The Effects of Oil and Gas Booms on State Revenues, Tax Burden, and Revenue Cyclicality

BY

DODY DHARMA HUTABARAT

B.A., Muhammadiyah Asahan College of Economics, 2002
M.Sc., University of Glasgow, 2008

THESIS

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Dissertation Committee:
David F. Merriman, Chairperson and Advisor
Michael A. Pagano
Rebecca M. Hendrick
Yonghong Wu
Thomas D. Hayes, Gas Technology Institute

This thesis is dedicated to my wife, Fitrya, for her love, support, and patience. Without her, it would never have been accomplished.

This thesis is also dedicated to my sons Zaky and Danish, for the joy, hope, and energy they share with me.

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SUMMARY

This dissertation investigates the effects of recent oil and gas booms on state revenues, tax burden, and cyclicality of state revenues. The diffusion of technological innovations in horizontal drilling and hydraulic fracturing, colloquially known as fracking, across states has enabled huge amounts of oil and natural gas to be extracted profitably from underground. The examination is pursued by way of panel data of 50 states during the period of 2000-2015 using aggregate data by drilling type.

This research presents four distinct findings. First, there is suggestive evidence that revenues from oil and gas extraction have similar characteristics to intergovernmental grants. The regression analysis finds that state oil and gas revenues are complementary to existing state revenues, suggesting that oil and gas revenues have crowd-in effects on state revenues. Second, estimates from statistical analysis indicate that oil and gas development results in a slight increase in resident's tax burden. The small increase in resident's tax burden is contributed by part of oil and gas production consumed by residents of producing states. Third, consistent with the political climate on a booming industry, this study finds that the oil and gas industry would see an increase in its state tax liabilities once it experiences a boom. The regression results indicate that the growth rate of state tax revenues paid by the industry would be higher than that of the industry's profitability. And finally, the revenue cyclicality of the energy states, regardless of whether they allow fracking or not, is not statistically different from that of non-energy states in the period of 2008-2015. This finding suggests that the resource boom does not affect the revenue cyclicality of the energy states.

Several conclusions can be drawn from the results of this study. First, fracking has transformed traditionally non-oil and gas states into producing states that gain from increased oil and gas revenues. Nationwide, state oil and gas revenues would be lower than they actually are without revenues from fracking production. Second, this research provides a theoretical foundation to extend our knowledge of the flypaper effect associated with revenues from resource extraction. It also improves our understanding of state behavior in responding to increased revenues from extractive industry. Instead of reducing residents' tax burden, the states treat oil and gas revenues simply to increase state revenues. This study also provides empirical evidence with regard to states' ability to shift the cost of public service to a booming industry.

1. INTRODUCTION

1.1 Statement of the problem

The development of hydraulic fracturing and horizontal drilling, collectively referred to as fracking, has been one of the most remarkable changes in the U.S. energy sector. Fracking "has allowed the United States to increase its oil production faster than at any time in its history", said the U.S. Energy Information Administration (2016a) in a recent report. It has enabled massive amounts of oil and natural gas to be extracted from shale deposits that were long thought to be economically unfeasible. The result is a substantial increase in U.S. domestic energy production that has led to an oil and gas boom, reducing its dependence on foreign energy. In 2015, nearly all U.S. natural gas consumption was produced domestically. The huge quantity of oil and gas extracted during the boom period also caused energy prices to drop significantly, increasing welfare for natural gas consumers and producers of $48 billion annually between 2007 and 2013 (Hausman and Kellogg 2015).

Such dramatic changes in the energy sector potentially have some implications for government finances. While public finance literature on the oil and gas boom is still developing, several studies have investigated the impacts of the resource boom on government finances in the U.S. For example, Raimi and Newell (2014), studying counties and municipalities in eight states, find that most local governments gain net financial benefits from the recent growth in oil and gas development. This windfall gain has also allowed local governments to protect themselves from fiscal stress and collect some revenue to offset costs associated with local fracking (Rahm, Farmer, and Fields 2016).

Most research on the effects of the recent oil and gas boom on public finance, however, has been conducted at local level, and little has focused on state level. Analysis at local level has become a primary concern since access to the oil and gas resources depends on the willingness of local communities to allow drilling within their neighborhoods (Bartik, Currie, Greenstone, and Knittel 2016). Nevertheless, investigation at state level is also important because the state governments have financial and economic interests regarding oil and gas investments within their jurisdictions. States collect the lion's share of revenues directly and indirectly generated from oil and gas exploitation, including severance, sales, individual, and corporate income taxes. Accordingly, states that do not yet have any fracking development, like Missouri, might consider the benefits and costs of allowing fracking. State government also has significant authority to allow or to ban fracking within its jurisdiction (Rahm 2011). Furthermore, states determine what local governments can do and/or cannot do with local fracking regulations.

In many states, a permit to allow drilling is issued by the state. While many states allow fracking within their boundaries, other states have banned it (e.g. Maryland, New York, and Vermont). The implications of allowing or banning fracking can differ from one jurisdiction to another. For some states, allowing fracking may result in an increase in economic output as well as a new revenue source. Accordingly, banning fracking might lead to an opportunity lost to generate wealth and revenue sources. However, this assumption may be taken for granted, and empirically, little factual evidence exists to determine whether this assumption is true. These experiential shortfalls are the driving forces behind this study.

1.2 Research question

This study will investigate the effects of the recent oil and gas boom on state revenues. Empirically, I investigate the effects of oil and gas development on state revenue collection, resident's tax burden, the oil and gas industry's tax burden, and cyclicality of state revenues.

1.3 Significance of the study

This study makes four contributions. First, it provides a model to predict state behavior in response to increased revenues from oil and gas production. To the best of my knowledge, literature on resource booms does not develop a clear theory for the study of government revenues from oil and gas extraction. Much of the recent work on oil and gas booms has been aimed at estimating the benefits and cost of fracking (e.g. Christopherson and Rightor 2012; Hausman and Kellogg 2015), as well as documenting state revenues from oil and gas production (e.g. Newell and Raimi 2018). James (2015) is an exception that provides a model of how states use additional government revenue created by natural resource endowments.

Second, this study documents the most recent state taxes on oil and gas production and applicable tax rates. The result of data collection updates Brown's (2003) report for the National Conference of State Legislatures, which has been the main data source for state taxes on oil and gas production. This study also includes data on state oil and gas revenues by type of production from each state during the study period of 2000-2015.

The third contribution of this study is to provide empirical evidence about the degree to which government is able to shift some portion of the tax burden to an industry once the industry experiences boom periods. Oftentimes, when an industry is growing, government officials would see it as an opportunity to extract more revenue from it. In this study, the oil and gas industry is the focus of investigation. In Ohio, for example, the Governor demanded to impose a higher tax on oil and gas companies with a 4 percent severance tax to compensate a reduction in income taxes paid by individuals and small businesses (Niquette 2012). Certainly, the oil and gas industry in Ohio opposed the plan, arguing that it is unfair to put the tax burden on one industry to offset a tax decrease for others. Findings from this study provide evidence of how successful government is in shifting the cost of public service to the extractive industry.

And lastly, this study investigates the states' ability to benefit from a recent resource boom within their jurisdictions. The a priori expectation is that the growth of oil and gas production would lead to an increase in state revenue due to an increase in state economic output. Accordingly, the states that experience an increase in oil and gas production would experience higher revenue growth than those that do not. What is unknown, however, is the magnitude of the effects on state revenues and which revenue sources are greatly affected by increased oil and gas development. The literature has been limited in addressing this assumption because most empirical studies I am aware of focus on local governments, such as school districts (e.g. Le and Plummer 2011), counties (e.g. Bartik et al 2016), and cities (e.g. Raimi and Newell 2016b). Findings from this study would have practical implications when the states assess the benefit and cost of oil and gas investments in their territory.

1.4 Organization and overview of the study

The rest of the study is organized as follows. Chapter 2 discusses the recent oil and gas boom in the U.S., including an overview of fracking, and oil and gas production at state level. Chapter 3 presents the theoretical framework and reviews of literature that have informed this study, including state tax treatments, and my hypotheses as concluded from a review of relevant literature. Chapter 4 provides the methods used in this study, as well as units of analysis, sample, and variable measurement. Chapter 5 reports state oil and gas revenues by type of production and the distribution of the revenues. Chapter 6 presents empirical findings. Chapter 7 discusses the policy implications of the findings, limitation and research extension.

2. THE OIL AND GAS BOOM IN THE UNITED STATES

This chapter provides the background of the oil and gas boom in the U.S during the study period of 2000-2015. I begin with an overview and history of fracking, the technology behind the recent boom. In the next section is a discussion of oil and gas production at national and state levels, followed by an examination of the distribution of drilling wells that drive the production.

2.1 Overview of fracking

2.1.1 A nontechnical description of fracking

A nontechnical explanation of fracking helps explain the productivity gains due to a technological breakthrough in extracting oil and gas deposits from shale formations. In simplified terms, fracking is considered an unconventional approach in the production of oil and gas. It involves the combination of horizontal drilling and fracking liquid. The process of fracking begins with a well vertically drilled from the surface, reaching the deep rock layers, or shale formations, where a large store of hydrocarbon is predicted to be located (Bartik et al 2016). To get to the targeted depth, the vertical drill can reach 2 miles or more. The entire process up to this point is often viewed as the traditional approach to gas and oil discovery.

The unconventional approach begins when the drill bends and starts to drill horizontally along the shale formation. Horizontal drilling can stretch out more than 1 mile from the vertical wellbore. Compared with vertical drilling, horizontal drilling can lead to more productive wells because it can pump out a broad area from a single drilling pad and reach targets that cannot be attained by vertical drilling (Drilling Info 2014). Once drilling is completed, the well is cemented and cased in steel to prevent contamination of groundwater when fracking liquid is ejected or removed. Fracking liquid, containing a mixture of water, sand, chemicals, and additives, is injected into the well at extremely high pressure to break the rocks and enlarge fractures within the shale formation (Frac Focus 2010). The proppants, or small particles in the liquid, keep the newly formed fractures open even after the pumping pressure is relieved. Once the shale is cracked, oil and gas can freely flow through the wellbore to the surface.

Fracking involves a number of transient steps beginning from the exploration of shale oil and gas reserves to site selection and preparation, and from drilling the wells to plugging and abandonment (Richardson, Gottlieb, Krupnick, and Wiseman 2013). Furthermore, the wells can be refractured several times, requiring additional water that can be more than 3.5 million gallons per horizontal well (Andrews, Folger, Humphries, Copeland, Tiemann, Meltz, and Brougher 2009). While the entire process of exploration and drilling can take up to 15-20 years, an average well can produce for over 60 years.

2.1.2 <u>The history of fracking</u>

Fracking is considered a new technological breakthrough to extract oil and gas from shale play.[1] The process used today, however, is an accumulation of improvements made over several decades. The method was firstly developed by Stanolind Oil on the well Klepper No. 1 in Grant County, Kansas in 1946 (Gold 2014). Its first method used napalm pumped into the well with high pressure to fracture the rock (Montgomery and Smith 2010). Although the original method was unable to increase production, Stanolind improved it and soon found that fracking could improve productivity (Gold 2014).

Initially, the targeted wells in the early development of fracking techniques were located in non-shale formations. While it had been known that shale formations contained large

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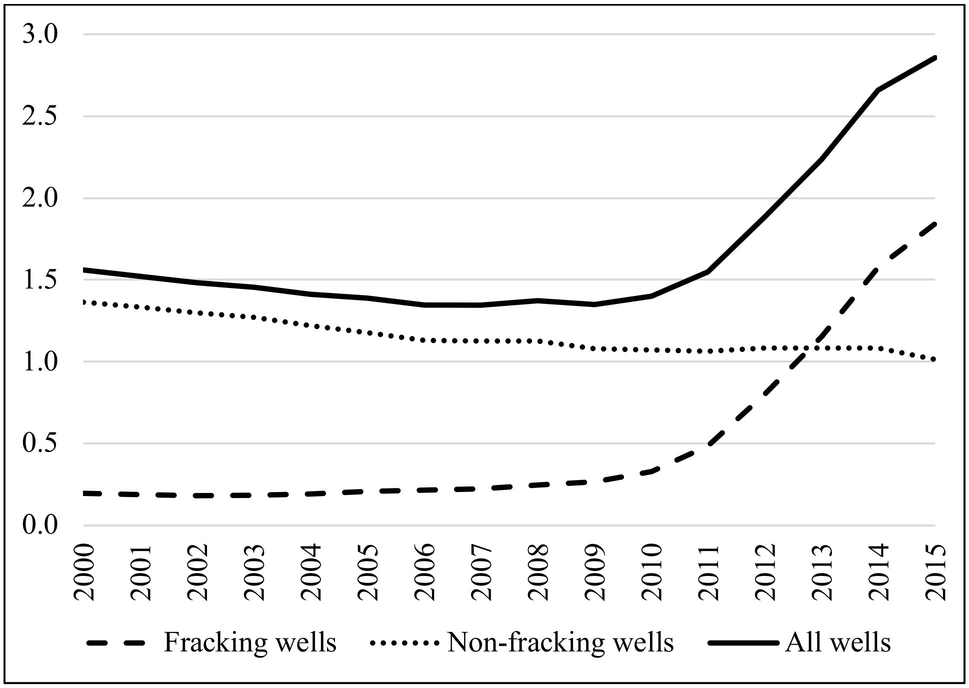
[1] A "shale play" is an area where oil and gas companies focus on a particular shale formation or a set of shale configurations.

hydrocarbon deposits, shale formations were much more impermeable than non-shale formations, resulting in only small percentages of oil and gas deposits that were able to flow through the rock to the wellhead with conventional drilling. Accordingly, a majority of people in the oil and gas industry cast doubt on the idea that a shale formation could be profitably exploited. As a result, most fracking wells in the early development of fracking techniques were located in non-shale formations.

The oil and gas industry began to target oil and gas deposits in shale formations in the 1980s. Mitchel Energy pioneered new exploration on shale formations in the Barnett Shale in Texas, when production from its conventional wells was decreasing (Martineau 2007). Experimenting with its fracking techniques in different ways, Mitchel had mixed success in its search for new sources of oil and gas deposits. Its experimentation paid off in 1998 when it began to use more water and less sand in an experimental well, resulting in a much higher production rate compared to other Barnett wells (Gold 2014). Moreover, the new technique cut the extraction cost by half compared with previous techniques. Mitchel then decided to roll out the new technique to all of its Barnett wells. Soon Mitchel’s success story inspired other oil and gas firms to use fracking techniques in the search for oil and gas deposits in shale formations.

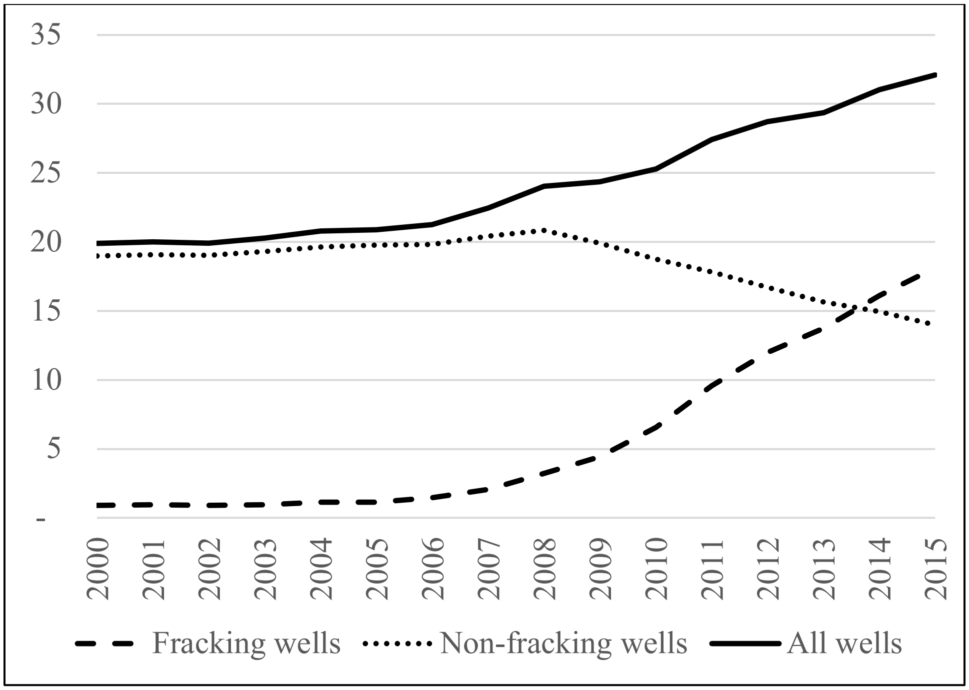
2.2 The oil and gas boom of 2008-2015

Since 2008, the United States has been experiencing an oil-and-gas boom. During the period of 2008-2015, domestic production increased significantly (Figures 1 and 2). In 2000, a total of 1.6 billion barrels of oil and roughly 20 trillion cubic feet (cf) of natural gas were produced domestically. Fifteen years later, in 2015, approximately 2.9 billion barrels of oil and 32 trillion cf of natural gas were extracted, following a declining oil production and a slow growth of natural gas production in previous years. Over the period, domestic crude oil production increased by 83 percent and natural gas by 61 percent, resulting in the U.S. becoming the largest oil and gas producing country in the world.



Notes: I report aggregate barrels of oil produced in a given year by drilling type. Non-fracking wells consist of three drilling types: vertical, directional, and unknown. The total annual production differs from EIA's national reports as I exclude Illinois, Indiana, and Idaho. Data source is drillinginfo.com.

Figure 1: U.S. Crude Oil Production in 31 states, 2000-2015 (billion barrels)



Notes: I report aggregate cubic feet of natural gas produced in a given year by drilling type. Non-fracking wells consist of three drilling types: vertical, directional, and unknown. The total annual production differs from EIA's national reports as I exclude Illinois, Indiana, and Idaho. Data source is drillinginfo.com.

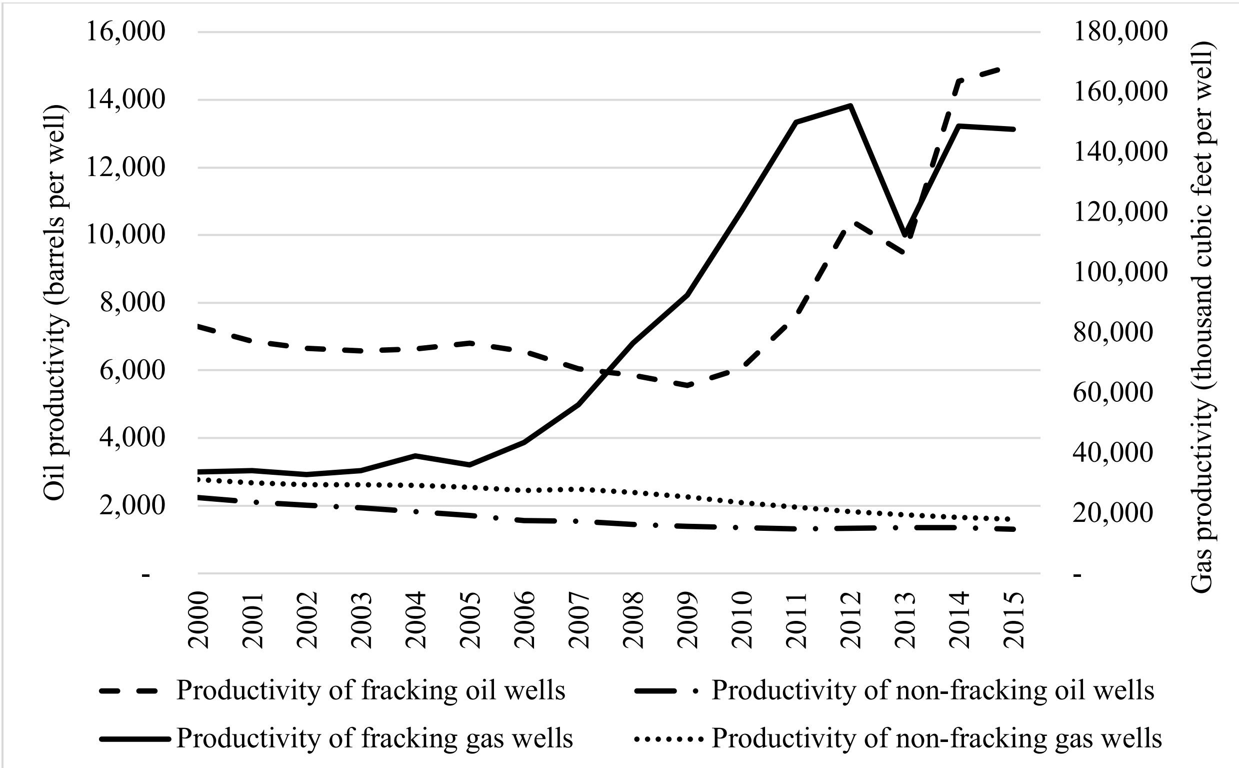
Figure 2: U.S. Natural Gas Production in 31 states, 2000-2015 (trillion cubic feet)

Almost all the increase in oil and gas production can be attributed to the combination of fracking and horizontal drilling techniques. Although output from conventional wells has been experiencing a downward path, production from fracking wells significantly boosts domestic production. In 2000, fracking wells only contributed 12 and 5 percent of total oil and gas production, respectively. In 2015, two thirds of crude oil production were extracted from fracking wells while fracking wells produced more than half of total gas production. Oil production from fracking wells grew ninefold during the period 2000 to 2015. Over the same period, gas from fracking wells increased 20 times. This has made the U.S. no longer dependent on foreign energy.

