologic Survey (USGS). In addition, to address concerns over unmeasured local economic factors, we have controlled for dynamic changes in personal income and population. Results for the full sample and the alternate specifications are provided below.

## V. Results

The findings in Table 1A indicate that there is no consistent effect of the Oklahoma tax policy for horizontal drilling on the number of horizontal permits issued after the implementation of the policy in 2002. Despite the dramatic increase in horizontal drilling demonstrated in Figure 2, the results suggest that the tax break was not a determining factor, rather it was oil prices that had a significant influence. The rise in horizontal drilling was not limited to Oklahoma. Figure 2 also demonstrates marked growth in the number of horizontal drilling permits in Texas, which did not have the policy. Clearly, the technological expansion of horizontal drilling crossed state lines and led to growth in permitting in both Texas and Oklahoma.

Figure 2: Horizontal and Conventional Permits by State




Unexpectedly, the findings indicate that the number of conventional drilling permits dropped in Oklahoma as compared to its neighbors after the implementation of the tax policy. This drop is demonstrated in Figure 2. Each of the states experiences a sharp decline in conventional permits in 2008, presumably as the result of the Great Recession. However, for both Texas and Kansas, conventional drilling activity recovers and resumes an upward trajectory through 2011, Oklahoma does not. The findings in Table 1B, Column 1 indicate that on average the tax policy led to a decline of approximately one permit per county month. This is an economically significant finding, because the mean county-month permits issued is 3.5. (See Appendix Table 1A for Summary Statistics). The findings for both conventional and horizontal permits are robust

to several modifications of the sample and alternative scaling of the dependent variable, presented below.[20]

[20] In addition, natural gas prices were also considered and the statistical and economic significance of the policy intervention were consistent when the analyses were conducted using natural gas rather than oil prices. Results available upon request.

**Table 1: Main Specification**

| | A: Horizontal Drilling Permits | | | | | B: Conventional Drilling Permits | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Dependent Variable: # of Month-County Oil/Gas Permits** | **All Counties (1)** | **Over-lapping Regions (2)** | **Share (3)** | **Exclude Oil Permits (4)** | **Oil And Gas Counties (5)** | **All Counties (1)** | **Over-lapping Regions (2)** | **Share (3)** | **Exclude Oil Permits (4)** | **Oil And Gas Counties (5)** |
| **Policy Intervention** | 0.0781 | -0.132 | **0.0626*** ** | 0.168 | 0.0355 | **-1.010*** ** | **-0.685*** | **-0.0869*** ** | **-0.577*** | **-1.153*** ** |
| | (0.364) | (-0.361) | (3.542) | (0.829) | (0.153) | (-3.713) | (-1.807) | (-3.444) | (-1.927) | (-3.837) |
| **Oil Price (State/Month)** | 0.0055*** | 0.00653*** | 0.00032*** | 0.0043*** | 0.0062*** | 0.0200*** | 0.0191*** | 0.0005*** | 0.0177*** | 0.0222*** |
| | (4.884) | (2.684) | (4.011) | (3.984) | (4.938) | (7.275) | (5.878) | (3.526) | (8.010) | (7.278) |
| **Personal Income (Cty/Year)** | $-3.04\times10^{-07}$ | $-5.00\times10^{-07}$ | $-3.94\times10^{-09}$ | $-3.12\times10^{-07}$ | $-3.84\times10^{-07}$ | $1.94\times10^{-07}$ | $8.42\times10^{-08}$ | $1.62\times10^{-09}$ | $-1.18\times10^{-07}$ | $2.45\times10^{-07}$ |
| | (-1.495) | (-1.473) | (-0.648) | (-1.543) | (-1.574) | (1.248) | (0.811) | (0.293) | (-0.479) | (1.251) |
| **Population (Cty/Year)** | $3.37\times10^{-05}$ | $8.05\times10^{-05}$* | $6.03\times10^{-07}$ | $3.48\times10^{-05}$ | $4.12\times10^{-05}$ | $-1.9\times10^{-05}$* | $-1.28\times10^{-05}$ | $-4.11\times10^{-07}$ | $1.56\times10^{-05}$ | $-2.4\times10^{-05}$* |
| | (1.356) | (1.805) | (0.918) | (1.402) | (1.414) | (-1.729) | (-1.329) | (-0.775) | (0.607) | (-1.697) |
| **Observations** | 95,076 | 36,480 | 95,076 | 95,076 | 85,044 | 95,076 | 36,480 | 95,076 | 95,076 | 85,044 |
| **R-Squared** | 0.055 | 0.132 | 0.067 | 0.052 | 0.063 | 0.028 | 0.043 | 0.021 | 0.043 | 0.031 |
| **Number of Counties** | 417 | 160 | 417 | 417 | 373 | 417 | 160 | 417 | 417 | 373 |