Horizontal drilling and the use of fracking liquid improves drilling productivity. As shown in Figure 3, a fracking well has higher oil and gas production rates than those of non-fracking wells.[2] In 2015, in average a fracking well could produce as much as 12 and 8 times more oil and gas respectively than other types of well. While oil and gas productivity from non-fracking wells was declining, the gas production rate of horizontal wells could be seen to increase in 2006, followed by the growth of oil productivity in 2010. In 2015, an average well could produce more than 15,000 barrels of oil per year; non-fracking wells could only produce approximately 1,300 barrels a year. Similarly, a fracking well could produce nearly 148 million cf of natural gas per year, while non-fracking wells only extracted 18 million cf of gas a year.

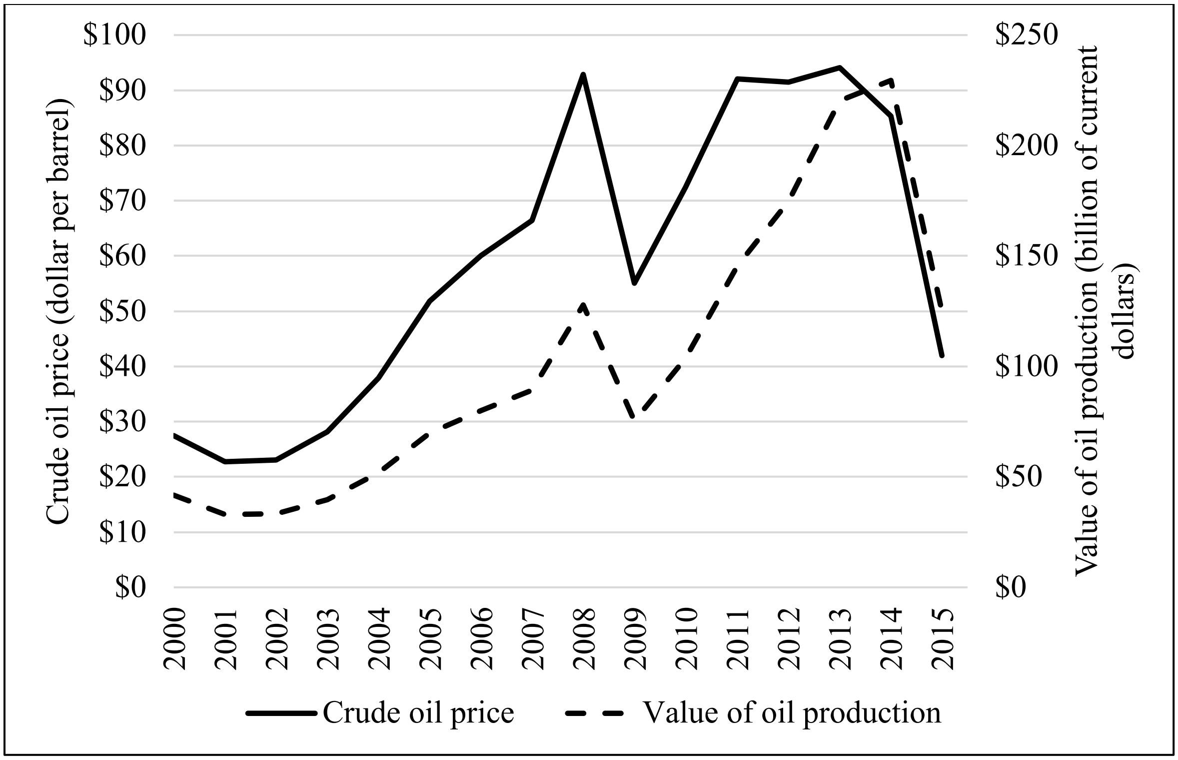
In 2015, a total of $125 billion of crude oil and $87.2 billion of natural gas was produced, resulting in an aggregate production value of $212.1 billion, or a 95 percent increase from total production value in 2000. However, the value of production in 2015 was lower than those in 2013 and 2014, primarily due to fall of oil and gas prices. In fact, the total value of oil and gas production was strongly determined by the fluctuation of oil and gas prices (Figures 4 and 5). The value of crude oil production reached its peak at $229.5 billion when crude oil price was near record-level at $85.3 per barrel in 2014. The value of gas production reached $189.8 billion when natural gas was priced at $7.8 per thousand cf in 2008.

[2] Non-fracking wells consist of three drilling types: vertical, directional, and unknown.



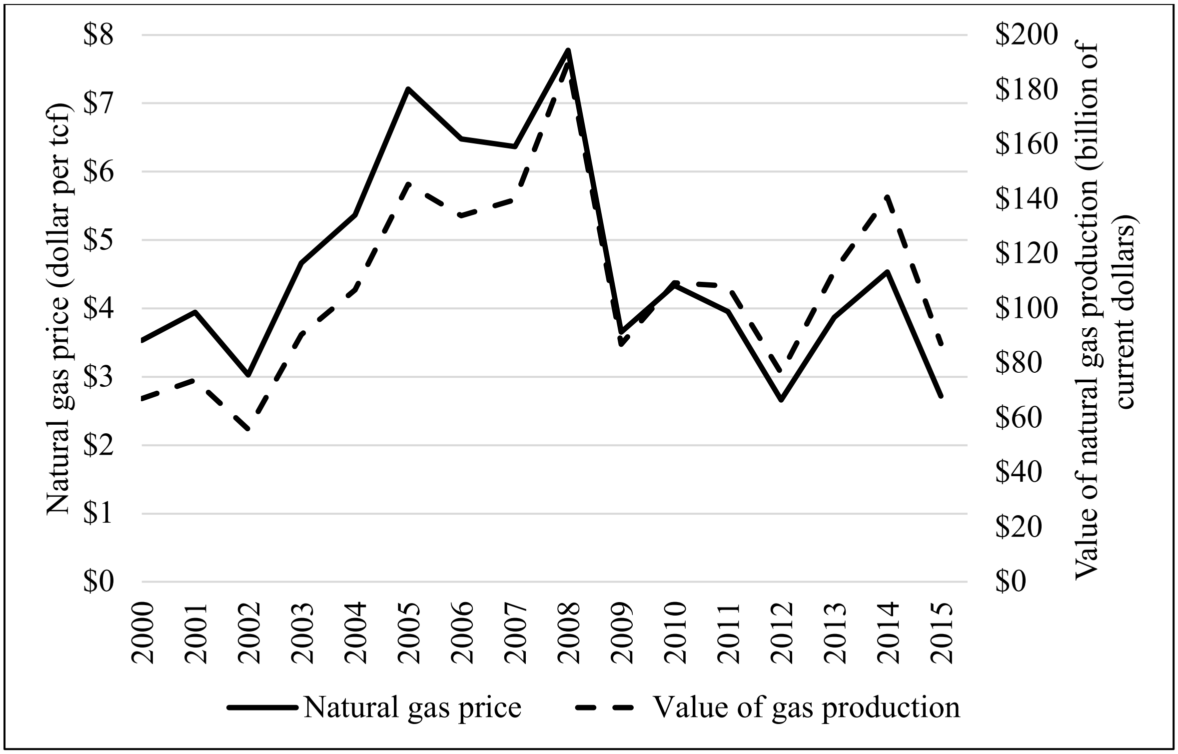
Notes: I report productivity of oil and gas wells in a given year by drilling type. Non-fracking wells consist of three drilling types: vertical, directional, and unknown. I estimate well productivity by dividing the total annual production of oil and gas of each drilling type by the number of wells in a given year. Data source is drillinginfo.com.

Figure 3: Annual Oil and Gas Well Productivity



Notes: The annual value of oil production is estimated by multiplying the state's annual oil production by the average annual price of oil in a given year. The total production value is the sum of production values of all states. Section 4.2 provides details on estimation on the total value of oil and gas produced. Data source for oil and gas production is drillinginfo.com.

Figure 4: Crude Oil Price vs. Value of U.S. Crude Oil Production



Notes: The annual value of gas production is estimated by multiplying the state's annual gas production by the average annual price of gas in a given year. The total production value is the sum of production values of all states. Section 4.2 provides details on estimation on the total value of oil and gas produced. Data source for oil and gas production is drillinginfo.com.

Figure 5: Natural Gas Price vs. Value of U.S. Gas Production

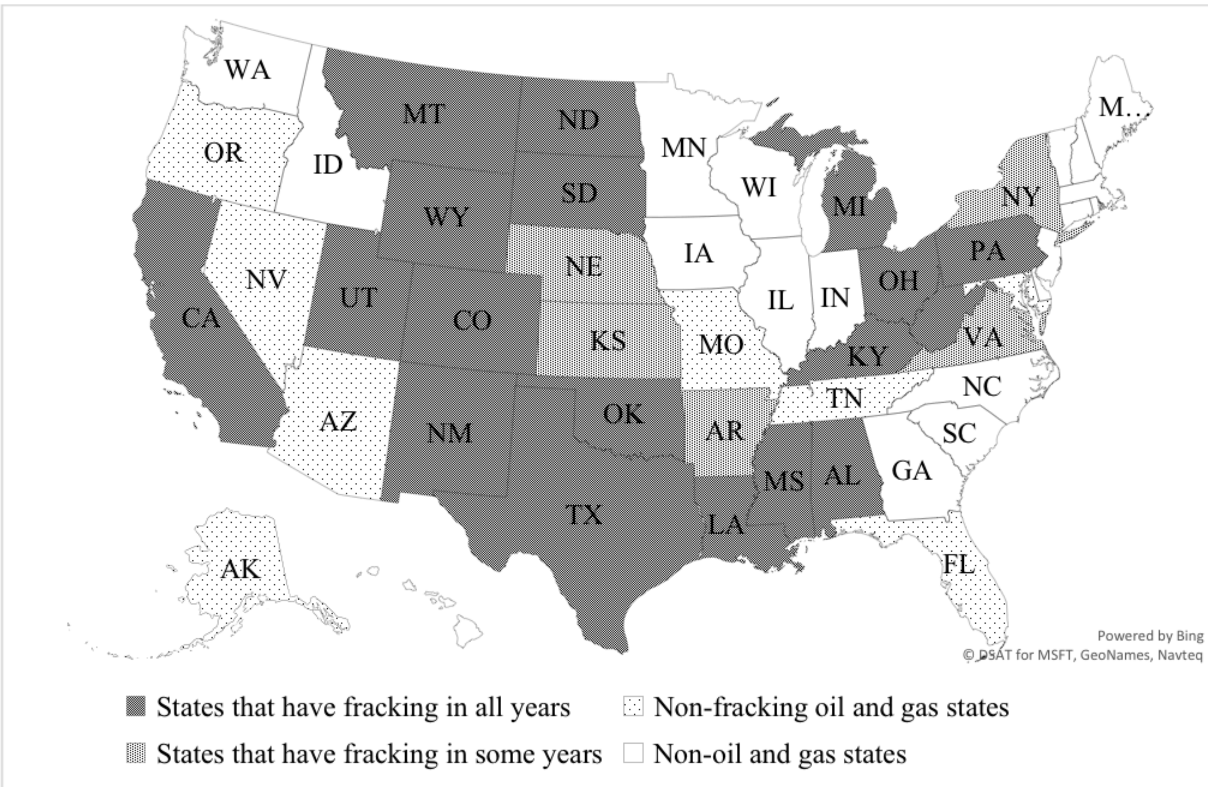
Although fracking produced significant oil and gas output during the boom period of 2008-2015, it should be recognized that some effects of fracking are not visible for some time, such as the need for new infrastructure due to the wear and tear of existing infrastructure. Nevertheless, in the near future, at least for a few years, oil and gas production are projected to increase, partly due to the reduction in the major cost categories.[3] In a recent study, the U.S. Energy Information Administration (2016b) found that the average cost per well has decreased due to the recent contraction of drilling activities, improved drilling efficiency, and the advancement of tools used in drilling and completing wells. In result, average well drilling and completion costs in 2015 were below their level in 2012 by between 25 and 30 percent, when costs per well hit the highest point over the past decade. The study anticipates further reduction in the major cost categories because their primary cost drivers are expected to decrease, thus potentially increasing production in the future.

2.3 Oil and gas production at state level

Before discussing oil and gas production at state level, I report the classification of the states. The 50 states are divided into two broad categories: 31 sample states and 19 non-sample states (Figure 6). The sample states have oil or gas drilling activities within their jurisdictions. However, not all these states have fracking wells. Only eighteen states have fracking wells in every year during the study period. Eight states do not have fracking wells at all. Five states have fracking wells only in some years. Kansas, for example, began to develop fracking in 2010.

[3] According to U.S. EIA (2016), four cost categories make up more than three quarters of the total costs for drilling and completing typical wells: frac pumps and equipment (24%), rig and drilling fluids (15%), proppant (14%), completion fluids and flow back (12%), and casing and cement (11%).

Before 2010, it had none. Similarly, Virginia had fracking wells only after 2003. The remaining 19 states are non-sample states that do not have oil and gas production in any year.[4]



Notes: Data source is drillinginfo.com.

Figure 6: Classification of States During the Period of 2000-2015

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[4] Data from U.S. EIA (2017) indicates that Illinois, Indiana, and Idaho produced oil and gas during the period. Yet, Drilling Info does not report any well belonged to these states. The combination of Illinois and Indiana gas production never exceeds 0.05 percent. Idaho had little gas production in 2015. Accordingly, these three states are categorized as non-sample states.

Table I shows how oil production across all states changed over the study period. In 2015, 26 out of 31 sample states had some oil production, collectively producing 2.9 billion barrels of oil, or an increase of 83 percent from oil production in 2000. Annual oil production also varied greatly among states, from less than 100,000 barrels to 1,252.8 million barrels in 2015. Texas, North Dakota, California, Alaska, and Oklahoma were the top five oil producers, producing 2.2 billion barrels of oil or 78 percent of total oil production. Three states did not have oil production: Maryland, Oregon, and Tennessee.

It is worth noting that North Dakota and Oklahoma gained a substantial increase in oil production in 2015, thanks to the development of fracking in these states. North Dakota's oil production of 429.4 billion barrels in 2015 exceeds that of California and Alaska combined. Alaska, which is traditionally recognized as an oil state, experienced a decline in oil production from 355.1 billion barrels in 2000 to 176.2 billion barrels in 2015, half of the annual production.

Some other states also gained substantial oil production from fracking wells. Until 2000 Texas was the only state that produced considerable volumes of oil from fracking wells. In 2015, North Dakota, Oklahoma, Colorado, and New Mexico saw a substantial production from fracking wells. More than 100 million barrels of crude oil were extracted by each of these states. In terms of percentage, fracking has allowed seven states to extract more than half of the state annual oil production: West Virginia (90%), Ohio (87%), Colorado (84%), Texas (79%), Montana (77%), Pennsylvania (76%), New Mexico (68%), and Oklahoma (65%).

TABLE I
ANNUAL OIL PRODUCTION BY STATE, 2000, 2007, 2015
(MILLION BARRELS)

State	Oil from fracking wells			Oil from non-fracking wells			Oil from all wells		
	2000	2007	2015	2000	2007	2015	2000	2007	2015
AL	0.4	0.1	0.3	10.0	7.1	9.4	10.5	7.2	9.7
AK	-	-	-	355.1	263.6	176.2	355.1	263.6	176.2
AZ	-	-	-	0.1	0.0	0.0	0.1	0.0	0.0
AR	-	0.0	0.1	6.7	5.9	6.1	6.7	5.9	6.2
CA	1.6	1.3	8.1	269.7	217.4	193.3	271.3	218.7	201.4
CO	0.0	0.1	101.6	20.0	26.1	19.8	20.1	26.2	121.4
FL	-	-	-	4.6	2.1	2.1	4.6	2.1	2.1
KS	-	-	0.0	35.1	36.6	45.5	35.1	36.6	45.5
KY	0.0	-	NA	2.7	2.2	NA	2.7	2.2	NA
LA	2.0	0.5	2.4	105.1	76.4	60.3	107.1	76.8	62.7
MD	-	-	-	-	-	-	-	-	-
MI	0.1	0.2	1.0	8.4	6.0	6.1	8.5	6.2	7.1
MS	0.6	0.2	4.7	20.4	20.7	20.4	21.0	20.9	25.0
MO	-	-	NA	0.1	0.1	NA	0.1	0.1	NA
MT	4.2	26.1	21.9	11.4	8.8	6.7	15.6	34.9	28.5
NE	-	-	-	3.0	2.3	2.6	3.0	2.3	2.6
NV	-	-	-	0.6	0.4	0.3	0.6	0.4	0.3
NM	1.7	2.7	100.2	66.9	56.6	47.3	68.7	59.3	147.6
NY	-	-	-	-	0.4	0.3	-	0.4	0.3
ND	8.1	31.9	422.5	24.3	12.9	6.9	32.4	44.8	429.4
OH	0.0	0.0	23.3	5.7	5.0	3.5	5.7	5.0	26.8
OK	0.6	3.0	108.4	70.3	59.9	58.9	70.9	62.9	167.3
OR	-	-	-	-	-	-	-	-	-
PA	-	0.0	5.4	1.4	1.4	1.7	1.4	1.4	7.1
SD	0.3	1.4	1.6	0.9	0.3	0.1	1.2	1.7	1.7
TN	-	-	-	0.4	0.3	-	0.4	0.3	-
TX	170.2	151.2	984.5	268.2	240.1	268.3	438.5	391.3	1,252.8
UT	0.1	0.1	3.7	15.5	19.5	33.5	15.6	19.5	37.1
VA	-	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WV	0.0	0.0	10.4	1.0	2.0	1.1	1.0	2.0	11.6
WY	4.8	3.5	42.9	56.0	50.6	43.5	60.8	54.2	86.4
Total	194.8	222.1	1,842.8	1,363.7	1,124.7	1,014.0	1,558.5	1,346.8	2,856.7

Notes: Non-fracking wells consist of three drilling types: vertical, directional, and unknown. Data source is drillinginfo.com.

For gas, in 2015, 26 states had some production (Table II). Collectively the states produced a total of 32.1 trillion cf of gas in 2015, a 60 percent increase from gas production in 2000. Like oil, annual gas production varies greatly among states, ranging from as little as 3.5 million cf in Nevada to approximately 8.8 trillion cf in Texas. Top gas producers include Texas, Pennsylvania, Alaska, Oklahoma, and Colorado. It is also worth noting how Pennsylvania, a non-producing state in the past, has become a top gas producer, surpassing Louisiana, New Mexico, and Wyoming, which were top producers in 2000 and 2007. In 2015 Pennsylvania produced more than 4.8 trillion cf of gas, a dramatic increase from only 144 billion cf of gas in 2000 and 179 billion cf of gas in 2007, thanks to fracking wells, which contributed 95 percent of its annual production.

Other states also saw substantial production from fracking wells. In 2000, Texas was the only state that was able to extract more than 500 billion cf of gas from fracking wells. In 2015, there were 9 states that produced more than 500 billion cf: Texas (6.2 tcf), Pennsylvania (4.6 tcf), Oklahoma (1.4 tcf), Louisiana (1.2 tcf), West Virginia (1.2 tcf), Ohio (956 bcf), Arkansas (925 bcf), North Dakota (570 bcf), and Colorado (543 bcf). Fracking caused some states, like Ohio, Arizona, and West Virginia, to experience a gas boom in 2015.

TABLE II
ANNUAL GAS PRODUCTION BY STATE, 2000, 2007, 2015
(BILLION CUBIC FEET)

State	Gas from fracking wells			Gas from non-fracking wells			Gas from all wells		
	2000	2007	2015	2000	2007	2015	2000	2007	2015
AL	2.3	0.5	0.7	401.2	290.7	168.5	403.5	291.2	169.2
AK	-	-	-	3,553.4	3,495.9	3,192.6	3,553.4	3,495.9	3,192.6
AZ	-	-	-	0.4	0.6	0.1	0.4	0.6	0.1
AR	-	84.5	925.3	174.9	187.8	90.6	174.9	272.2	1,015.9
CA	1.0	0.5	4.5	512.2	504.1	404.7	513.3	504.6	409.2
CO	1.3	5.7	543.1	1,115.1	1,741.3	1,550.9	1,116.3	1,747.0	2,094.0
FL	-	-	-	7.3	2.0	23.6	7.3	2.0	23.6
KS	-	-	0.1	533.6	371.0	285.6	533.6	371.0	285.7
KY	0.0	1.4	NA	77.2	87.3	NA	77.2	88.7	NA
LA	12.9	13.9	1,195.7	1,454.6	1,341.3	604.5	1,467.5	1,355.3	1,800.2
MD	-	-	-	0.1	0.0	0.0	0.1	0.0	0.0
MI	0.5	0.3	2.2	245.8	166.3	105.7	246.3	166.6	107.9
MS	0.0	6.3	37.9	122.3	280.9	277.9	122.4	287.1	315.8
MO	-	-	NA	-	-	NA	-	-	NA
MT	1.5	21.2	25.8	69.9	99.5	57.1	71.4	120.6	83.0
NE	-	-	-	1.2	1.6	0.4	1.2	1.6	0.4
NV	-	-	-	0.0	0.0	0.0	0.0	0.0	0.0
NM	3.2	24.3	335.2	1,795.5	1,612.4	1,044.0	1,798.7	1,636.6	1,379.2
NY	-	1.9	2.3	17.8	53.1	15.6	17.8	55.0	17.8
ND	14.2	38.7	570.9	41.5	32.1	13.7	55.7	70.8	584.6
OH	0.2	0.1	955.6	91.9	77.1	53.8	92.2	77.2	1,009.4
OK	13.9	205.2	1,391.1	1,687.9	1,618.2	703.7	1,701.8	1,823.3	2,094.8
OR	-	-	-	1.6	0.4	0.5	1.6	0.4	0.5
PA	0.1	0.3	4,590.6	143.6	169.6	227.7	143.7	170.0	4,818.3
SD	0.8	8.9	13.5	9.9	3.0	1.0	10.7	11.9	14.6
TN	-	-	-	0.5	3.1	-	0.5	3.1	-
TX	771.0	1,568.4	6,189.3	4,987.8	5,353.3	2,640.8	5,758.8	6,921.7	8,830.2
UT	0.0	0.2	4.8	281.1	385.3	412.3	281.2	385.5	417.0
VA	-	0.2	3.2	71.5	111.9	124.4	71.5	112.1	127.6
WV	0.4	1.0	1,164.2	160.9	233.0	151.1	161.4	234.0	1,315.2
WY	80.6	78.5	166.5	1,428.8	2,183.2	1,830.1	1,509.4	2,261.7	1,996.5
Total	904.1	2,061.8	18,122.5	18,989.6	20,405.9	13,981.0	19,893.7	22,467.7	32,103.6

Notes: Non-fracking wells consist of three drilling types: vertical, directional, and unknown. Data source is drillinginfo.com.

2.4 The growth of drilling activity in the United States

The development of the oil and gas industry in the U.S. is indicated by the number of active oil and gas wells. Nationwide, the number of oil and gas wells has grown considerably, from 635,189 wells in 2007 to 899,205 in 2015, or an increase of 264,016 over the period (Table III). Much of the growth in the period of 2000-2007 can be attributed to the increase in non-fracking wells, while the growth in 2007-2015 was driven by the increase in fracking wells. During the period of 2007-2015, the number of non-fracking wells grew by 20 percent from 608,480 wells in 2000 to 729,090in 2007. The number of fracking wells experienced the most dramatic growth from only 36,778 wells in 2007 to 122,713 in 2015.

Some states saw drastic increases in the number of wells. Much of the increase in all wells took place in three states: Texas, Pennsylvania, and Colorado. Texas, for example, experienced an increase of 77,717 wells from 208,736 wells in 2007 to 286,453 in 2015. Similarly, Pennsylvania and Colorado saw an increase of 41,532 and 29,272 wells, respectively. The growth in number of wells at national level is partly attributed to these three states.

Before the fracking boom, most fracking wells were located in Texas, in which 93 percent of fracking wells in 2000 were to be found. The diffusion of fracking technology across states, which began in the 2000s, resulted in substantial growth of fracking wells in many states. Although Texas remained the state with the most fracking wells in the U.S. in 2015, its share of total fracking wells declined to only 59 percent nationally. Four states experienced substantial growth in the number of fracking wells: Ohio (10,734), North Dakota (10,216), Pennsylvania

(5,861), and Arizona (5,383).[5] The combination of fracking wells in the four states contributed approximately 27 percent of fracking wells in the U.S. in 2015, up from only 3.2 percent in 2000.

[5] Furthermore, fracking wells contributed more than half of total wells in North Dakota (85.9%) and Arizona (48.6%).

TABLE III
NUMBER OF ACTIVE WELLS BY DRILLING TYPE IN 2000, 2007, AND 2015

State	Fracking wells			Non-fracking wells			All wells		
	2000	2007	2015	2000	2007	2015	2000	2007	2015
AL	6	6	21	3,891	5,985	6,411	3,897	5,991	6,432
AK	-	-	-	1,909	1,821	1,957	1,909	1,821	1,957
AZ	-	-	-	33	18	21	33	18	21
AR	-	307	5,383	4,212	5,604	5,690	4,212	5,911	11,072
CA	113	163	842	43,254	47,995	50,652	43,367	48,157	51,494
CO	20	57	3,611	20,627	34,187	46,308	20,647	34,244	49,919
FL	-	-	-	71	54	60	71	54	60
KS	-	-	1	45,258	51,655	58,991	45,258	51,655	58,992
KY	3	30	NA	12,844	15,608	NA	12,847	15,638	NA
LA	15	126	2,905	30,178	32,883	31,806	30,192	33,009	34,711
MD	-	-	-	7	6	3	7	6	3
MI	18	26	111	9,985	13,027	13,652	10,003	13,052	13,763
MS	28	44	156	2,057	3,118	3,187	2,085	3,162	3,342
MO	-	-	NA	197	223	NA	197	223	NA
MT	327	1,042	1,656	6,547	8,854	8,128	6,874	9,896	9,784
NE	-	-	-	2,160	1,952	2,054	2,160	1,952	2,054
NV	-	-	-	63	70	62	63	70	62
NM	137	286	3,267	38,450	50,037	53,271	38,587	50,323	56,538
NY	-	3	55	5,667	8,967	9,519	5,667	8,969	9,574
ND	672	1,248	10,888	2,556	2,496	1,786	3,228	3,744	12,674
OH	7	17	1,043	38,349	41,694	41,771	38,356	41,711	42,814
OK	181	2,034	10,915	61,637	66,964	55,831	61,818	68,998	66,746
OR	-	-	-	17	12	10	17	12	10
PA	1	10	5,862	38,054	38,526	73,725	38,055	38,535	79,587
SD	16	77	130	173	121	84	188	198	214
TN	-	-	NA	268	1,017	NA	268	1,017	NA
TX	24,846	30,838	72,103	183,890	200,261	214,350	208,736	231,099	286,453
UT	9	13	118	3,974	7,408	12,113	3,984	7,421	12,231
VA	-	5	103	2,424	5,228	7,856	2,424	5,232	7,958
WV	24	58	2,106	30,425	45,238	46,041	30,449	45,296	48,147
WY	287	388	1,437	19,303	38,061	31,157	19,590	38,449	32,593
Total	26,710	36,775	122,711	608,477	729,088	776,494	635,187	765,863	899,206

Notes: Non-fracking wells consists of three drilling types: vertical, directional, and unknown. Data source is drillinginfo.com.

3. THEORETICAL FRAMEWORK AND LITERATURE

This chapter provides a theoretical framework of state tax policies on oil and gas production. First, I discuss state potential responses to windfall gains from oil and gas extraction. Then, I review state tax treatments on oil and gas production, including fracking production, followed by a discussion of the distribution of the oil and gas revenues. In the next section, I review recent literature that investigates the effects of oil and gas booms on government finances. The last section states hypotheses to be tested in this study.

3.1 A behavioral model

To develop a model of state fiscal behavior regarding windfall gains from natural resource exploitation, I first discuss state motivations for imposing taxes on oil and gas production. My review on literature suggests that there are three distinct state motivations for taxes on oil and gas exploitation. The first motivation is to compensate for negative externalities caused by the extraction of oil and gas (Tietenberg 2004). In the areas where fracking is developed, local communities suffer from increased traffic congestion and deteriorating infrastructure. The increase in use of heavy trucks to transport water has created traffic congestion and degraded local roads. Regions with increased fracking also experience an increase in the crime rate (Bartik et al 2016). Accordingly, imposing taxes on oil and gas exploitation should cause fracking companies to internalize the environmental and social costs of resource extraction (VanDeveer 2013).

Recognition that oil and gas are exhaustible and non-renewable resources is another motive for states to tax oil and gas extraction activities (Rabe and Hampton 2015). Once oil and gas reserves are extracted from underground, the resources are permanently withdrawn and consumed. States impose a tax to create revenue in exchange for the permanent withdrawal. This motivation is justified by a philosophical argument that natural resources of country, state, or community are the property of the people of the country, state, or community. Wenar (2008) argues that the moral ground that states the resources of a jurisdiction belong to the people of that jurisdiction is generally recognized in international law. Accordingly, state taxes on oil and gas production are intended to benefit the residents of the states.

A third motivation, which is the focus of this study, is that states collect taxes on oil and gas production in order to increase state revenues. From a fiscal perspective, oil and gas booms are viewed as an opportunity for states to collect more revenues by exporting the tax burden to residents outside the state. Alaska is a classic example of the tax exporting phenomenon, in which the greater share of its tax collection comes from severance tax that falls on non-Alaska residents because the majority of the extracted oil goes to other states. The consumers of its oil products across the country bear the tax burden as Alaska severance tax is bundled in the oil price.

States are also inclined to tax oil and gas production due to relatively few political constraints. Rabe and Hampton (2015) argue that tax on the oil and gas industry is politically appealing. Different from broad base taxes that are imposed on general taxpayers, like personal income and general sales taxes, oil and gas taxes have a narrow tax base. It is the oil and gas companies that legally pay oil and gas taxes. Accordingly, public reaction to a legislative bill to increase tax rates on oil and gas production is expected to garner political support. It does not mean, however, that the oil and gas industry have little opposition relative to general taxpayers as the oil and gas companies are outnumbered by general taxpayers. Recent news has shown how the industry strongly opposes any attempt to increase state tax rates on oil and gas production

(Wertz 2017). Burford (2012) finds that lobbying from the industry helps shape state policies, including oil and gas regulations and state taxes.

Borrowing the work of Bae and Feiock (2004), Figure 7 illustrates a simple framework for the study of state behavior in responding to an increase in oil and gas revenues.

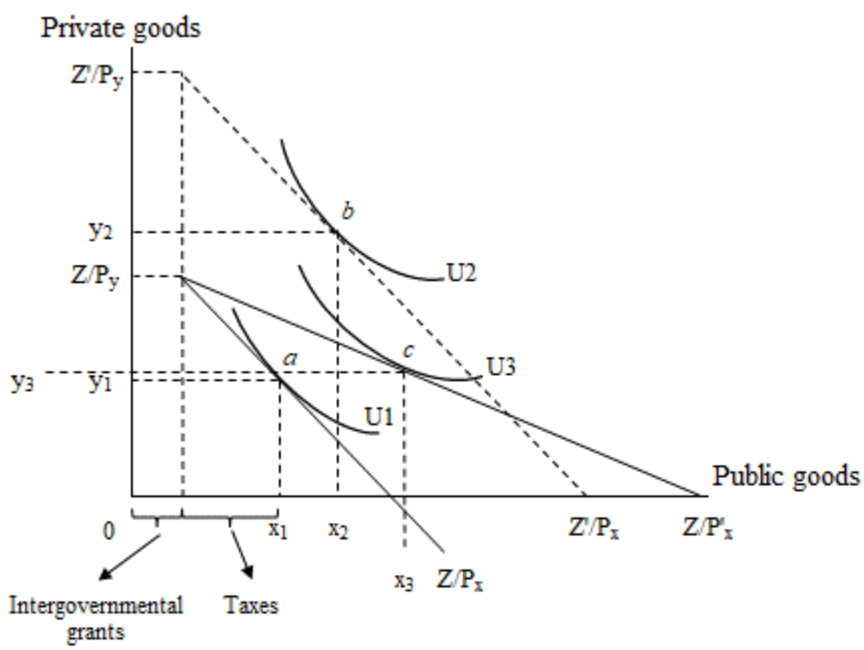

Figure 7: A Model of State Behavior

Assume that state budget is determined according to median voter preference, according to the following equation:

$$Z = P_xX + P_yY \quad (1)$$

$$\text{or } Y = Z/P_y - (P_x/P_y)\,X \quad (2)$$

where Z denotes the median voter's income, P_x is the median voter's tax-price to provide an amount of public goods, X is the amount of public goods, P_y is the price of private goods, Y is the amount of private goods, and – (P_x/P_y) is the slope of the median voter's budget constraint.

While the median voter model is basically a model to explain government spending behavior, it is also a useful framework to explain state behavior in response to a rapid increase in resource revenues. First, from a legal perspective, state revenues and expenditures are interrelated due to constitution or statute requirements to balance state budget. And second, from a practical viewpoint, both revenue and expenditure sides of state budget are determined simultaneously in the annual budget process. A theoretical work by Bassetto and Benhabib (2006) provides an example how the median voter theorem can be used to explain redistribution of wealth and optimal redistributive tax rates.

Oil and gas boom shifts the budget line to Z'/P_y-Z'/P_x, shifting the equilibrium *a* to *b* because a larger portion of the revenue burden can be exported to out-of-state residents. Intergovernmental grants finance a fraction of spending on public goods. Therefore, total spending on public goods at *a* will be less than $P_x * x_1$. The additional spending on public goods (X) when the optimal bundle move from to *a* to *b* will be financed by combination of intergovernmental grants and additional taxes. Therefore, total own-source revenue is expected to rise.

If the same amount of oil and gas tax revenues are given to residents in proportion to their state tax rate, the median voter's income would increase from Z to Z'. We call this the income effect of oil and gas taxes.[6] An equivalent increase in the median voter's disposable

[6] In this model, oil and gas booms are assumed to be exogenous for two reasons: 1) states do not invest in technologies to extract oil and gas, and 2) oil and gas prices are determined by the market.

income, equal to Z'-Z, would have the same effect as the amount of oil and gas revenues since it would also produce the budget line Z'/P_y-Z'/P_x, with equilibrium again at *b*.

If state officials enact the state budget according to the median voter's preference, new state expenditure is determined at the level of *b*. For instance, suppose that ten cents of an extra dollar of the median voter's disposable income is usually spent on education. For each dollar of oil and gas revenues, we would expect that the state spends ten cents on education spending, and ninety cents would be returned to the taxpayer in the form of reduced tax liability. The amount of money returned to taxpayers, however, would be lower than ninety cents, given the imperfect nature of government budget information, associated with a phenomenon called fiscal illusion (Downs 1957, Wagner 1976).

As Oates (1979) concludes, budget maximizing bureaucrats would hide government budget tax-price information. If the state officials inform the median voter of the amount of benefit he gets from the oil and gas windfall gain, the median voter's preference will change from *a* to *b* because the windfall gain creates income effect. The oil and gas revenues do not change the median voter's marginal tax-price (P_x). What the median voter would perceive as his tax-price, however, is not the marginal tax-price. Instead, the median voter would perceive a fraction of the total cost of state budget financed by state tax revenues other than oil and gas taxes. Oates (1979) labels it the average tax price. Accordingly, the median voter's perceived average tax-price can be expressed as follows:

$$P'_x = (E - N) / E \qquad (3)$$

where, P'_x denotes the median voter's perceived average tax-price, E is the state expenditure, and N is oil and gas tax revenues.

As the median voter's perceived tax-price decreases from P_x to P'_x, he would think that his budget constraint had changed from $Z/P_y–Z/P_x$ to $Z/P_y–Z/P'_x$. Accordingly, the median voter's equilibrium changes from *a* to *c*, at which he would consume more public goods and more private goods. The median voter's utility function at *c* (U_3) is higher than at *a* (U_1), but lower than at *b* (U_2). The lower average tax-price also induces a price effect as well as an income effect. An oil and gas boom would persuade the median voter to accept higher state expenditures than those from before the state experienced the resource boom. In summary, an increase in oil and gas revenues leads to a greater increase in public spending than in private income of an equivalent size.

With regard to spending behavior, states will likely use oil and gas revenues to increase state budget. As discussed in the model, oil and gas tax revenues look a lot like intergovernmental transfers. Similar to lump-sum grants to a recipient government, oil and gas revenues would increase government spending more than an increase in private income of an equivalent size. Arthur Okun called this phenomenon the flypaper effect because money "sticks where it hits" (Hines and Thaler 1995). In this scenario, states would use oil and gas revenues to finance current spending just as they would spend other revenues.

From a practical point of view, when enacting state budgets, governors and legislators would consider total revenues and not necessarily differentiate revenues coming from specific sources (Sjoquist, Stephenson, and Wallace 2011). Theoretically, this scenario is in line with the budget-maximizing model that depicts states' public officials as rational and self-interested actors who aim to maximize their budget and power (Niskanen, 1971, 1991). States are keen to use oil and gas revenues for current spending, supported by budget maximizing bureaucrats. If this is the case, then budgetary responses to changes in revenues financed by an increase in oil and gas revenues or other revenues would be identical. As a result, states will spend oil and gas revenues just as it would spend other revenues.

States might deviate from this spending behavior if there exists an institutional arrangement to mandate states to save some portion of oil and gas revenues for specific purposes. If such a requirement exists, then states have to allocate a certain amount or percentage of oil and gas revenues into specific spending categories, and thus potentially increase total spending in those categories by an amount equal to net oil and gas revenues. Texas and Montana, for example, allocate some portion of oil and gas revenues for public primary and secondary education. In result, part of the oil and gas revenues that are earmarked may not be available for general spending.