Note: Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1

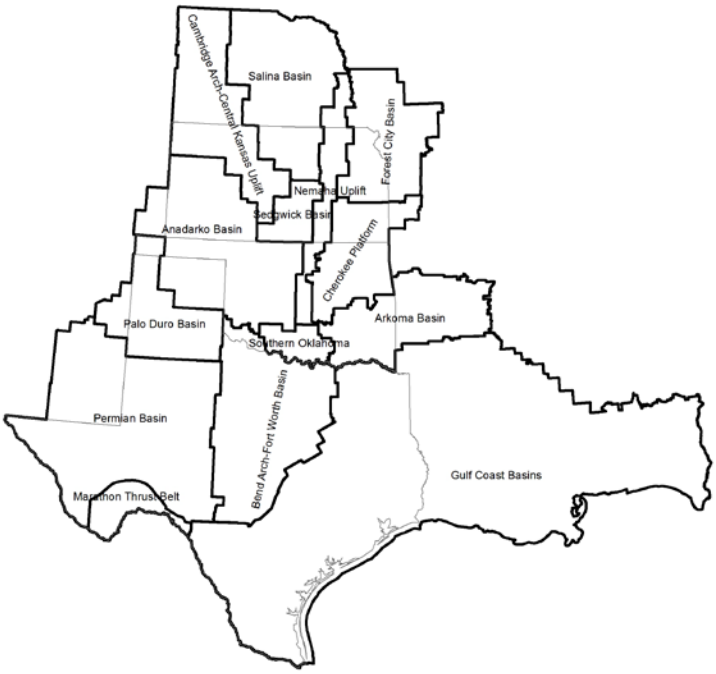
a: County, month and year fixed effects are included in all specifications.

b: The results in columns (3) regarding the share of horizontal/conventional remain significant for the smaller overlapping regions sample and for the sample restricted to only oil and gas counties.

c: Personal income and wellhead oil price are reported in real 2009 U.S. dollars.

*V.1 Oil and Gas Resource Availability*

Figure 3: USGS Oil and Gas Provinces for Kansas, Oklahoma, and Texas



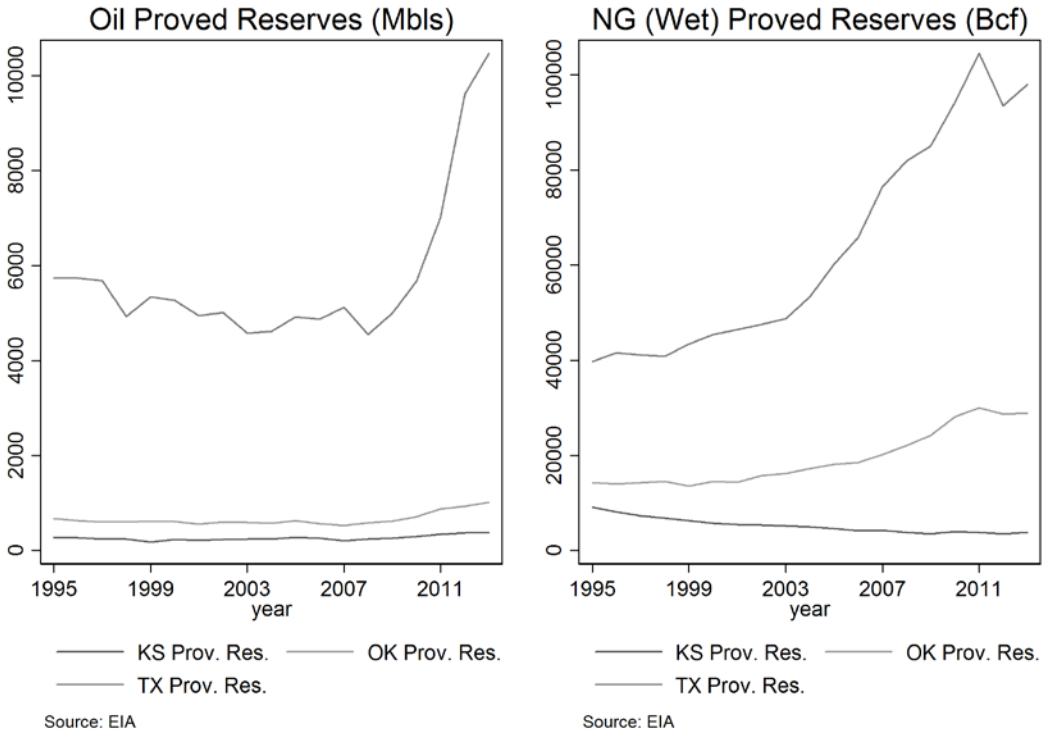

Source: http://energy.usgs.gov/OilGas/AssessmentsData/NationalOilGasAssessment.aspx#.VW3Pcc-6dpj, http://certmapper.cr.usgs.gov/data/noga00/natl/spatial/geodatabase/usprov12gdb.zip

There are several distinct geologic areas throughout the sample area. The USGS Central Region Energy Team assessed the oil and gas resources of the United States and developed geologic boundaries for the Oil and Gas Resource Assessment Project from 2005 through 2012. Each region, called a province, is defined by major geologic changes.[21] (See Figure 3) The amount of oil and natural gas resource available is a key factor in determining the amount of drilling that will take place. Figure 4 demonstrates that Texas has significantly more oil and gas resources than either Oklahoma or Kansas. The heterogeneity in resource availability may confound the effects of the tax policy, i.e. differences in the three states in resource availability

[21] See http://energy.usgs.gov/OilGas/AssessmentsData/NationalOilGasAssessment.aspx#.VW3Pcc-6dpj, http://certmapper.cr.usgs.gov/data/noga00/natl/spatial/geodatabase/usprov12gdb.zip

may lead to differential development behavior by firms independent of the tax policy. In order to control for resource availability, we analyzed a sample of counties which are in geologic regions that overlap the boundaries of at least two of the three states.[22] The assumption underlying this analysis is that counties in the same geologic region would be expected to have the same development potential before and after 2002, but for the change in Oklahoma's tax policy.

Figure 4: Proved Reserves




The findings remain consistent with the full sample if the analysis is completed for the overlapping geologic regions sample. Table 1, column 2 indicates that the policy does not have a statistically significant influence on horizontal permitting, but reduces conventional permitting by approximately 0.7 permits per county-month. Once again this is an economically significant

[22] The provinces that are included in the overlapping regions sample are the Anadarko Basin, Cherokee Platform, Bend Arch-Fort Worth Basin, and the Nemaha Uplift.

reduction in county-month permitting, mean county-month permits for this sample are approximately three permits.

*V.2 Share of Permits*

Figure 2 demonstrates that Texas has issued considerably more permits than Oklahoma, while Kansas has appreciably fewer. In order to determine if the findings are driven by variation in the magnitude of the number of permits issued, we have also analyzed the share of conventional and horizontal permits. Table 1, columns 3 show that for the alternative dependent variable, share of permits, the results for horizontal permitting become significant and conventional drilling remains significant. Specifically, the findings in Table 1A indicate that after the implementation of the tax policy, horizontal permitting increased by 6 percent, an economically significant finding. In Table 1B, column 3, the results indicate that conventional permitting declines by approximately 9 percent, consistent with the previous findings. The significant findings regarding horizontal permitting are limited to the construction of the alternative dependent variable, while the results regarding conventional permits are robust across specifications.

*V.3 Permits – Oil and Gas*

The findings thus far have distinguished wells by type, horizontal or conventional permit, but not by fuel, oil or natural gas. In order to determine if the tax policy was differentially affecting oil and gas wells, we examined the number of permits issued for wells other than oil wells. Oil and gas permits are often issued for oil and gas wells jointly, rather than specifically designating either oil or gas individually. In addition, many wells produce oil and natural gas with the ratio of oil and natural gas produced used to determine whether the well is designated oil or natural gas in a particular year. In order to analyze the wells separately, we constructed a

variable that is a measure of the total number of county-month permits minus those that were designated as oil permits. The findings in Table 1, columns 4 indicate that the significance of the coefficient on the policy intervention is robust to this alternate sample. The policy did not have a statistically significant influence on horizontal permitting, but did decrease the number of conventional permits.

*V.4 Resource Rich Counties*

In Section V.2, we restricted the sample to overlapping geologic regions in order to analyze a more homogeneous sample in terms of the oil and gas resource availability. Table 1, columns 5, presents results for a sample that is restricted to counties that had continuous oil and/or gas production as reported by ERS-USDA.[23] This specification eliminates counties that had marginal resource development from the analysis in order to focus on a more homogeneous sample in terms of resource development. The findings in Table 1B, column 5 indicate that conventional permitting declined in this sample as a result of the tax policy in Oklahoma. The results are once again consistent with the previous results. The findings in Table 1A, column 5 indicate that there was not a statistically significant influence on horizontal permitting.