3.2 State tax treatments of oil and gas production

In general, there is no difference in state tax treatment between resources extracted via fracking compared to those with more conventional drilling techniques. In many states, severance tax is collected on oil and gas production, including production extracted from fracking wells. Among various sources of state taxes, the severance tax is the only revenue source that is directly intended to tax economic activities related to oil and gas exploitation. Originally imposed on the extraction of coal, iron ore, and other minerals, states with substantial amounts of oil or natural gas started to collect such taxes on oil and gas early in the 20th century (Rabe and Hampton 2015). Severance taxes can have several terminologies, including severance tax, conservation fee/tax, royalties, excise tax, restoration fee, privilege and license, processor tax, production tax/fee, extraction tax, gas well fee, impact fee, and regulatory fee. The U.S. Census Bureau (2014) codifies all these taxes under the terminology of severance taxes.[7]

In 2010, there were 36 states that collected severance taxes (U.S. Census Bureau 2011).[8] Among 22 states that have fracking wells, Pennsylvania and New York are the only states that do not impose severance taxes. Nationwide, total severance taxes nearly doubled from $6.4 billion in 2001 to $11.3 billion in 2010 (Table IV). Severance taxes contributed more than 10 percent of total tax revenues in seven states in 2010, up from five in 2001. Eleven states were able to collect more than $100 million of severance taxes with Alaska, Texas, and North Dakota as the top three. Associating severance tax with oil and gas reserves, one can infer that when a state has abundant natural resources, it is more likely to impose severance taxes and collect substantial revenue from it.

Although states do not differentiate tax treatment between fracking and other conventional drilling techniques, there is a wide variation in tax treatment across states. Technically, there are two main differences in how states tax oil and gas exploitation. First, states differ in severance tax rates. Table V shows the variation in effective rates of state severance taxes across states in 2013 with North Carolina has the lowest rate of 0.02% and Alaska has the highest rate of 25%. At $2.46/Mcf price of gas, Alaska would collect 61.5 cent per Mcf gas extracted. However, all the severance tax it collects is from conventional drilling as it has no fracking wells.

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[7] U.S. Census Bureau (2014) defines severance taxes as "taxes imposed distinctively on removal of natural products (e.g. oil, gas, other minerals, timber, fish, etc.) from land or water and measured by value or quantity of products removed or sold".

[8] The states that did not impose severance taxes were Delaware, Georgia, Hawaii, Iowa, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, South Carolina, and Vermont.

TABLE IV
OIL AND GAS RESERVES AND STATE SEVERANCE TAXES, 2001 AND 2010

State	Crude oil reserve (million barrels)		Dry Gas Reserve (billion cubic feet)		State Severance Taxes (million dollar)		Percent Share of State Severance Taxes in Total State Tax Revenue	
	2001	2010	2001	2010	2001	2010	2001	2010
Alabama	42	42	3,915	2,629	118.3	90.5	1.8%	1.1%
Alaska	4,851	3,722	8,800	8,838	772.4	3,355.0	54.1%	74.2%
Arizona	3	5	8	35	4.2	29.1	0.1%	0.3%
Arkansas	43	40	1,616	14,178	15.9	65.1	0.3%	0.9%
California	3,627	2,938	2,681	2,647	24.6	24.4	0.0%	0.0%
Colorado	196	386	12,527	24,119	61.9	71.4	0.8%	0.8%
Connecticut	-	-	-	-	-	0.1	-	0.0%
Delaware	-	-	-	-	-	-	-	-
Florida	75	18	84	56	49.3	71.0	0.2%	0.2%
Georgia	-	-	-	-	-	-	-	-
Hawaii	-	-	-	-	-	-	-	-
Idaho	-	-	-	-	2.6	6.7	0.1%	0.2%
Illinois	92	64	8	35	0.3	-	0.0%	-
Indiana	12	8	8	35	0.6	1.4	0.0%	0.0%
Iowa	-	-	-	-	-	-	-	-
Kansas	216	295	5,101	3,673	114.0	102.9	2.3%	1.6%
Kentucky	17	15	1,860	2,613	175.0	317.1	2.2%	3.3%
Louisiana	564	424	9,811	29,277	464.4	758.5	6.5%	8.7%
Maine	-	-	-	-	-	-	-	-
Maryland	-	-	8	35	-	-	-	-
Massachusetts	-	-	-	-	-	-	-	-
Michigan	46	40	2,976	2,919	61.8	63.1	0.3%	0.3%
Minnesota	-	-	-	-	1.1	23.3	0.0%	0.1%
Mississippi	167	247	661	853	35.1	90.8	0.7%	1.4%
Missouri	3	5	8	35	0.1	0.0	0.0%	0.0%
Montana	260	369	898	944	131.9	253.6	8.8%	11.8%
Nebraska	15	10	8	35	2.0	3.5	0.1%	0.1%
Nevada	3	5	8	35	29.7	182.8	0.8%	3.1%
New Hampshire	-	-	-	-	-	-	-	-
New Jersey	-	-	-	-	-	-	-	-
New Mexico	715	823	17,414	15,412	675.2	654.8	16.9%	15.2%
New York	3	5	318	281	-	-	-	-
North Carolina	-	-	-	-	2.0	1.5	0.0%	0.0%
North Dakota	328	1,814	443	1,667	164.6	1,136.6	14.1%	43.0%

TABLE IV
OIL AND GAS RESERVES AND STATE SEVERANCE TAXES, 2001 AND 2010

State	Crude oil reserve (million barrels)		Dry Gas Reserve (billion cubic feet)		State Severance Taxes (million dollar)		Percent Share of State Severance Taxes in Total State Tax Revenue	
	2001	2010	2001	2010	2001	2010	2001	2010
Ohio	46	42	970	832	8.3	10.6	0.0%	0.0%
Oklahoma	556	710	13,558	26,345	711.1	743.7	11.2%	10.5%
Oregon	-	-	8	35	34.9	12.7	0.6%	0.2%
Pennsylvania	10	22	1,775	13,960	-	-	-	-
Rhode Island	-	-	-	-	-	-	-	-
South Carolina	-	-	-	-	-	-	-	-
South Dakota	3	5	8	35	2.2	8.4	0.2%	0.6%
Tennessee	3	5	8	35	1.1	2.3	0.0%	0.0%
Texas	4,944	5,674	43,527	88,997	2,044.8	1,856.3	6.9%	4.7%
Utah	271	449	4,579	6,981	51.9	89.2	1.3%	1.7%
Vermont	-	-	-	-	-	-	-	-
Virginia	3	5	1,752	3,215	1.7	1.9	0.0%	0.0%
Washington	-	-	-	-	55.2	20.9	0.4%	0.1%
West Virginia	8	17	2,678	7,000	167.8	546.3	4.9%	11.4%
Wisconsin	-	-	-	-	1.3	5.0	0.0%	0.0%
Wyoming	489	567	18,398	35,074	421.3	721.0	37.5%	33.4%
Total	17,611	18,771	156,422	292,860	6,408.6	11,321.5		

Notes: Data source for crude oil proved reserves is U.S. Energy Information Administration, https://www.eia.gov/dnav/pet/pet_crd_pres_a_EPC0_R01_mmbbl_a.htm. Data source for dry natural gas proved reserves is U.S. Energy Information Administration, https://www.eia.gov/dnav/ng/ng_enr_dry_a_EPG0_r11_bcf_a.htm. Data source for state severance tax is U.S. Census Bureau, Government Finance Statistics, https://www.census.gov/govs/financegen.
Data source for number of fracking wells is drillinginfo.com.

TABLE V
EFFECTIVE RATES OF STATE SEVERANCE TAXES ON GAS PRODUCTION AT $2.46/MCF PRICE IN 2013

State	In percentage	In cent dollar
Alabama	8.00%	19.68
Alaska	25.00%	61.50
Arizona	3.13%	7.69
Arkansas	7.00%	12.30
California	0.50%	1.40
Colorado	5.00%	12.30
Connecticut	N/A	N/A
Delaware	No severance tax	
Florida	14.02%	34.50
Georgia	No severance tax	
Hawaii	No severance tax	
Idaho	2.50%	6.15
Illinois	0.10%	0.25
Indiana	1.00%	3.00
Iowa	No severance tax	
Kansas	8.00%	19.68
Kentucky	4.50%	11.07
Louisiana	6.70%	16.40
Maine	No severance tax	
Maryland	7.00%	17.22
Massachusetts	No severance tax	
Michigan	5.00%	12.30
Minnesota	N/A	N/A
Mississippi	6.00%	14.76
Missouri	N/A	N/A
Montana	9.00%	22.14
Nebraska	3.00%	7.38
Nevada	N/A	N/A
New Hampshire	No severance tax	
New Jersey	No severance tax	
New Mexico	3.75%	9.28
New York	No severance tax	
North Carolina	0.02%	0.05
North Dakota	3.80%	9.40
Ohio	1.00%	2.50
Oklahoma	7.00%	17.22
Oregon	6.00%	14.76
Pennsylvania	No severance tax	

TABLE V
EFFECTIVE RATES OF STATE SEVERANCE TAXES ON GAS PRODUCTION AT $2.46/MCF PRICE IN 2013

State	In percentage	In cent dollar
Rhode Island	No severance tax	
South Carolina	No severance tax	
South Dakota	4.50%	11.07
Tennessee	3.00%	7.38
Texas	7.50%	18.45
Utah	5.00%	12.30
Vermont	No severance tax	
Virginia	1.00%	2.46
Washington	N/A	N/A
West Virginia	5.00%	12.30
Wisconsin	7.00%	17.22
Wyoming	6.00%	14.76

Notes: The effective tax rates are calculated by using each state's prevailing long-term tax rate for producing wells, and ignoring tax credits, any incentive programs, or lower rates during initial production. Data for these states are collected from the Resource for the Future report by Richardson et al (2013): Alabama, Arkansas, California, Colorado, Georgia, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maryland, Michigan, Mississippi, Montana, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, West Virginia, and Wyoming. Data for these states are collected from Brown (2013): Alaska, Arizona, Florida, Idaho, New Hampshire, Oregon, and Wisconsin.

The second difference is how states calculate severance taxes. In general, there are three ways states calculate severance taxes: volume based, value based, and a combination of both. In their survey, Richardson et al (2013) find that eighteen states calculate severance taxes as a percentage of extracted gas value, five states tax the volume of gas extracted, and three states used the hybrid method.

A volume-based tax uses a flat tax rate on the volume of oil or gas being extracted, generally in terms of per barrel of oil or per one thousand cubic feet of gas (Brown 2013). Under this tax mechanism, tax revenue from oil and gas production is the function of volume of produced oil and gas. California, for example, imposes a $ 0.3243123 on each barrel of oil and 10,000 cubic feet of natural gas produced (State California Department of Conservation 2017).

While simple to implement and predictable, a volume-based tax does not account for the fluctuation of oil and gas prices. When oil and gas prices are high, the state misses the opportunity to generate more revenues. Vice versa, when oil and gas prices are low, oil and gas companies are under greater pressure to swallow a greater tax portion to the total cost of extraction. To address these issues, states often adjust the flat rate annually. In California's case, the tax rate is updated in June of each year.

A value-based tax is a mechanism in which the tax a state collects depends on the market value of oil and gas being produced, minus applicable deductions, credits, and exemptions (Brown 2013).[9] Deductions and credits include distribution and transportation costs; exemptions include low producing wells and incentives on research on reserve exploration. Michigan, for example, collects taxes on oil and gas at 6.6% and 5% of the gross market value, respectively (Michigan Department of Treasury 2017). Since a value-based mechanism reflects price

[9] States also vary in deduction, exemption, and credit.

fluctuation, revenue from oil and gas becomes less predictable and thus leaves state revenues subject to volatility in the oil and gas market. One way to reduce revenue volatility is by combining volume and value-based tax mechanisms.

The combination of volume and value-based tax allows states to apply separate tax rates to the volume and value of produced oil and gas. Louisiana, for example, has two sets of tax rates imposed on oil production: a single volume based flat rate under Oil Field Restoration Fee and multiple value-based tax rates under Natural Resources Severance Tax (State of Louisiana Department of Natural Resources 2017). By using the combination of volume and value-based taxes, states are able to increase revenue when oil and gas firms enjoy a market boom, and reduce fiscal pressure when the industry plummets (Brown 2013).

3.3 Research development on oil and gas boom and government finances

Table VI summarizes the research designs and key findings from 10 empirical studies on oil and gas boom and government finances in the last six years. Although there seems to be no consensus regarding how studies on resource boom and government finances should be conducted, all the studies are empirical in nature and examine whether and to what extent resource boom affects government finances. The summary of empirical studies indicates there are wide variations in how long a period should be examined. Some studies observe the effects of oil and gas booms over ten years time (e.g. Le and Plummer 2011), while the others have shorter time periods (e.g. 2 years in Raimi and Newell 2016c; and 1 year in Rahm et al 2016). Some studies use cross-sectional data that examine the presence and impact of oil and gas booms at a given point of time (e.g. Rahm et al 2016; Raimi and Newell 2016d). The difference in the duration of observation suggests that the length of observation can be an issue in examining the effects of resource boom on government finances.

TABLE VI
EMPIRICAL STUDIES ON THE EFFECTS OF OIL AND GAS BOOMS ON GOVERNMENT FINANCES

Author (Year)	Dependent Variables	Units of Analysis and Sample	Period	Analytical Strategy	Endoge-neity treated?	Primary independent variable	Other independent variables	Findings
Rahm, Farmer, and Fields (2016)	Increase in local revenue from various sources of own-source revenues	16 cities with population greater than 2,000 people and 18 counties over Eagle Ford Shale	2014	Kendall's T-test	No	Oil and gas development in the counties and cities	Ability to manage fiscal stress, changed tax rates, the presence of budget strategies to mitigate long-term future costs, and the presence of revenue stabilization fund.	Counties and cities within the region have gained substantial revenue increases as the result of fracking. The local governments generally gained increases from taxation and spillover investments from oil and gas development. Over half of counties within the Eagle Ford Shale lowered the tax rate when drilling activities result in a profitable business.
Bartik, Currie, Greenstone, and Knittel (2016)	Total revenues, total expenditures	County wide local governments in nine different shale plays	2002 and 2012	Difference-in-differences, i.e. measuring the change in the difference between high and low prospectivity counties within shale plays, after fracking was initiated, relative to before its initiation.	Yes, using geological variation within shale plays across the US and variation in the timing of the onset of fracking	Index of geological variation in the application of fracking techniques within US shale deposits		Successful fracking techniques would increase local government revenues in nine different shale plays by 15.5 percent and expenditures by 12.9 percent.
Le and Plummer (2011)	School district tax revenues	1,034 school districts in Texas	1991-2009	- Comparing high oil and gas and low	Yes	Oil and gas property		- High oil and gas districts are as twice as healthy as low oil and gas districts.

TABLE VI
EMPIRICAL STUDIES ON THE EFFECTS OF OIL AND GAS BOOMS ON GOVERNMENT FINANCES

Author (Year)	Dependent Variables	Units of Analysis and Sample	Period	Analytical Strategy	Endoge-neity treated?	Primary independent variable	Other independent variables	Findings
				oil and gas school districts by size, wealth, and ruralness - Comparing taxable property value per student in high oil and gas and low oil and gas school districts				In average, taxable value per student in high oil and gas districts is $297,441, while low oil and gas districts collect $150,112. - Oil and gas property is the major source of wealth in high oil and gas districts. In average, about 60% of their wealth come from oil and gas properties. Oil and gas property only contributes 2% of wealth to low oil and gas districts.
Sances and You (2016)	County revenue or spending	9,297 local governments aggregated at county level	1996-2012	Ordinary least square, fixed effect	No	Total new value from production at county level	Total new value from production at state level, population, share of population older than 65 years old, race, college degree, median family income, and unemployment level	- Fracking significantly increased own-source revenues for local governments. - Fracking has mainly increased non-educational spending and salaries. - Insignificant and smaller impacts on education spending and salaries.
Raimi and Newell (2016a)	Financial condition of local governments	Dunn County and Watford City, two local governments in North Dakota	2013-2015	Case study and descriptive analysis, including interview, and	Yes	Local fracking activities	Transfer from the state	- Rapid growth in government revenues was outstripped by increased demand for public services

TABLE VI
EMPIRICAL STUDIES ON THE EFFECTS OF OIL AND GAS BOOMS ON GOVERNMENT FINANCES

Author (Year)	Dependent Variables	Units of Analysis and Sample	Period	Analytical Strategy	Endoge-neity treated?	Primary independent variable	Other independent variables	Findings
				analysis financial data				- Transfer from the state helped meet the need of expanded city and county
Raimi and Newell (2016b)	Local government revenue and costs: infrastructure cost, property tax, impact fee, and sales tax.	- Two counties: Garfield and Rio Blanco - Two cities: Grand Junction and Rifle The four local governments are located in Colorado	2013-2014	Case study and descriptive analysis, including interview, and analysis on financial data	Yes	Local fracking activities	Government capacity, rapid population growth	- Garfield County was able to benefit from fracking, while Rio Blanco faced fiscal problems. Garfield County shifted the cost of infrastructure to operators by requiring them to repair roads damaged during operations. Rio Blanco County was unable to avoid the cost due to less government capacity and the absence of such agreements with the operators - The cities experienced substantial population growth driven by oil and gas development, while the smaller, more isolated, and less economically diverse city of Rifle experienced greater challenges.
Raimi and Newell (2016c)	Local government revenues and costs associated	Sixty-seven local governments (29 counties and	2014-2015	Survey and descriptive analysis, including	Yes	Oil and gas production from shale resources	Collaboration with oil and gas operators, government	- The effects of fracking on fiscal condition vary depending on local factors.

TABLE VI
EMPIRICAL STUDIES ON THE EFFECTS OF OIL AND GAS BOOMS ON GOVERNMENT FINANCES

Author (Year)	Dependent Variables	Units of Analysis and Sample	Period	Analytical Strategy	Endoge-neity treated?	Primary independent variable	Other independent variables	Findings
	with oil and gas development	38 municipalities) in eight states		interview, and analysis on financial data			capacity, and rurality of region	- For most regions, fracking has been a net positive for local finances. - For highly rural areas with limited existing infrastructure, increased fracking activities leads to large new infrastructure and staff costs.
Raimi and Newell (2016d)	Various sources of local government revenues: state taxes or fees on oil and gas production, local property taxes on oil and gas property, leasing of state-owned land, and leasing of federally owned land	16 states	2013	Survey, descriptive analysis	No	Value of oil and gas production	N/A	- Different policies among states led to wide variation of the share of oil and gas production value allocated to and collected by local governments. - School districts experienced the highest share of revenue, followed by counties. - Municipalities and other local governments received smaller shares of oil and gas driven revenue due to limited geographic boundaries.
Raimi and Newell (2014)	Local government revenues	Counties and municipalities in eight states	2007-2012	Descriptive analysis	No	Local fracking activities	Collaboration with oil and gas operators, the relative scale and speed of oil and gas boom, and	- Most local governments gained net financial benefits from the recent increase in oil and gas development

TABLE VI
EMPIRICAL STUDIES ON THE EFFECTS OF OIL AND GAS BOOMS ON GOVERNMENT FINANCES

Author (Year)	Dependent Variables	Units of Analysis and Sample	Period	Analytical Strategy	Endoge-neity treated?	Primary independent variable	Other independent variables	Findings
							the rurality of a given region	- Local governments also faced higher demand for local services.
Costanzo & Kelsey (2012)	Local collection of state taxes	Counties in Pennsylvania	2007-2011	Descriptive statistics and F-statistics	No	The number of wells in each county	No	While producing counties experienced a smaller decrease in realty transfer tax collections than did other Pennsylvania counties, state collections of sales and personal income taxes increase at a higher level in the producing counties than in other counties.

As for units of analysis, almost all the studies look at local governments. One reason for this choice is that people in local jurisdictions have firsthand experience regarding the effects of oil and gas exploitation on their communities. Raimi and Newell (2016d) is the exception – they assess the effects of oil and gas development in sixteen states across shale formations.

While sub-national governments are the primary units of analysis in the research, there is also wide variation in the type of local government being studied, including counties (Bartik et al 2016), cities (Rahm et al 2016; Raimi and Newell 2016b), and school districts (Le and Plummer 2011). Sances and You (2016) aggregate local governments at county level. While most of the studies focus on local governments within one state, Raimi and Newell (2014, 2016c) observe local governments in several states to improve generalizability of the findings and get a bigger picture about the effects of oil and gas development.