*V.5 Texas Comparison*

The analyses in Table 1 use both Texas and Kansas as the control group. In order to determine if the choice of control states is leading to the findings, we have constructed an alternate control group restricted to counties in Texas only. Figure 1 demonstrates that in terms of the adoption of horizontal drilling technology, Kansas remained largely a conventional drilling state, potentially due to the geology in the region. The findings in Table 2A indicate that once again, there is not a consistently significant influence of the Oklahoma tax policy on

[23] See http://www.ers.usda.gov/data-products/county-level-oil-and-gas-production-in-the-us.aspx. The data on oil and gas production cover the period 2000-2011.

horizontal permitting. The findings in Table 2B indicate that the results for the number of conventional permitting are not consistently robust to the alternate specification. The magnitude and significance of the finding are robust for two of the analyses, Table 2B, columns 1, and 4. However, for three of the robustness checks, Table 2B, columns 2, 3, and 5, there is not a significant effect on conventional permitting.

**Table 2: Texas Comparison**

| | A: Horizontal Drilling Permits | | | | | B: Conventional Drilling Permits | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Dependent Variable: # of Month-County Oil/Gas Permits** | **All Counties (1)** | **Over-lapping Regions (2)** | **Share (3)** | **Exclude Oil (4)** | **Oil And Gas Counties (5)** | **All Counties (1)** | **Over-lapping Regions (2)** | **Share (3)** | **Exclude Oil (4)** | **Oil And Gas Counties (5)** |
| **Policy Intervention** | -0.270 | -0.822 | 0.0396** | -0.136 | -1.060* | **-0.616**** | 0.0759 | -0.0252 | **-0.798**** | 0.0355 |
| | (-1.045) | (-1.475) | (2.084) | (-0.564) | (-1.707) | (-1.978) | (0.216) | (-1.008) | (-2.220) | (0.0891) |
| **Oil Price (State/Month)** | 0.0038*** | 0.00508* | 0.00021** | 0.00267** | 0.00590** | 0.0232*** | 0.0190*** | 0.0008*** | 0.0171*** | 0.0203*** |
| | (3.349) | (1.950) | (2.107) | (2.390) | (2.090) | (8.124) | (5.734) | (5.414) | (7.566) | (5.639) |
| **Personal Income (Cty/Year)** | $-2.96\times10^{-07}$ | $-5.17\times10^{-07}$ | $-3.11\times10^{-09}$ | $-3.06\times10^{-07}$ | $-6.99\times10^{-07**}$ | $1.78\times10^{-07}$ | $8.69\times10^{-08}$ | $-4.58\times10^{-10}$ | $-1.16\times10^{-07}$ | $2.52\times10^{-07}$ |
| | (-1.447) | (-1.505) | (-0.508) | (-1.501) | (-2.197) | (1.127) | (0.844) | (-0.0802) | (-0.466) | (1.193) |
| **Population (Cty/Year)** | $3.20\times10^{-05}$ | $7.90\times10^{-05}$* | $4.62\times10^{-07}$ | $3.33\times10^{-05}$ | 0.000123*** | $-1.70\times10^{-05}$ | $-9.50\times10^{-06}$ | $-4.23\times10^{-08}$ | $1.47\times10^{-05}$ | $-2.26\times10^{-05}$ |
| | (1.273) | (1.750) | (0.698) | (1.330) | (3.459) | (-1.492) | (-1.002) | (-0.0800) | (0.566) | (-1.502) |
| **Observations** | 71,820 | 25,764 | 71,820 | 71,820 | 23,256 | 71,820 | 25,764 | 71,820 | 71,820 | 23,256 |
| **R-Squared** | 0.066 | 0.144 | 0.079 | 0.061 | 0.210 | 0.023 | 0.054 | 0.041 | 0.045 | 0.061 |
| **Number of Counties** | 315 | 113 | 315 | 315 | 102 | 315 | 113 | 315 | 315 | 102 |

Note: Robust t-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1

a: County, month and year fixed effects are included in all specifications.

b: The results in columns (3) regarding the share of horizontal/conventional is insignificant for the smaller overlapping regions sample.

c: Personal income and wellhead oil price are reported in real 2009 U.S. dollars.