Regarding research methods, case studies and econometric analysis dominates research on oil and gas booms. Case studies conducted by Raimi and Newell (2016a, 2016b) are helpful to understand the variation of effects of oil and gas booms on local public finance. All the studies conducted by Raimi and Newell (2014, 2016a, 2016b, 2016c, 2016d) use descriptive analysis as the analytical strategy. Half of the studies address endogeneity issues. Bartik et al (2016), for example, uses geological variation within shale plays across the US and variation in the timing of the onset of fracking to address endogeneity issues.

Finally, there is a wide variety of independent variables in examining the fiscal effects of oil and gas extraction. The absence of a single measure across the studies indicates that there is no consensus about how oil and gas activities should be measured. In general, there are two distinct groups of variables used to measure drilling activities: the number of horizontal wells (Costanzo and Kelsey 2012; Tunstall 2015) and total value of production from fracking wells (Sances and You 2016; Raimi and Newell 2016c, 2016d). Bartik et al (2016) is the exception by using an index of geological variations in the application of fracking techniques within US shale deposits. Nevertheless, the studies generally agree on the use of government revenues or expenditures as the variable to be affected by fracking.

3.4 Hypothesis development

3.4.1 Oil and gas booms and state revenues

As mentioned previously, states take advantage of oil and gas development in their territories by increasing the exportability of tax burden to non-residents. Following prior studies from the literature of intergovernmental transfers and budget maximization models, we have reason to believe that governments that receive additional revenues from exporting taxes simply use the revenues to expand their budgets.

In many states, the majority of revenues from oil and gas production are deposited into general revenue funds. Consequently, in the annual budget process, state policymakers consider revenues from resource extraction no differently than other revenues. To the extent that the oil and gas revenues are operative in state budget, one would predict that the windfalls would remain in state government coffers, adding existing revenues.

While an increase in oil and gas revenues would result in an increase in total revenues, an increase from resource extraction could also substitute other revenue sources, resulting in an increase in total revenues less than net oil and gas revenues. If this is the case, oil and gas revenues would be substitutive on other revenue sources. However, states can also benefit from oil and gas booms from a variety of tax revenues. In addition to oil and gas revenues, states could also gain from sales, personal income, and corporate taxes resulting from the economic effect of oil and gas investment. Accordingly, I propose:

Hypothesis 1: An increase in oil and gas revenues would result in an increase in total revenues equal or greater than an amount equal to net oil and gas revenues.

3.4.2 Oil and gas booms and resident's tax burden

The Tax Foundation (2016) defines tax burden as the portion of state personal income that goes to state and local taxes, including to the states and localities in which a taxpayer does not live. To compute state and local tax burdens, the Tax Foundation calculates the total amount of state and local taxes paid by the residents, then divides those taxes by the state personal income. The tax burden can be categorized in two parts: taxes paid to own state and taxes paid to other states. Taxes paid to own state are taxes paid to a taxpayer's own place of residence, while taxes paid to other states are taxes paid to the governments of states and localities in which the taxpayer does not live. In this study, my intention is to investigate whether increased revenues from oil and gas booms reduce the total amount of own-state and local taxes paid by the residents.

One form of tax exporting is energy extraction. Regions with more energy resources have greater ability to export some portion of the tax burden to outside their boundaries (Malm and Prante 2012). Royalties and taxes on energy economies are imposed on firms that extract oil and gas and sell the commodities to customers. As a result, exporting the tax burden leads to lower taxes paid by in-state taxpayers. Alaska, Wyoming, and Texas are good examples of tax exporting associated with natural resource-based economies. The three oil-rich states are always among the states with lowest state-local tax burden in the country in annual surveys conducted by the Tax Foundation.

The development of fracking has a potential to further reduce the tax burden as it begins to generate revenues to the state. As the state experiences a fracking boom in the following years, fracking potentially reduces the tax burden on general taxpayers as fracking revenues rise faster than non-fracking revenues. The State of North Dakota is the best example to illustrate how fracking affects the state economy, tax revenue, and tax burden. Prior to the development of fracking, North Dakota's economy grew at the same rate as the United States average (Raimi and Newell 2016a). The successful development of fracking in the Bakken formation drove the state economy. Since 1997, North Dakota's economy has grown by more than 120 percent in real terms, faster than any other state (Raimi and Newell 2016a).

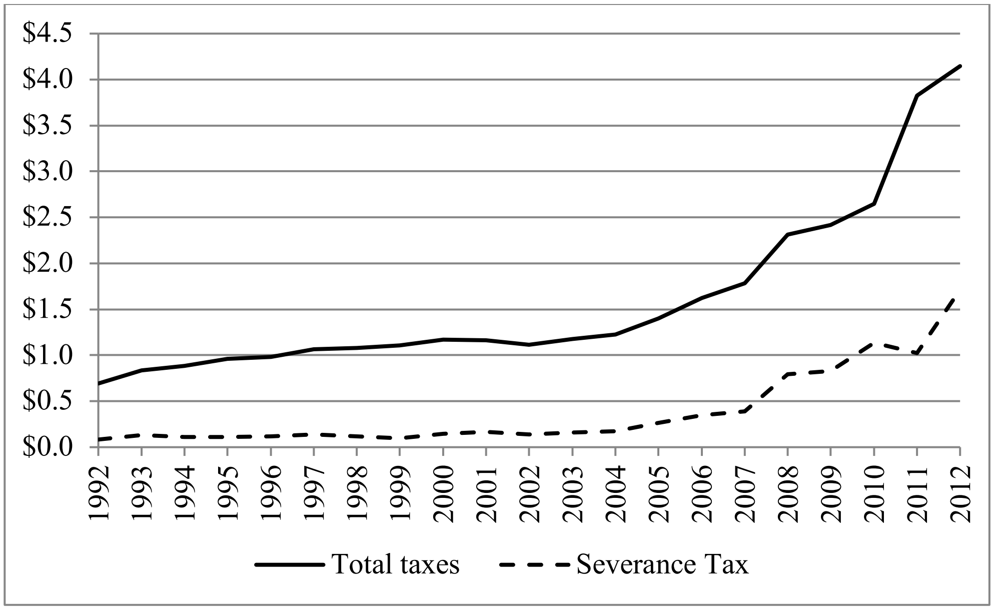
North Dakota's rapid tax growth has been led by oil and gas development. In 1995, there were only 401 horizontal wells in the state. By 2012, the number of horizontal wells increased almost ten times to 5,218 wells. Fracking has dramatically improved the volume of oil and gas extraction. From 1997 to 2012, oil production increased by 55 times, while gas production shot up by 34 times.

During the same period, North Dakota's tax revenue grew nearly four times, from $958.8 million in 1995 to $4.1 billion in 2012 (Figure 8). Most of the growth in total taxes is attributed to severance taxes that rise by almost 15 times. In 1995, severance tax contributed roughly 12 percent, while in 2012 its contribution to total taxes reached 41 percent.

As North Dakota is able to export some portion of its tax collection, general taxpayers experience a decrease in their tax burden (Figure 9). In 1995, state-local tax burden in North Dakota is estimated to be 10.3 percent, meaning that 10.3 percent of total state personal income went to state and local taxes. In 2012, the tax burden is estimated to be 9.0 percent, or down by 12.6 percent. While there was some fluctuation during the period, the rate of tax burden never surpassed the rate in 1995, when fracking had not yet been developed.

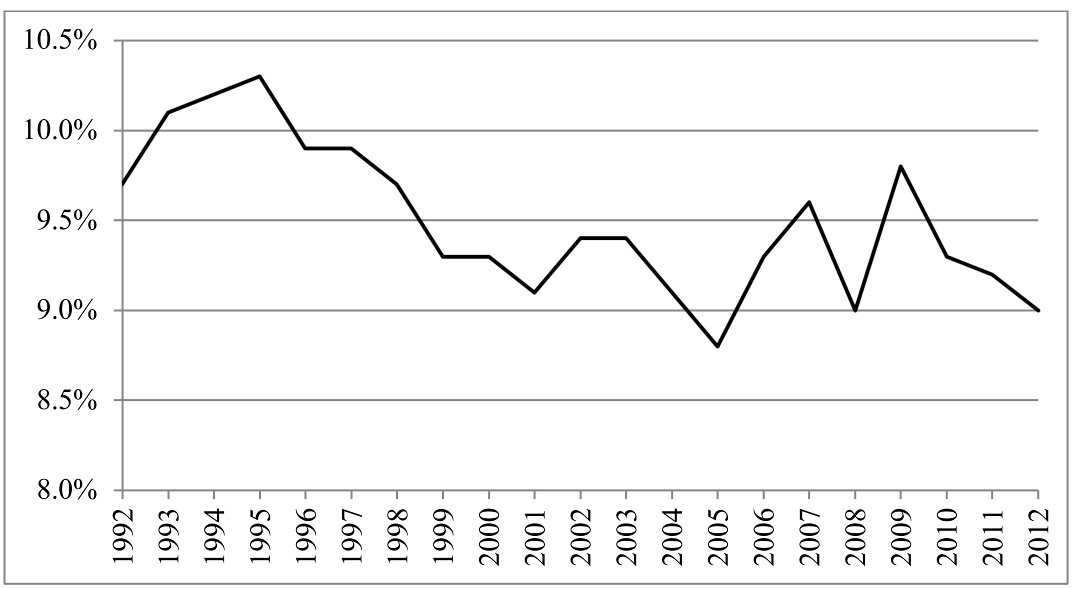
The case of North Dakota supports the second hypotheses regarding the association between fracking and effective tax burden. I propose:

Hypothesis 2: An increase in oil and gas revenues will result in a lower tax burden on the residents of the state.



Notes: Data source is U.S. Census of Bureau. State Government Tax Collections.

Figure 8: North Dakota Tax Revenues, 1992-2012 (in billions of current dollars)



Notes: Tax burden is the portion of total state personal income that goes to state and local taxes, including to the states and localities in which a taxpayer does not live. Data source is the Tax Foundation.

Figure 9: Tax Burden, North Dakota, 1992-2012

3.4.3 <u>Oil and gas booms and the oil and gas industry's tax burden</u>

During a boom period, the profitability of the natural resource industry is often seen as an opportunity to further shift the tax burden to the industry. The oil and gas industry is no exception. When government officials and local taxpayers see that drilling activities result in a lucrative business, they further want to shift the tax burden to the oil and gas companies.

There are four factors that can encourage the shift in tax burden to the oil and gas industry. First, government officials and citizens believe that the available natural resources are abundant; creating a perception that the oil and gas industry can take up a greater portion of the cost of public goods. When proposing a new severance tax on natural gas production in the state, the Governor of Pennsylvania claimed that "we sit atop of one of the richest deposits of natural gas in the world. We have the natural resources to do something…" (McKelvey 2015a).

Second, the trend of rising prices creates a perception that oil and gas revenues are substantial and can be used to reduce the tax burden of general taxpayers. In the case of Pennsylvania, the plan for taxing drilling activities began to develop following the gas boom in the state that began in 2009. The governor's plan would generate $1 billion tax revenue per year (Cusick 2017).

Third, there is a presumption about a special treatment of taxation received by the industry as the companies are able to profit from oil and gas extraction. The oil and gas industry allegedly pays less tax than it should. As quoted in the local media, President of SEIU Local 668, representing 80,000 social workers in Pennsylvania, argued that "these oil and gas companies are reaping enormous profits by taking a huge amount of gas from our state. It's time to end the special treatment and require Marcellus Shale drillers to fulfill their responsibility to all Pennsylvanians" (McKelvey 2015b). The CEO of Penn Future, a supporter of the new tax, shares the same sentiment and claims, “Pennsylvania is currently the largest natural gas-producing state without a severance tax, and it’s time that drillers pay their fair share” (McKelvey 2015b).

And fourth, taxes on drilling activities are not imposed on the general taxpayers, but only on a limited number of companies. The opposition from the general public is expected to be minimal. Even more, in Pennsylvania the general taxpayers tended to support the new severance tax, including environmental groups and labor unions. The only opposition came from the industry, which argued that a 6.5 percent severance tax would debilitate the industry amid declining gas prices. In Ohio, the industry opposed the Governor’s plan criticizing the new tax as unfair as to offset the tax rate cut for others. Similar opposition also came from the oil and gas firms in Pennsylvania when the Governor wanted the state’s natural gas drillers to pay a 6.5 percent tax on Marcellus Shale production (Phillips 2016).

The cases of Pennsylvania and Ohio lend a hypothesis that would examine the relationship between the profitability of the oil and gas industry and the shift of tax burden to the industry. I propose:

Hypothesis 3: An increase in the profitability of the oil and gas industry will lead to a shift in the tax burden toward the industry.

3.4.4 Oil and gas booms and revenue cyclicality

As defined by Dye (2004), revenue cyclicality refers to the short-run cyclical variability or stability of revenue over the business cycle. Stability of revenue during the business cycle is critical as the states are required to balance their budget. When revenue falls, states must take action, such as delaying capital projects, expenditure re-prioritization, fund relocation, increased bonds issuance, spending cuts, and increasing taxes, or a combination of these actions. Hence, revenue stability over the business cycle is an important criterion to assess state taxes as it provides certainty about the continuation of government programs and public services.

A study by Felix (2008) that examines the growth and volatility of state tax revenue sources in the seven states of the 10th District of the Federal Reserve suggests a potential direction of examining the effect of oil and gas booms on revenue cyclicality, though the study does not specifically address the effect of fracking.[10] With respect to the changes in the growth of state personal income, the states that have oil or gas exploitation tend to have a pro-cyclical pattern of tax revenue compared to those that do not, especially for general sales, corporate income, and severance taxes. Furthermore, the three sources of tax revenues in the states are more volatile than the U.S. average.

There is also a wide variation regarding the short run cyclical variability of severance tax in the states. Oklahoma experiences the most pro-cyclical severance taxes as a 1 percent increase in the growth of state personal income is associated with a 4.43 percent increase in the growth of its severance taxes. Nebraska is the opposite as its severance tax tends to be counter-cyclical. The growth of its severance tax would decline by 2.57 percent as the growth of state personal income increases by 1 percent. All these cases imply that states that collect substantial revenues from natural resources tend to experience more pro-cyclical revenues than those that do not. Severance taxes from oil, gas, and coal annually contribute nearly a billion dollars to Oklahoma, but only $2.5 million to Nebraska in 2007 (Felix 2008). As a state increases its reliance on revenue from natural resource extraction, its tax revenue becomes more subject to the volatility in the commodity price. I propose:

Hypothesis 4: States with a higher degree of oil and gas activities have more pro-cyclical revenues compared to those with a lower degree.

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[10] The Tenth Districts include Colorado, Kansas, Missouri, Nebraska, New Mexico, Oklahoma, and Wyoming.

4. THE CURRENT RESEARCH: DESIGN AND IMPLEMENTATION

This chapter discusses my research strategy, including the sample and data sources, measurement of variables, and analytical strategy.

4.1 Units of analysis and sample

The units of analysis of this study are 50 state governments in the U.S. States include those that do and do not sit atop shale formations. State governments are selected as the unit of analysis because they collect the greatest share of revenue from oil and gas production and have the decisive authority regarding oil and gas regulations within their jurisdictions.

The study period is 1990-2015 with 756 state-year observations. This period is chosen for two reasons. First, it was the period when oil and gas prices reached both their peaks and lowest levels as well as the period when the commodity prices were very volatile. Therefore, it makes it possible to investigate the fiscal effect of oil and gas development in various levels of oil price. Second, it also covers the period when fracking gained popularity. During this time period, the use of fracking techniques spread across the country that began in 2008.

As the whole process of fracking may take up to 20 years and may have started long before the boom period, in this study, I limit the focus of my analysis to the production stage of oil and gas development, indicated by years when active wells are present and produce oil and gas.

4.2 Data source

Oil and gas production data source. The oil and gas data sources include a detailed data set of U.S. oil and gas wells from Drilling Info Inc, a private company that provides data on oil and gas production and reserves, both from horizontal wells over shale formation and other wells. I also use datasets from the U.S. Energy Information Administration, which provides data on production and prices of crude oil and natural gas. The fracking-related variables I use in the models are a dummy variable for presence of fracking wells and fracking intensity in a state in a given year. Both variables are two direct indicators of the economic activity associated with fracking.

To estimate fracking intensity, I first quantify the value of oil and gas production from fracking and non-fracking wells in each state. To estimate the total value of oil and gas produced, I use oil and gas production data from Drilling Info and price data from the US Energy Information Administration (EIA). To calculate the value of production in each year, I multiply the volume of oil and gas produced by the average prices of oil and gas in the year. For oil, I use Domestic Crude Oil First Purchase Prices by Area. And to estimate the production value of natural gas, I use the State Natural Gas Wellhead Price for gas prices in FY 2000-2010. EIA has not reported the gas wellhead price at state level since 2011. Accordingly, for gas prices in FY 2011-2012, I use the U.S. Natural Gas Wellhead Price. And for gas prices in FY 2013-2015, I use the Henry Hub Natural Gas Spot Price.[11] The total value of oil and gas produced in each state is the sum of estimated oil and gas values. Fracking intensity is estimated by dividing the value of oil and gas production from fracking wells by production value from all wells. The estimated value of fracking intensity ranges from 0 to 1. A value of zero suggests that no production comes from fracking wells, while a value of one indicates that all production is attributed to fracking. Accordingly, the variable indicates the magnitude of fracking output in the states.

Financial and other data sources. State oil and gas revenues are available through various annual reports or online databases. When it was not available, I sent emails to the state agencies requesting the data or relied on Newell and Raimi's (2018) tax description report to

[11] Price per thousand cubic feet equals price per MMBtu multiplied by 1.037. Information to convert gas prices for different volume standards is available at https://www.eia.gov/tools/faqs/faq.php?id=45&t=8.

estimate the oil and gas taxes. Other financial data on state governments and other data are collected from Government Finance Statistics of U.S. Bureau of Census, World Tax Database, Tax Policy Center, the Book of the States, the Tax Foundation, and Bureau of Economic Analysis. Tables VII, VIII, and IX provide a summary of measurements and data source. All dollar amounts are adjusted to 2010 dollars using the consumer price index from the Bureau of Labor Statistics.

TABLE VII
MEASUREMENT OF FISCAL OUTCOMES

Hypothesis	Fiscal outcomes	Dependent variables	Main source
1	Revenue	Own-source and total tax revenues as shares of state personal income	U.S. Census and Bureau of Economic Analysis
2	Resident's tax burden	Total amount of own-state and local taxes paid by state residents as share of state personal income	U.S. Census and Bureau of Economic Analysis
3	The oil and gas industry's tax burden	State oil and gas revenue as share of state tax collection	Census
4	Revenue cyclicality	The changes in the growth of total tax and major tax revenues	Census

TABLE VIII
INDEPENDENT VARIABLES

Hypothesis	Independent variables	Main source
1 and 2	State oil and gas revenues as share of state personal income	Census and various state reports
3	The oil and gas industry's share of state GDP	U.S. Bureau of Economic Analysis
4	The changes in the growth rates of state personal income	U.S. Bureau of Economic Analysis

TABLE IX
OTHER VARIABLES

	Control variables	Main source
Fracking data	- Presence of fracking wells (a dummy variable indicating whether a state has fracking wells in a given year; coded as a 1 if yes and 0 if no fracking wells) - Fracking intensity (the value of oil and gas production from fracking divided by the value of total production)	Drilling Info and U.S. Energy Information Administration
Political factors	- Republican legislators as the share of state legislators - A dummy variable indicating whether the governor is a Republican or not; coded as a 1 if yes and 0 otherwise.	Census
Socio economic factor	- Poverty rate - Population older than 65 years old	Census
Change in tax policy	- The tax rate of the highest individual income tax bracket - The tax rate of the highest corporate income tax bracket - State sales tax rate - Food exemption - Drug prescription exemption	World Tax Database, Tax Policy Center, and the Book of the States

4.3 Analytical strategy

4.3.1 Effects of oil and gas booms on state revenues

To estimate the effects of oil and gas booms on revenue collection, I use a two-way fixed-effect model. A fixed-effect model is employed due to its ability to account for omitted variables that vary between states but are constant over time, such as weather and geography. Following is the equation of the model:

$$\text{State revenues}_{st} = \beta_1 \text{OG revenues}_{st} + \beta_2 \text{Fracking}_{st} + \beta_3 \text{OG revenues}_{st} * \text{Fracking}_{st} + \beta \text{X}_{st} + \alpha_s + \gamma_t + \epsilon_{st}$$

where the dependent variable is measured as state own-source revenues or total tax collection as shares of state personal income. Own-source revenues are all revenues collected by the states from their own source, including taxes, charges and miscellaneous general revenues, excluding intergovernmental transfers. In FY 2015, own-source revenues contributed two thirds of states' general revenues. The independent variable is state oil and gas revenues as a share of state personal income in state *s* in year *t*.

In the equation, β_1 indicates whether and to what extent oil and gas revenues substitute other revenue sources. When β_1 is positive but less than 1, it implies that states gain positive revenues from oil and gas production, but the revenues substitute other revenue sources as total revenues grow at lower rate than oil and gas revenues. Conversely, when β_1 is greater than 1, the states collect revenues from oil and gas production with no substitution effect on other revenue sources.

To differentiate the effects of state oil and gas revenues from fracking and non-fracking productions, I use an interaction term between oil and gas revenues and two measures of fracking activities: a dummy variable for presence of fracking well and fracking intensity. Fracking intensity, which is a continuous variable, is estimated by dividing the value of oil and gas production from fracking wells by production value from all wells. Thus, it indicates the magnitude of fracking output in the states.

X is a vector of control variables, α the state-fixed effects, γ the year-fixed effects, and ϵ is an error term. Following Sjoquist, Stephenson, and Wallace (2011), two measures of political factors are included in the model: republican legislators as the share of state legislators and a dummy variable indicating the political party of the state governor coded as 1 if the governor is a Republican and 0 otherwise. The variables are expected to be negatively associated with the dependent variable. Following the conventional model of revenue determinants, including Carroll (2005) and Merrifield (2000), I also include demographic factors as control variables: population, the percent of elderly population, and poverty rate.

There might be the possibility of a simultaneity bias in the model. Simultaneity bias is present when reverse causation exists between the independent and dependent variables, for example where fracking causes changes in revenue as specified and changes in revenue stimulate states to change policies on fracking. States might adjust tax rate, deductions, credits, and exemptions in one year as their response to oil and gas taxes in the previous year. To overcome problems with endogeneity, I include the one-year lag of fracking as an additional control in the model. Including a one-year lag of fracking would allow us to see whether state policy in one year affects tax revenue in the following year. I cluster standard errors at the state-year level.

4.3.2 Effects of oil and gas booms on resident's tax burden

Resident's tax burden is measured by the share of state personal income that goes to own-state and local taxes. To estimate own-state and local tax burdens paid by the residents, I took two steps of calculation. First, I multiplied the amount of taxes paid to own state per capita by the population of the state in a given year to generate the total amount of own state and local taxes paid by the residents.[12] And then, I divided the total amount of taxes paid by the residents by state personal income to estimate the share of state personal income that goes to own-state and local taxes.

To estimate the effects of oil and gas booms on resident's tax burden, I use the following model:

$$\text{Tax burden}_{st} = \beta_4 \text{OG revenues}_{st} + \beta_5 \text{Fracking}_{st} + \beta_6 \text{OG revenues}_{st} * \text{Fracking}_{st} + \beta \text{X}_{st} + \alpha_s + \gamma_t + \epsilon_{st}$$

where the dependent variable is own-state and local taxes paid by state residents as the share of state personal income. The independent variable is state oil and gas revenues as the share of state personal income in state *s* in year *t*. This variable is expected to be negatively associated with the dependent variable.

I also include an interaction term between oil and gas revenues and two measures of fracking activities to separate the impacts of state oil and gas revenues from fracking and non-fracking productions. Control variables in the model include the same set of control variables in the previous model.

4.3.3 Effects of oil and gas booms on the oil and gas industry's tax burden

To estimate the effects of oil and gas booms on the oil and gas industry's tax burden, I use the following equation:

$$\begin{aligned}\text{OG industry's tax burden}_{st} &= \beta_7 \text{Oil \& } gas\ GDP\ share_{st} + \beta_8 \text{Fracking}_{st} + \beta_9 \text{Oil \& } gas\ GDP\ share_{st} \\ &* \text{Fracking}_{st} + \beta \text{X}_{st} + \alpha_s + \gamma_t + \epsilon_{st}\end{aligned}$$

[12] Data source for the amount of taxes paid to own state per capita is Tax Foundation. Taxes paid to own state includes state and local taxes. Data and methodology can be accessed at https://taxfoundation.org/state-and-local-tax-burdens-historic-data.

where the dependent variable is measured as state oil and gas revenue as the share of state tax collection, indicating the tax contribution of the oil and gas industry to state tax revenues. The independent variable is the oil and gas industry's share of state GDP. The industry's share of state economic output is used as a proxy of its profitability because the actual profitability of the industry by state is not available. Comparing the economic size of the oil and gas industry relative to the whole state economy would be a good proxy to its profitability. First, shifting the tax burden to the oil and gas industry involves some sense of perceptibility to determine which industry is experiencing a boom. The size of economic contribution of an industry relative to state economy provides a good indication to how important an industry is to the state. And second, the size of the oil and gas industry relative to state GDP varies by year and by state. Accordingly, any effects on dependent variables should be noticeable in the regression. It is expected that this variable would be positively associated with the dependent variable. Following previous models, to distinguish the effects of oil and gas profit from fracking and non-fracking productions, I include an interaction term between oil and gas GDP share and two measures of fracking activities. Control variables in the model include the same set of control variables in the previous models.

4.3.4 Effects of oil and gas booms on revenue cyclicality

The cyclicality of revenues refers to the relationship between state revenues and a state's business cycle (Sobel and Holcombe 1996, Dye 2004). The revenue cyclicality is measured by the changes in the growth of tax revenues relative to the changes in the growth of state personal income (Felix 2008). I expect that oil and gas states and fracking states would experience more volatile revenues in the short term compared to those without oil and gas activities. As such, I expect to see positive and significant coefficients of all major revenues for states that have oil and gas production as well as for those that allow fracking.

To examine the effects of fracking on cyclicality of state revenues, I use the following equation, which is the modification of Felix (2008) that compares the change in the growth of major tax revenue categories to the change in the growth of state personal income.

$$\Delta \ln(\text{Revenue}) = \beta_{10} + \beta_{11}\Delta \ln(\text{Personal Income}) + \beta_{12}\text{Fracking} + \beta_{13}\Delta \ln\,(\text{Personal income}) * \text{Fracking} + \beta_{14}\Delta \text{Tax rate} + \epsilon_{st}$$

Major tax revenue categories as the dependent variable are own-source revenue, tax revenue, general sales, selective sales, personal income, and corporate income taxes. In the equation, the elasticity of state tax revenues in states that have no fracking wells is indicated by β_{11}. Since we are interested in estimating the effects of fracking activities on revenue cyclicality, I include the interaction term between the change in the growth of state personal income and fracking.

Felix’s (2008) model is similar to the standard model in estimating revenue cyclicality developed by Sobel and Holcombe (1996). The only difference between their models is that Felix (2008) uses tax revenue data while Sobel and Holcombe (1996) use tax base data. I will use tax revenue data for practical reasons as tax revenue is readily available. Dye (2004) argues that elasticity estimates will be biased when revenue data is used as it is not only subject to the change in economic activity, but also the changes in tax policy (e.g. change in tax rate and definition of tax base) in a way that is correlated with the business cycle. To overcome this problem, I include changes in tax rate in the model.

When β_{13} is greater than 1, it implies that the higher the change in the growth of state personal income, the greater (more positive) the effect of fracking on the change in revenue. In other words, states that have more fracking wells are said to have more pro-cyclical revenue than those with fewer fracking wells. To prevent changes in the tax rate affecting the changes in tax revenue, the changes in tax rates of major tax revenue sources are included as control variables: general sales tax rates and dummies for food exemptions and prescription drug exemptions for general sales tax, gasoline and cigarette tax rates for selective sales tax, the highest marginal personal income tax rates for personal income tax, and the highest marginal corporate tax rate for corporate income tax.

5. STATE OIL AND GAS REVENUES

In this chapter, I provide some estimates about how much states collect tax revenues from fracking and non-fracking production. This chapter also discusses the distribution of state oil and gas revenues.

5.1 State revenues from fracking and non-fracking production

Data collection on 31 sample states indicates 27 states collected taxes on oil and gas production in 2017 (Table X). Only four states did not collect oil and gas taxes: Maryland, Missouri, New York, and Virginia. Most of the states (24 states) collected taxes based on the value of oil and gas produced. Three states collected taxes or fees based on the volume of oil and gas produced: California, Nevada, and Ohio. California, for example, assessed oil and gas production taxes of $0.3243123 on each barrel of oil and each 10,000 cf of natural gas produced. The names and rates of the taxes collected by the state vary considerably (see Appendix A). Many states name their tax severance or production tax. Some states have a privilege tax or conservation fee.

As discussed in the previous chapter, oil and gas production in the period of 2000-2015 was marked by two major patterns, i.e. oil and gas production from fracking wells increased significantly from 2008 and non-fracking production declined after 2008.[13] Looking at the trend of oil and gas production, we could estimate that the growth of fracking production was more than what is indicated in the total oil and gas production. Yet, since we are interested in investigating the effects of the oil and gas boom on state revenues, we need to understand to what extent the states are able to gain from the oil and gas boom from fracking development. In

[13] Oil production from non-fracking wells has been declining since 2000.

other words, we need to separate the effects of fracking production on state revenues from those of non-fracking production.

TABLE X
CLASSIFICATION OF STATES BASED ON DISTRIBUTION OF OIL AND GAS TAXES FY 2017

States that do not collect taxes	States that collect taxes		States that transfer to local governments	States that do not transfer to local governments	States that have trust fund	States that do not have trust fund
	Volume-based	Value-based				
4 states	3 states	24 states	17 states	10 states	5 states	22 states
MD, MO, NY, VA	CA, NE, OH	AL, AK, AZ, AR, CO, FL, KS, KY, LA, MI, MS, MT, NE, NM, ND, OK, OR, PA, SD, TN, TX, UT, WV, WY	AL, AR, AZ, CO, KS, KY, LA, MS, MT, ND, NV, OK, PA, SD, TN, WV, WY	AK, CA, FL, MI, NE, NM, OH, OR, TX, UT	AK, CO, KS, ND, WY	AL, AR, AZ, CA, FL, KY, LA, MI, MS, MT, NE, NM, NV, OH, OK, OR, PA, SD, TN, TX, UT, WV

Notes: Data source is collected from various sources.

While data on state oil and gas revenues does not distinguish oil and gas revenues by drilling type, using data on oil and gas production and applicable state tax rates on oil and gas production, one can estimate how much fracking contributes to state oil and gas revenues. To estimate how much state oil and gas revenue is collected from fracking and non-fracking production, I first quantify the tax base of oil and gas taxes for each state.[14] While most of the producing states have either value or volume-based tax systems, some states have a combination of both.[15] The tax bases of oil and gas production are classified into four production categories: fracking oil, fracking gas, non-fracking oil, and non-fracking gas. The next step is to estimate the possible maximum taxes collected from each category, which is calculated by multiplying the tax bases of each production category and applicable tax rates in each state.[16] The estimated revenue of each production category in a state in a given year is the ratio of the possible maximum taxes from each production category relative to the possible maximum taxes collected from all categories, multiplied by the actual oil and gas revenues reported by the state.[17] The final step is to total estimated revenues collected from fracking oil and gas for fracking production, and non-fracking oil and gas for non-fracking production.

Figure 10 depicts total oil and gas revenues collected by the states by type of production during the period of 2000-2015. Nationwide, states oil and gas tax revenues continued to grow with some fluctuations during the period of 2000-2015. After a gradual increase in revenues from \$2.7 billion in 2000 to just \$4 billion in 2005, oil and gas tax revenues rocketed to a peak of \$17.2 billion in 2008, due to rising oil and gas prices that multiplied the tax bases of oil and gas taxes in many producing states. However, declining oil and gas prices in the following years

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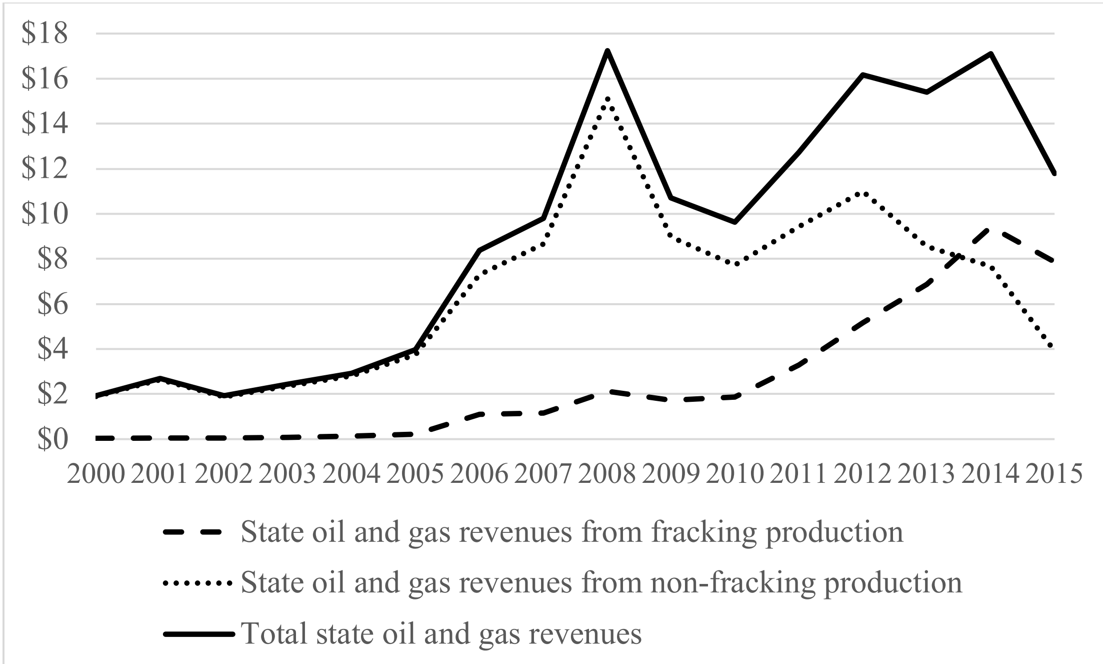
[14] The tax base of value-based tax system is the value of oil or gas production, and the tax base of volume-based system is the quantity of oil or gas production in each state in given year. More information about the estimation of value of oil and gas production is detailed in section 4.2.
[15] Louisiana, for example, uses two tax systems: value-based tax for oil production and volume-based tax for gas production.
[16] Following Richardson et al (2013), applicable tax rates are the states' prevailing long-term tax rates for producing wells, and ignoring tax credits, deductions, any incentive programs, or lower rates during initial production. If a state collects two different taxes on the tax base, the applicable tax rate is the sum of the two tax rates. Details on tax rates of each state are available in APPENDIX A.
[17] The prevailing tax rates are assumed to be stable over time and states have similar tax policies on fracking and non-fracking production.

resulted in a sharp decline in total oil and gas collection to $9.6 billion in 2010. Until 2010, the up and down of state oil and gas revenues are primarily attributed to the changes in oil and gas tax revenues collected from non-fracking production. Since 2011, state oil and gas revenues began to recover and hit another peak of $17.1 billion in 2014 thanks to a steady growth in revenues collected from fracking production that offset the decrease in revenues from non-fracking production. Until 2013, revenues from non-fracking production contributed the largest share of oil and gas tax revenues.

Figure 10 also indicates that during the years of 2014-2015, state oil and gas revenues from fracking production surpassed revenues from non-fracking wells. In 2015, however, total oil and gas revenues fell to only $11.8 billion as revenues from both fracking and non-fracking production declined. In total, during the period of 2000-2015, nationwide the states collected oil and gas revenues from fracking and non-fracking production approximately $41.2 and $103.7 billion, respectively.

Analysis of oil and gas revenues at state level offers a different picture. Some states, such as Colorado, Montana, North Dakota, Pennsylvania, Texas, and West Virginia, experienced a substantial increase in oil and gas tax revenues due to fracking development. In these states, the net increase in oil and gas tax revenues was mainly driven by growth in revenues from fracking wells. However, in other states like Louisiana, New Mexico, Oklahoma, and Wyoming, revenue growth from fracking production was not sufficient to offset the decline in revenues from non-fracking wells, resulting in a net decrease in total revenues from oil and gas production. Furthermore, fracking did not improve oil and gas revenue collection in these states: Alabama, Kansas, Michigan, and Mississippi because the fracking industry in these states was still in its infancy as the introduction of fracking came later than in other states.



Notes: Total state oil and gas revenues are the total amount of oil and gas revenues collected by the producing states. Revenues from fracking and non-fracking production are estimated using the share of each production category relative to total value of production in a state in each year multiplied by the actual oil and gas revenues reported by the state. Details on estimation are explained in Chapter 5.

Figure 10: Total State Oil and Gas Revenues, 2000-2015 (in billions of current dollars)

It should be noted that only some states are able to collect significant oil and gas revenues, relative to total state tax collection. Out of 457 state-year observations that have oil and gas revenues, only 64 observations, or 14 percent, have oil and gas revenues greater than 10 percent of total state tax collection (Table XI).[18] Over two thirds of the observations record less than five percent of total tax revenues coming from oil and gas revenues.

[18] Thirty-nine observations have missing data on state oil and gas revenues.

TABLE XI
DISTRIBUTION OF STATE-YEAR OBSERVATIONS BASED ON CONTRIBUTION OF STATE OIL AND GAS REVENUES TO TOTAL STATE TAX COLLECTION

Contribution of state oil and gas revenues to total state tax collection	Number of observations	In percentage of total observations	States
Zero	75	16.4%	MD, MO, NY, PA, VA[19]
Greater than zero but less than 5 percent	273	59.7%	AL, AZ, AR, CA, CO, FL, KS, KY, MI, MS, MT, NE, NV, ND, OH, OR, PA, SD, TN, TX, UT, WV
Equal or greater than 5 percent but less than 10 percent	45	9.8%	LA, MT, ND, OK, TX
Equal or greater than 10 percent but less than 25 percent	32	7.0%	MT, NM, ND, OK, TX, WY
Equal or greater than 25 percent but less than 50 percent	20	4.4%	AK, NM, ND, WY
Equal or greater than 50 percent but less than 75 percent	7	1.5%	AK, ND
75 percent or more	5	1.1%	AK
Total	457		

5.2 Distribution of State Oil and Gas Revenues

Table XII provides the distribution of oil and gas revenues for FY 2015. The states collectively generated $11.8 billion of tax from oil and gas exploitation, or roughly 2 percent of total state taxes in FY 2015. In seven states, oil and gas revenues contributed more than $500 million to the state revenues: Texas ($4.2 billion), North Dakota ($2.8 billion), New Mexico ($993 million), Louisiana ($716 million), Oklahoma ($684 million), and Alaska ($524 million). Alaska experienced a sharp decline in oil and gas revenues due to the fall in production in 2015. In 2012, Alaska was able to collect $2.7 billion from oil and gas production. In 2015, these states

[19] PA did not collect oil and gas revenues prior to FY 2011.

reported a substantial portion of total tax collection coming from oil and gas production: North Dakota (49%), Alaska (38%), Wyoming (21%), and New Mexico (17%).

States vary in terms of how taxes and fees from oil and gas extraction are used. In general, there are three major categories to describe how state oil and gas revenues are used for different purposes and levels of government. The first category is general and other funds. This is the flow of state oil and gas revenues into general revenue funds, transportation funds, education funds, environment protection funds, or other funds that are designed to finance current spending or short-term government operations, including budget stabilization funds or rainy-day funds. Pennsylvania, for example, earmarks fee revenues from oil or gas wells to be distributed to Department of Environmental Protection and County Conservation Districts (Brown 2013). Texas also allocates some portion of oil and gas revenues to the Texas Permanent School Fund to provide revenues for public primary and secondary education. Most of the oil and gas revenues were used to finance current spending. In 2015, the general and other funds received at least $8 billion or 67.9 percent of total oil and gas revenues.