## VI. Conclusion and Discussion

Oklahoma's severance tax reduction was designed to promote the adoption of what was at the time a technological advancement in drilling. Resource rich states, such as Oklahoma rely on tax revenue from energy production in order to meet their fiscal obligations. This reliance has proven particularly salient recently as Oklahoma faces a budget shortfall. According to the Oklahoma Policy Institute, this shortfall is due not only to declining oil and gas production due to falling prices, but to tax incentives, both income and the severance tax reduction. (OK Policy 2016) Prior to the current environment of declining energy prices, the boom in oil and gas drilling that followed the adoption of hydraulic fracturing technology was credited with providing jobs and revenue for state and local governments. The state tax implications of increased oil and gas production seem clear, but the benefits of the tax break can only be realized if the industry responds by ramping up production when the policy is implemented. Industry leaders, including the three largest oil companies in Oklahoma indicated that they would reduce drilling if the horizontal tax reduction was allowed to lapse, resulting in a production tax increase back to the full seven percent from the reduced one percent. (Veith 2014) The results in this paper suggest, however, that the rise in hydraulic fracturing was due to resource prices, rather than a response from oil and gas producers to the tax policy. In the case of Oklahoma's policy, it seems that at best the policy led to a decrease in tax revenue without a commensurate increase in horizontal drilling and at worst the policy had the unintended consequence of decreasing conventional drilling.

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**Appendix**

**Table 1A: Summary Statistics**

| | Mean | Median | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| Conventional Drilling Permits (Cty/Mnth) | 3.45 | 1 | 6.87 | 0 | 222 |
| Horizontal Drilling Permits (Cty/Mnth) | 0.81 | 0 | 4.08 | 0 | 135 |
| Share Conv. Permits | 0.53 | 0.75 | 0.48 | 0 | 1 |
| Share Hor. Permits | 0.09 | 0 | 0.25 | 0 | 1 |
| Conventional Drilling Permits - Excl. Oil (Cty/Mnth) | 3.01 | 1 | 6.70 | 0 | 149 |
| Horizontal Drilling Permits - Excl. Oil (Cty/Mnth) | 0.67 | 0 | 3.75 | 0 | 135 |
| Population (Cty/Year) | 66253.93 | 14551 | 254658 | 55 | 4336853 |
| Real Personal Income (1000s $) | 2376469 | 400845 | $1.08 \times 10^{07}$ | 3139.80 | $2.16 \times 10^{08}$ |
| Real Wellhead Oil Price ($/Barrel) | 50.61 | 39.33 | 27.88 | 11.39 | 132.37 |

a: Personal income and wellhead oil price are reported in real 2009 U.S. dollars.

## Table 2A: Summary of Key Policy Changes for Gas Severance Tax Exemptions

**I. Kansas Oil and Gas Tax exemptions** (KS 79-4219. (4), (5), and (6))

| | |
|---|---|
| Production of gas from any pool, on or after | 1983 |
| Three year inactive well, on or after | 1996 |
| Incremental severance, on or after | 1998 |

Tax does not apply to gas:

- Injected into earth
- Flared or vented
- Inadvertently lost on the lease
- Used for domestic purposes, or
- Gas placed on underground storage

**Kansas Gas Tax credits**

Allow a credit of 3.67 % of gross value of gas severed when taxpayers are liable for property taxes on gas property

**II. Oklahoma Oil and Gas Tax exemptions** (OS 68.1001. D, E, F, G, H, I, and J)

| | |
|---|---|
| Incremental production from enhanced recovery projects, on or after | 1994 |
| *Horizontally drilled production wells, on or after* | *2002* |
| Reestablished production from inactive wells, on or after | 1994 |
| Production enhancement projects, on or after | 1994 |
| Production from deep wells, on or after | 1997 |
| Production from new discovery wells, on or after | 1995 |
| Production based on three dimensional seismic technology, on or after | 2000 |

**Oklahoma Oil and Gas Tax credits**

Oil and gas exemptions are paid when operators file claims for refunds at the end of the fiscal year. The payment can be paid out over a period of 36 months, but in case of late payment the state will be charged a penalty rate of 9 percent interest accrue for each day the required payment is not made.

**III. Texas Natural Oil and Gas Tax exemptions** (Tax Code title 2 chapter 201.056, 057, 059; 202.056, 060)

| | |
|---|---|
| High cost gas, on or after | 1996 |
| Inactive wells, on or after | 1997 |

Gas that are not taxed are those:

- Injected into earth
- Produced from oil wells and lawfully flared or vented
- Used for lifting oil

**Texas Natural Gas Tax credits**

Oil tax credit on inactive wells equal to the difference between the tax paid and the tax which would have been due at the recovered oil tax rate for all production. A low producing gas well is entitled to 25 percent credit if the average price of gas is more than $3 per mcf but less than $3.50 per mcf; a 50 percent credit if the average price of gas is more than $2.50 per mcf but less than $3 per mcf; and 100 percent if the average price of gas is not more than $2.50 per mcf.