The second category is transfer to local governments. It is the flow of state oil and gas revenues from the state to counties/parishes, municipalities, cities, townships, and school districts. Transfer of oil and gas revenues to local governments is part of a revenue sharing mechanism with a wide variation in the share of revenue local governments would receive and how they are allowed to use the money. The local share of oil and gas revenues depends on several factors, including the revenue sharing formula, produced oil and gas, location of producing wells, and population density. While some states give local governments more freedom over the use of the revenue, others set specific rules over the use of the revenue.

TABLE XII
DISTRIBUTION OF STATE OIL AND GAS REVENUES IN FY 2015
(IN MILLIONS OF CURRENT DOLLARS)

State	Oil and gas revenues	Oil and gas revenues as share of tax revenues	Transfer to local governments		Flow to trust funds		Flow to general fund or other funds	
			($ million)	in %	($ million)	in %	($ million)	in %
AL	70.2	0.01	NA	NA	-	0%	NA	NA
AK	524.0	0.38	-	0.0%	NA	NA	NA	NA
AZ	0.1	0.000004	0.0	0.7%	-	0%	0.1	99%
AR	98.3	0.01	16.6	16.9%	-	0%	81.7	83%
CA	61.6	0.0004	-	0.0%	-	0%	61.6	100%
CO	284.7	0.02	141.6	49.7%	141.6	50%	1.5	1%
FL	5.5	0.00	-	0.0%	-	0%	5.5	100%
KS	121.4	0.02	8.5	7.0%	19.6	16%	93.4	77%
KY	40.3	0.003	20.2	50.0%	-	0%	20.2	50%
LA	716.5	0.07	71.6	10.0%	-	0%	644.8	90%
MD	No oil and gas tax							
MI	45.8	0.002	-	0.0%	-	0%	45.8	100%
MS	73.8	0.01	19.1	25.8%	-	0%	54.8	74%
MO	No oil and gas tax							
MT	159.1	0.06	73.2	46.0%	-	0%	85.9	54%
NE	5.3	0.001	-	0.0%	-	0%	5.3	100%
NV	0.4	0.0001	0.2	49.9%	-	0%	0.2	50%
NM	993.4	0.17	-	0.0%	-	0%	993.4	100%
NY	No oil and gas tax							
ND	2,801.0	0.49	269.3	9.6%	1,860.0	66%	671.7	24%
OH	15.9	0.001	-	0.0%	-	0%	15.9	100%
OK	683.5	0.07	176.8	25.9%	-	0%	506.7	74%
OR	0.1	0.00001	-	0.0%	-	0%	0.1	100%
PA	187.7	0.01	101.8	54.2%	67.9	36%	18.0	10%
SD	5.0	0.003	2.5	50.0%	-	0%	2.5	50%
TN	1.4	0.0001	0.5	33.3%	-	0%	1.0	67%
TX	4,159.5	0.08	-	0.0%	-	0%	4,159.5	100%
UT	76.4	0.01	-	0.0%	-	0%	76.4	100%
VA	No oil and gas tax							
WV	215.4	0.04	14.9	6.9%	-	0%	200.5	93%
WY	493.1	0.21	37.0	7.5%	164.4	33%	291.8	59%
Total	11,839.4	0.02	953.8	8.1%	2,253.4	19%	8,632.3	73%

Notes: Data sources for state oil and gas revenues, transfer to local governments, flow to trust funds are various sources of states' reports.

Generally, states do not specify how the local governments use the transfer. Oklahoma is an exception, where its allocation of oil and gas revenues to counties is used for the purposes of road and bridge maintenance. Seventeen states transferred some portion of state oil and gas taxes to local governments, while ten others did not share state oil and gas revenues. Some states, however, allowed the local governments to collect some taxes on the oil and gas industry, such as property tax or fees. In 2015, the total transfer to local governments amounted to $953.8 million, or 8 percent of total state oil and gas revenues. Some states, however, were quite generous to their local governments. In terms of percentage, seven states distributed more than one third of their oil and gas revenues to local governments, with Pennsylvania as the most generous state sharing 54 percent of oil and gas revenues to its local governments. Four states distributed more than $100 million to the local governments, with North Dakota having the highest transfer of $269 million out of $2.8 billion oil and gas revenues it collected in 2015.

The third category is state trust funds. It is the flow of state oil and gas revenues into savings funds, legacy funds, or endowment funds that are intended to finance future government operations or provide long-term benefits for citizens instead of current or short-term spending (Newell and Raimi 2018). The establishment of a trust fund is intended to protect fiscal resources from the boom-and-bust cycles due to volatility in the oil and gas market, it also preserves revenues from non-renewable resources for future generations. In 2015, $2.2 billion or 19 percent was allocated to trust funds. However, the annual allocation to trust funds was quite volatile. In 2014, the states allocated $434 million, or only 2.5 percent of annual oil and gas revenues.

Most of the states spent their oil and gas revenues for current use. Only five states have trust funds or legacy funds: Alaska, Colorado, Kansas, North Dakota, and Wyoming (Table

XIII). The states vary with regard to the time at which they first allocated some portion of the oil and gas revenues to the trust funds. Alaska first allocated oil and gas revenues into The Alaska Permanent Fund in 1980, following the establishment of the fund (Alaska Permanent Fund Corporation 2018). Colorado and Wyoming set up and allocated the oil and gas revenues to the trust funds in 1990s, while Kansas is the most recent state that has an oil and gas trust fund. In terms of percentage, Colorado was the state that allocated the highest portion of oil and gas revenues to trust funds, approximately half of the total oil and gas revenues it collected since the inception of its trust fund. North Dakota allocated $4.8 billion to trust funds out of $13.2 billion of oil and gas revenues collected, or roughly 36 percent of the total revenues.

TABLE XIII
DISTRIBUTION OF OIL AND GAS REVENUES TO TRUST FUNDS

State	First-time allocation to trust fund	Oil and gas revenues	Oil and gas revenue allocation to trust funds	Ratio
Alaska	1980	N/A	N/A	N/A
Colorado	1995	$2.2 billion	$1.1 billion	50%
Kansas	2010	$732 million	$69 million	9%
North Dakota	2000	$13.2 billion	$4.8 billion	36%
Wyoming	1998	$8.6 billion	$2.9 billion	33%

Notes: Oil and gas revenues are state revenues collected from oil and gas production beginning from the inception of trust fund to FY 2015. Allocation to trust funds covers the period beginning from the inception date to FY 2015. Data source for Colorado's oil and gas revenue is Colorado Department of Revenue's Annual Reports (https://www.colorado.gov/pacific/revenue/annual-report). Data source for Kansas is Kansas Department of Revenue's Annual Statistical Reports (https://www.ksrevenue.org/prannualreport.html). Data source for Wyoming's oil and gas revenue is Wyoming's Comprehensive Annual Reports (http://sao.wyo.gov/publications). Colorado's and Wyoming's oil and gas revenue allocation to trust funds is estimated according to the distribution formula of the states' severance taxes in Newell and Raimi's (2018) report.

6. EMPIRICAL FINDINGS

In this chapter, I report the effects of the oil and gas booms on four aspects of state revenues: state revenue collection, resident's tax burden, the oil and gas industry's tax burden, and the cyclicality of state revenues. Before discussing the results from the regression analyses, I report the missing data here. A full sample would have 800 observations (50 states for 16 years from 2000 to 2015). However, three states have missing oil and gas production data for some years: Kentucky, Missouri, and Tennessee. This results in five missing values. There are another nine states that are missing states' oil and gas revenues, which total an additional 39 missing values. As a result, the models with all state observations have 756 in total. For the models that only include oil and gas states, the number of observations is reduced to only 452 samples due to the exclusion of non-sample states that do not have oil or gas activities. Table XIV outlines sources of missing data for other models in the analysis.

Table XV provides summary statistics of all variables used in the analyses. States vary widely in their overall revenue collection and the contribution of the oil and gas industry on revenue collection. For example, the minimum own-source revenue as the share of state personal income from 2000-2015 is 0.04 was New Hampshire in 2004. A ratio of 0.04 indicates own-source revenue for New Hampshire in 2004 represented only 4 percent of total state personal income. By contrast, the maximum value of the variable is 0.28, which occurred in Alaska in 2008. This indicates that Alaska' own source revenues were roughly 28 percent of state personal income.

TABLE XIV
SOURCES OF MISSING DATA

	Number of observations	
	All states	Only states with oil & gas activities
Models for general models		
Full sample: 50 states for 16 years (2000-2015)	800	800
Sample states (31 states): 496 observations		
Non-sample states (19 states): 304 observations		
Missing oil and gas revenue data: nine states	-39	-39
Missing oil and gas data: Kentucky (2015), Missouri (2015), and Tennessee (2013-2015)	-5	-5
Exclusion of non-sample states		-304
Total available data	**756**	**452**
Total available data with lagged oil & gas revenue	**706**	**421**
Models using tax system		
Full sample: 50 states for 16 years (2000-2015)		800
Sample states (31 states): 496 observations		
Non-sample states (19 states): 304 observations		
Oil and gas states that do not collect tax: four states		-64
Missing oil and gas revenue data: nine states		-39
Exclusion of non-sample states		-304
Total available data		**393**
Models estimating state and local tax burden		
Full sample: 50 states for 16 years (2000-2015)	800	800
Sample states (31 states): 496 observations		
Non-sample states (19 states): 304 observations		
Missing taxes paid to own state per capita (FY 2013, 2014, and 2015)	-150	-150
Missing oil and gas revenue data: nine states	-39	-39
Exclusion of non-sample states		-247
Total available data	**611**	**364**

TABLE XV
SUMMARY STATISTICS

Variable	Mean	SD	Median	Min	Max	N
State own-source revenue as share of state personal income	0.08	0.02	0.08	0.04	0.28	800
State tax collection as share of state personal income	0.06	0.02	0.06	0.03	0.27	800
Own-state and local taxes paid by state residents as share of state personal income	0.07	0.01	0.07	0.03	0.11	650
State oil and gas revenue as share of state tax collection	0.03	0.11	0.00001	0	0.87	761
State oil and gas revenue as share of state personal income	0.003	0.01	0.0000004	0	0.21	761
The oil and gas industry's share of state GDP	0.02	0.04	0.0001	0	0.33	800
Dummy variable for presence of fracking well	0.42	--- a)	0	0	1	795
Fracking intensity	0.14	0.26	0.01	0	0.98	491
Republican legislators as share of state legislators	0.49	0.17	0.50	0	0.89	800
Dummy variable for republican governor	0.53	--- a)	1	0	1	800
Total population (thousand)	6,031	6,652	4,310	494	38,994	800
Population aged 65 or over as share of total population	0.13	0.02	0.13	0.06	0.19	800
Poverty rate	0.13	0.03	0.12	0.05	0.26	800
Dummy variable for tax system (0 for volume based, 1 for value based)	0.89	--- a)	1	0	1	432
No corporate income tax	0.12	--- a)	0	0	1	800
No individual income tax	0.14	--- a)	0	0	1	800
No sales tax	0.10	--- a)	0	0	1	800

Notes: a) denotes dichotomous variable where standard deviation lacks statistical meaning.

There are two variables used to indicate the contribution of the oil and gas industry to the state revenues. The first one is state oil and gas revenues as a share of total tax collection. Table XV indicates the variety of oil and gas contribution to state tax collection, ranging from zero to 0.87. While many states earned nothing from the oil and gas production, Alaska generated 87 percent of its tax revenues from oil and gas production. The table also indicates the skewness in the distribution of oil and gas revenues across states. The average state had three percent of total tax collection coming from oil and gas production, while the median state year observation is only 0.00001.

The second variable is the contribution of the oil and gas industry to state GDP, indicating the magnitude of the oil and gas industry in the states. The minimum value of the variable is zero because many states did not have oil and gas production within their jurisdiction. By contrast, Alaska saw nearly one third of its economy coming from the oil and gas industry in 2008. The table also shows the skewness in the distribution of oil and gas production values across states. In the average state, the oil and gas industry accounted for two percent of its economic performance, while the median state year observation is only 0.01 percent.

6.1 Effects of oil and gas booms on state revenues

Estimating the effects of oil and gas booms on revenue is straightforward. State revenue is measured by two dependent variables: own-source revenue and total tax collection, with oil and gas revenues as the primary independent variable. Both the dependent and independent variables are expressed in shares of state personal income. I expect a coefficient greater than one of the independent variable because oil and gas revenues would complement total revenues with no substitutive effect on non-oil and gas revenues. Tables XVI and XVII report the results of a set of regressions that analyze the effect of oil and gas booms on state revenues by controlling for unobserved time-invariant state characteristics and state-invariant time effects.

Fixed-effect regressions presented in Table XVI shows that the coefficients on state oil and gas revenues as share of state personal income are greater than one and statistically significant at the one percent level. The finding indicates that states that collect revenues from oil and gas production would gain slightly over one dollar in own-source revenue for every dollar revenue they earn from oil and gas taxes. In Model 1, a one-dollar increase in state revenue from oil and gas production would result in an additional \$1.05 in own-source revenues. Adding a dummy variable for presence of fracking wells in Model 2 does not change the estimate of the coefficient on the primary independent variable. Adding an interaction term between state oil and gas revenues and presence of fracking wells does not change the direction of the coefficient, yet slightly increases the magnitude of the effect (Model 3). States with fracking wells would only gain an insignificant increase in own-source revenues.

Models 4 and 5 are basically similar to Models 2 and 3. The only difference is in Models 4 and 5, I use fracking intensity instead of a dummy variable for presence of fracking well as a control variable. When the models control for fracking intensity and its interaction with state oil and gas revenues, the direction and estimates of the coefficient of oil and gas revenues are not different from the estimates in Models 2 and 3. Fracking intensity and the interaction term, however, are not statistically significant, suggesting that the effect of oil and gas extraction on state own-source revenues does not depend on the share of oil and gas production from fracking wells.

TABLE XVI
ESTIMATES OF THE EFFECTS OF OIL AND GAS BOOMS ON STATE OWN SOURCE REVENUE

	Dependent variable: State own-source revenues as share of state personal income				
	Model 1	Model 2	Model 3	Model 4	Model 5
State oil and gas revenues as share of state personal income	1.051*** (0.050)	1.053*** (0.049)	1.061*** (0.056)	1.055*** (0.051)	1.062*** (0.058)
Presence of fracking well		0.003*** (0.001)	0.003*** (0.001)		
Fracking intensity				-0.002 (0.001)	-0.002 (0.001)
Republican legislators as share of state legislators	-0.022*** (0.003)	-0.022*** (0.003)	-0.022*** (0.003)	-0.022*** (0.004)	-0.022*** (0.004)
Republican governor	-0.0001 (0.0004)	-0.0001 (0.0004)	-0.0001 (0.0004)	-0.001 (0.0005)	-0.001 (0.0005)
Log (population)	-0.023*** (0.006)	-0.022*** (0.006)	-0.021*** (0.006)	-0.014* (0.008)	-0.013* (0.008)
Population aged 65 or over as share of total population	0.034 (0.051)	0.048 (0.051)	0.024 (0.053)	0.085 (0.073)	0.047 (0.081)
Poverty rate	-0.020 (0.012)	-0.019 (0.012)	-0.019 (0.012)	-0.035** (0.015)	-0.035** (0.015)
Oil and gas revenues x Presence of fracking well			-0.056 (0.073)		
Oil and gas revenues x Fracking intensity					-0.052 (0.082)
Constant	0.369*** (0.082)	0.356*** (0.082)	0.345*** (0.082)	0.247** (0.105)	0.232** (0.103)
State fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	761	756	756	452	452
R^2 with the fixed effects	0.960	0.960	0.960	0.964	0.965
R^2 without the fixed effects	0.496	0.505	0.505	0.628	0.645
F Statistic	236.792***	231.851***	228.715***	208.109***	204.066***

Notes: This table shows regressions of state's own-source revenues on state's oil and gas revenues between 2000 and 2015 with presence of fracking well and fracking intensity as moderating variables. All monetary figures are adjusted to 2010 dollars using the consumer price index from the Bureau of Labor Statistics. Robust standard errors are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01.

These findings suggest that oil and gas revenues are supplemental to existing own-source revenues. How states behave toward oil and gas revenues is consistent with "Leviathan" model of governmental behavior. According to Brennan and Buchanan (1980), a Leviathan government would maximize revenues subject only to the constraints placed on their tax generating power by the constitution. Because states aim to benefit from an increase in oil and gas revenues, instead of changing the structure of tax revenues to maintain spending level and reduce resident's tax burden, states simply treat oil and gas revenues as extra money to the state treasury.

Consistent with some previous studies, Republican legislators, as the share of state legislators, show a negative, statistically significant effect on state own-source revenues in the regression. The estimated coefficient indicates that an increase of Republican legislators as the share of state legislators by one percentage point would reduce state own-source revenues as share of state personal income by over 2 percentage points. Change in state population is negatively associated with state own-source revenues as share of state personal income and statistically significant at the one and ten percent levels, respectively.

The coefficients on Republican governor and the share of elderly residents in population are not statistically significant, suggesting that these variables do not affect own-source revenue collection. In Models 2 and 3 that control for presence of fracking well, poverty rate shows negative coefficient, but not statistically significant at the ten percent level. However, when controlling for fracking intensity in Models 4 and 5, the coefficient on poverty rate is negative and statistically significant at the five percent level. The negative sign suggests increased poverty reduces state ability to raise own-source revenue collection.

Table XVII reports the results of regressions that analyze the effects of oil and gas booms on state tax collection. Overall, I find support for the hypothesis that revenues from oil and gas production would result in higher growth of tax collection. In all model specifications, an additional dollar revenue from oil and gas production would add state tax collection by slightly over a dollar. This finding suggests that the presence of oil and gas industry in the states would also positively affect other tax revenues. However, the findings do not support my hypothesis that fracking strengthens the effect of oil and gas revenue on tax collection. None of the coefficients that indicate the presence and intensity of fracking is statistically significant. Consistent with previous studies, Republican legislators have a negative, statistically significant effect on state tax revenues.

Besides the results reported in Tables XVI and XVII, I also run a set of fixed effect regressions with one-year lagged oil and gas revenue as another independent variable to investigate whether state tax policy on oil and gas production in previous year affects current revenues. The results indicate that oil and gas revenues from previous years do not affect own-source and tax revenues for the current year (Appendices B and C). I also ran a set of regressions investigating whether states with a value-based tax system differ from those with a volume-based tax system. The results suggest that the choice of tax system does not affect the relationship between oil and gas revenues and own-source and tax revenues (Appendix D).

TABLE XVII
ESTIMATES OF THE EFFECTS OF OIL AND GAS BOOMS ON STATE TAX REVENUE

	Dependent variable: State tax collection as share of state personal income				
	Model 1	Model 2	Model 3	Model 4	Model 5
State oil and gas revenues as share of state personal income	1.086*** (0.040)	1.086*** (0.040)	1.076*** (0.049)	1.086*** (0.041)	1.073*** (0.050)
Presence of fracking well		0.0001 (0.001)	0.0002 (0.001)		
Fracking intensity				0.001 (0.001)	0.001 (0.001)
Republican legislators as share of state legislators	-0.018*** (0.002)	-0.018*** (0.003)	-0.018*** (0.003)	-0.017*** (0.004)	-0.017*** (0.004)
Republican governor	-0.0003 (0.0004)	-0.0003 (0.0004)	-0.0002 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)
Log (population)	-0.025*** (0.006)	-0.026*** (0.006)	-0.027*** (0.006)	-0.012* (0.007)	-0.014* (0.007)
Population aged 65 or over as share of total population	-0.019 (0.045)	-0.021 (0.045)	0.010 (0.048)	0.014 (0.057)	0.083 (0.063)
Poverty rate	-0.026** (0.012)	-0.026** (0.012)	-0.025** (0.012)	-0.043*** (0.014)	-0.043*** (0.014)
Oil and gas revenues x Presence of fracking well			0.069 (0.068)		
Oil and gas revenues x Fracking intensity					0.096 (0.075)
Constant	0.385*** (0.076)	0.388*** (0.076)	0.401*** (0.077)	0.203** (0.095)	0.231** (0.097)
State fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	761	756	756	452	452
R^2 with the fixed effects	0.958	0.958	0.958	0.965	0.965
R^2 without the fixed effects	0.556	0.557	0.561	0.719	0.734
F Statistic	224.929***	219.087***	216.444***	209.629***	206.786***

Notes: This table shows regressions of state's tax revenues on state's oil and gas revenues between 2000 and 2015 with presence of fracking well and fracking intensity as moderating variables. All monetary figures are adjusted to 2010 dollars using the consumer price index from the Bureau of Labor Statistics. Robust standard errors are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01.

6.2 Effects of oil and gas booms on resident's tax burden

Table XVIII reports the results of a set of regressions that analyze the effect of oil and gas booms on resident's tax burden. Resident's tax burden is measured by the share of state personal income that goes to the governments of states and localities in which resident's lives.[20] Similar to the models that investigate the effects of oil and gas booms on state tax revenue, the independent variable is oil and gas revenues as a share of state personal income. I expect a negative coefficient on this variable because more oil and gas revenues are expected to reduce the total amount of taxes paid by residents to the governments of states and localities in which the taxpayers live.

Overall, the findings do not support my hypothesis that residents in states that have oil and gas production or allow fracking would experience a decrease in own-state and local tax burden. On the contrary, I find evidence that suggests the more oil and gas revenues are, the higher the amount paid by the residents in their own-state and local taxes. However, the size of additional tax burden is relatively small. Findings from all the models suggest that an additional million dollar from oil and gas revenues would increase the total amount of own-state and local taxes paid by the residents by between $69,000 and $79,000.

[20] There are two differences between resident tax burden and state tax revenues, the dependent variable, in the previous section. First, resident tax burden includes all taxes paid to both state and local governments in which taxpayers live, while state tax revenues in the previous section do not include local taxes. Second, resident tax burden excludes taxes paid by non-residents, while state tax revenues in the previous section include taxes paid by non-residents.

TABLE XVIII
ESTIMATES OF THE EFFECTS OF OIL AND GAS BOOMS ON RESIDENT'S TAX BURDEN

	Dependent variable: Share of state personal income that goes to the governments of states and localities in which resident's lives				
	Model 1	Model 2	Model 3	Model 4	Model 5
State oil and gas revenues as share of state personal income	0.075^{***} (0.024)	0.076^{***} (0.024)	0.079^{***} (0.027)	0.069^{***} (0.024)	0.069^{***} (0.026)
Presence of fracking well		0.001 (0.001)	0.001 (0.001)		
Fracking intensity				-0.002 (0.002)	-0.002 (0.002)
Republican legislators as share of state legislators	-0.014^{***} (0.003)	-0.014^{***} (0.003)	-0.014^{***} (0.003)	-0.015^{***} (0.005)	-0.015^{***} (0.005)
Republican governor	-0.00001 (0.0004)	-0.00002 (0.0004)	-0.00003 (0.0004)	-0.001 (0.0004)	-0.001 (0.0004)
Log (population)	-0.002 (0.007)	-0.002 (0.007)	-0.001 (0.007)	0.001 (0.008)	0.001 (0.008)
Population aged 65 or over as share of total population	-0.041 (0.054)	-0.036 (0.054)	-0.053 (0.059)	0.125^{*} (0.074)	0.124 (0.086)
Poverty rate	0.018 (0.011)	0.018 (0.011)	0.018 (0.011)	-0.002 (0.013)	-0.002 (0.013)
Oil and gas revenues x Presence of fracking well			-0.067 (0.058)		
Oil and gas revenues x Fracking intensity					-0.003 (0.066)
Constant	0.065 (0.087)	0.059 (0.086)	0.057 (0.086)	0.021 (0.113)	0.021 (0.114)
State fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	611	611	611	364	364
R^2 with the fixed effects	0.956	0.956	0.956	0.966	0.966
R^2 without the fixed effects	0.475	0.475	0.478	0.574	0.582
F Statistic	174.384^{***}	171.953^{***}	169.452^{***}	181.487^{***}	177.292^{***}

Notes: This table shows regressions of own-state and local taxes paid by state residents on state's oil and gas revenues between 2000 and 2015 with presence of fracking well and fracking intensity as moderating variables. Both the dependent and independent variables are expressed in shares of state personal income. The number of observations in the models is reduced as these models only include the states that have oil and gas production. All monetary figures are adjusted to 2010 dollars using the consumer price index from the Bureau of Labor Statistics. Robust standard errors are reported in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

The key to understanding the effects of fracking in these models is the interaction coefficients that indicate whether oil and gas revenue from fracking reduces resident's state and local tax burden. A positive coefficient means fracking states have a higher tax burden than non-fracking oil and gas states; a negative coefficient indicates vice versa. The coefficients of two interactions are not statistically significant, suggesting that there is no difference between the tax burden of residents who live in the states that allow fracking and of those who live in the oil and gas states that do not. The results also show that fracking intensity has no implications for residents' own-state and local tax burdens.

As discussed in the theoretical model, the median voter in a state that experiences an oil and gas boom would perceive that her average tax-price is decreased because some portion of the total cost of state budget is financed by oil and gas tax revenues. In result, she would demand an increase in the amount of public goods. The increasing demand comes at a cost, although it is hardly noticeable. For a median voter in Texas, for example, state oil and gas tax revenues amounted $4.2 billion in 2015 would only result in an additional tax burden by $10-12.[21]

The coefficient on Republican legislators as the share of state legislators is negative and statistically significant at the one percent level. The estimated coefficient suggests that as Republican legislators as the share of state legislators increases by one percentage point, the total amount of own state and local taxes paid by residents as share of state personal income would fall by 1.5 percentage points. This finding is consistent with previous studies on the effect of

[21] To estimate additional tax burden, first we calculate additional tax burden for the entire population in 2015. As indicated by the regression results, the total amount of own-state and local taxes paid by residents would increase by between $0.069-$0.076 for each extra dollar from oil and gas revenues. Accordingly, $4.2 billion oil and gas revenues increase the tax burden of Texas population by between $287 and $329 million. Dividing the additional tax burden by Texas population in 2015 results in an additional tax burden of $10-$12 for the tax payer.

political party affiliation on taxes. Change in state population is negatively associated with state own-source revenues as share of state personal income and statistically significant at the one and ten percent levels, respectively. None of the coefficients on republican governor, change in population, percent of elderly residents, and poverty rate are significant at the five percent level, suggesting that these variables do not affect resident's tax burden.

My preferred specification uses own-state and local taxes paid by state residents as the share of state personal income on the right-hand side. There is another alternative measure of tax burden that was also considered: taxes paid to own state and local taxes per capita. In Appendix E, I consider whether the amount of taxes paid to own state and local taxes is affected by the amount of state oil and gas revenues per capita. This does not turn out to be the case. In all models, I find that the amount of taxes paid to own state and local taxes is positively associated with the amount of state oil and gas revenues and statistically significant at the one percent level. The estimated coefficient indicates that an increase of state oil and gas revenues by one dollar per capita would increase the amount of taxes paid to own state and local governments by ten cents per capita. The interaction terms also have positive and statistically significant coefficients, indicating that an increase in fracking activities increases the tax burden of residents.

6.3 Effects of oil and gas booms on the oil and gas industry's tax burden

When the oil and gas industry experiences a boom, the government might see it as an opportunity to raise additional tax revenues resulting in a shift of the tax burden toward the industry. The tax burden on the oil and gas industry is measured by the share of state tax revenues collected from oil and gas production. I expect that the share of state tax revenue from the oil and gas industry increases at a higher rate than the growth rate of the industry, once the industry enjoys growing profit from oil and gas booms. Table XIX reports the regression results that analyze the effects of oil and gas development on the oil and gas industry's tax burden. As discussed in section 4.3, the economic output of the oil and gas industry as its share of state GDP is used as a proxy of profitability of the oil and gas industry.

In all the models, the coefficient on the oil and gas industry's share of state GPD are positive and statistically significant at the one percent level. This finding suggests that an increase in the industry's economic output as share of state GDP would result in a greater share of state tax collection paid by the industry. In Model 2, which control for the presence of fracking wells, a one percentage point increase in the oil and gas industry's share of state GDP would increase the share of state tax revenues collected from the industry by 1.4 percentage points. When I add an interaction term between the share of state GDP from the industry and the presence of fracking wells in Model 3, the estimate increases to approximately 1.8 percentage points, suggesting that as the industry's share of state economic output increases by one percentage point, oil and gas revenues as a share of state tax collection would increase by 1.8 percentage points in the states that do not have fracking.

TABLE XIX
ESTIMATES OF THE EFFECTS OF OIL AND GAS BOOMS ON THE OIL AND GAS INDUSTRY'S TAX BURDEN

	Dependent variable: State oil and gas revenue as share of state tax collection				
	Model 1	Model 2	Model 3	Model 4	Model 5
The oil and gas industry's share of state GDP	1.438*** (0.200)	1.434*** (0.199)	1.765*** (0.286)	1.446*** (0.204)	1.403*** (0.206)
Presence of fracking well		-0.012*** (0.005)	-0.012** (0.005)		
Fracking intensity				-0.011 (0.011)	-0.019 (0.017)
Republican legislators as share of state legislators	-0.051** (0.021)	-0.054** (0.022)	-0.046** (0.020)	-0.102** (0.041)	-0.112*** (0.040)
Republican governor	-0.0002 (0.002)	-0.0001 (0.002)	-0.001 (0.002)	0.001 (0.004)	0.001 (0.004)
Log (population)	0.114** (0.052)	0.110** (0.051)	0.115** (0.051)	0.079 (0.060)	0.063 (0.060)
Population aged 65 or over as share of total population	-2.244*** (0.879)	-2.311*** (0.891)	-2.618*** (0.875)	-3.797*** (1.331)	-3.639*** (1.242)
Poverty rate	-0.154* (0.090)	-0.157* (0.090)	-0.148* (0.085)	-0.195 (0.134)	-0.207 (0.133)
Share of state GDP from the oil and gas industry x Presence of fracking well			-0.647* (0.358)		
Share of state GDP from the oil and gas industry x Fracking intensity					0.269 (0.597)
Constant	-1.014 (0.649)	-0.955 (0.635)	-1.074* (0.629)	-0.419 (0.770)	-0.202 (0.772)
State fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	761	756	756	452	452
R^2 with the fixed effects	0.944	0.944	0.945	0.943	0.943
R^2 without the fixed effects	0.809	0.813	0.869	0.811	0.818
F Statistic	164.721***	161.460***	164.180***	127.223***	124.839***

Notes: This table shows regressions of state's oil and gas revenues on share of state GDP from the oil and gas industry between 2000 and 2015 with presence of fracking well and fracking intensity as moderating variables. All monetary figures are adjusted to 2010 dollars using the consumer price index from the Bureau of Labor Statistics. Robust standard errors are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01.

The results in Model 3 also indicate that the effect of an increase of the industry's share of state economic size would be different in the states that allow fracking. In these states, the oil and gas industry would only experience an increase of 1.1 percentage points in the share of state tax collection for each additional percentage point increase in the growth of industry's share of state GDP.[22] In Models 4 and 5, which control fracking intensity, the industry's tax contribution increases by approximately 1.4 percentage points regardless the magnitude of fracking in the states.

Consistent with findings from previous models, affiliation with Republican party is negatively associated with taxes. Republican legislators as the share of state legislators have a negative coefficient and are highly significant at the five percent level in the panel regression. The percentage of elderly population also shows a negative coefficient and is statistically significant at the one percent level. A one percentage point increase in elderly population reduces the contribution of oil and gas revenues to total tax collection by between 2.3 and 3.8 percentage points.

Overall, the results show that the share of state tax revenues collected from the oil and gas industry is positively associated with the profitability of the industry. This finding implies that state officials are successful in shifting some portion of the cost of public goods to the industry. Although lobbying from the industry is quite strong in influencing state policies, it does not, however, significantly help reduce, or at least maintain, the industry's share of tax collection, indicated by the growth of its tax contribution being higher than that of its economic contribution.

[22] The coefficient estimate of fracking states is the sum of coefficient estimates of the oil and gas industry's share of state GDP, dummy for presence of fracking well, and the interaction term. As such, 1.1 percentage point is the sum of 1.765 + (-0.012) + (-0.647).

The growth in the oil and gas industry also provides a justification for state officials to raise more taxes from the industry. As a response, the industry warned about delaying investment or shifting any drilling to other states with lower tax rates (The Oklahoman Editorial Board 2017). This threat could stir up competition among energy producing states. Following the method used by Weber, Wang, and Chomas (2015), Table XX shows that the effective tax rates on oil and gas production vary over time and across states, ranging from zero percent in some states that did not collect oil and gas taxes to as much as 14.5 percent in North Dakota in FY 2015. The table also shows that the effective tax rates changeover time, suggesting a strategic interaction among states to maximize revenue collection.

At national level, however, the states are able to take advantage from the oil and gas booms to export some portion of taxes to non-residents. Nationwide, the average effective tax rates on oil and gas production show an upward trend. Prior to the fracking boom, in 2000, the national effective rate was only 2.6 percent, indicating that states collected oil and gas revenues equal to 2.6 percent of total production value in that year. In 2007, the effective tax rate increased to 3.4 percent. And in 2015, the effective tax rate grew to 4.6 percent. Despite the threat from the oil and gas industry, the oil and gas boom has provided a means for the energy states to increase the exportability of their taxes to non-residents.

TABLE XX
EFFECTIVE RATES OF STATE TAXES ON OIL AND GAS PRODUCTION FY 2000, 2007, AND 2015

State	FY 2000	FY 2007	FY 2015	Is tax rate in FY 2007 greater than FY 2000?	Is tax rate in FY 2015 greater than FY 2007?
AL	3.6	5.2	7.9	Yes	Yes
AK	4.9	6.3	3.3	Yes	No
AZ	3.6	3.4	3.4	No	Yes
AR	NA	NA	3.2	NA	NA
CA	0.1	0.1	0.6	No	Yes
CO	0.5	1.3	2.7	Yes	Yes
FL	NA	6.0	3.8	NA	No
KS	2.1	2.7	4.4	Yes	Yes
KY	8.1	6.7	NA	No	NA
LA	4.2	6.0	9.0	Yes	Yes
MD	-	-	-	No	No
MI	NA	5.2	7.4	NA	Yes
MS	NA	2.4	3.6	NA	Yes
MO	-	-	NA	No	NA
MT	NA	7.1	11.5	NA	Yes
NE	2.6	1.8	5.1	No	Yes
NV	NA	1.1	3.2	NA	Yes
NM	NA	6.9	9.6	NA	Yes
NY	-	-	-	No	No
ND	5.2	5.5	14.5	Yes	Yes
OH	0.6	0.3	0.4	No	Yes
OK	4.9	6.3	5.2	Yes	No
OR	8.2	7.1	6.0	No	No
PA	-	-	1.4	No	Yes
SD	1.5	1.7	4.5	Yes	Yes
TN	2.9	2.6	NA	No	NA
TX	NA	3.6	5.2	NA	Yes
UT	1.4	1.9	2.9	Yes	Yes
VA	-	-	-	No	No
WV	NA	5.6	5.4	NA	No
WY	2.7	4.6	5.5	Yes	Yes
U.S. average	2.6	3.4	4.6	Yes	Yes

Notes: Following the method used by Weber, Wang, and Chomas (2015), effective tax rates of state tax on oil and gas production are estimated by dividing state oil and gas revenues by state annual value of oil and gas production in a given year. For U.S. average, each state-year observation is given the same weight, regardless of how much production or revenue was involved.

6.4 Effects of oil and gas booms on revenue cyclicality

The cyclicality of revenues refers to the relationship between state revenues and a state's business cycle (Sobel and Holcombe 1996, Dye 2004). The revenue cyclicality is measured as the changes in the growth of tax revenues relative to the changes in the growth of state personal income (Felix 2008). I expect that oil and gas states and fracking states would experience more volatile revenues in the short term compared to those without oil and gas activities.

Felix (2008) finds that oil and gas producing states are more likely to have a pro-cyclical pattern of tax revenue compared to non-producing states. Following Felix's work, in order to understand the effects of resource boom on cyclicality of state revenues, this study divides the sample into two periods: before fracking boom (2000-2007) and during fracking boom (2008-2015). The motivation for splitting the sample is to identify whether revenue cyclicality of the producing states would be different from that of non-producing states in different level of oil and gas production. It is expected that the oil and gas boom would result in more pro-cyclical pattern of revenues of the producing states compared to the period before the states experience the oil and gas boom.

I tested for cross-equation equality of regression coefficients to examine the differences in coefficients of three different subgroups in the data: non-oil and gas states, non-fracking oil and gas states, and fracking states. Non-fracking oil and gas states are producing states that do not have fracking wells. In these states, oil and gas are solely extracted from non-fracking production. The baseline is non-oil and gas states. I expect to see positive and significant coefficients of all major revenues for states that have oil and gas production as well as for those that allow fracking.

Table XXI provides the results of a set of regressions that analyze the effect of oil and gas booms on revenue cyclicality in major revenue categories. The dependent variable is the changes in the growth rates of major revenue sources. The main independent variable is the changes in the growth rates of state personal income.

Panel A reports on the values of short-run elasticities of state tax revenues prior to the fracking boom, which preceded the diffusion of fracking technology in the U.S. (2000-2007), while Panel B reports on revenue elasticities during the fracking boom (2008-2015). The estimates in column (1) indicate the cyclicality of revenues in non-oil and gas states as a baseline in order to provide a sense of the magnitude of the differences in means between two groups of states in the remaining columns. Column (2) shows the estimate differences between non-fracking oil and gas states and non-oil and gas states. Column (3) shows the estimate differences between fracking states and non-oil and gas states. I expect positive and statistically significant coefficients in these two columns.

In general, non-oil and gas states experienced less volatile own-source and tax revenues relative to state personal income prior to the fracking booms. As reported in column (1) in panel A, the coefficients of revenue cyclicality are lower than one, indicating that the changes in the growth rates of own-source and tax revenues in these states were less volatile than the changes in the growth rates of state personal income. The estimate of tax revenue of 0.803, for example, is interpreted that as state personal income grew by 1 percentage point, state tax revenues only grew by 0.8 percentage point at the one percent level. Personal and corporate income taxes, however, were more volatile than state personal income over the pre-fracking period.

TABLE XXI
ESTIMATES OF THE EFFECTS OF OIL AND GAS BOOMS ON CYCLICALITY OF STATE REVENUES

State Revenues	Non-oil & gas states	Non-fracking oil & gas states vs. non-oil & gas states	Fracking states vs. non-oil & gas states
	(1)	(2)	(3)
Panel A: prior to fracking boom (FY 2000-2007)			
Own-source revenue	0.758***	1.115***	0.502
	(0.288)	(0.389)	(0.317)
Tax revenue	0.803***	1.285***	0.662*
	(0.303)	(0.423)	(0.340)
General sales tax a)	0.476*	0.979**	0.413
	(0.263)	(0.461)	(0.293)
Selective sales tax b)	0.273	0.756	-0.131
	(0.293)	(0.499)	(0.345)
Personal income tax c)	1.511***	0.649	0.336
	(0.465)	(0.638)	(0.560)
Corporate income tax d)	1.580	4.379*	3.212
	(1.955)	(2.330)	(2.139)
Panel B: during fracking boom (FY 2008-2015)			
Own-source revenue	0.816***	0.566	-0.174
	(0.138)	(0.723)	(0.247)
Tax revenue	1.159***	0.539	-0.290
	(0.159)	(0.808)	(0.281)
General sales tax a)	1.008***	0.154	-0.083
	(0.216)	(0.318)	(0.349)
Selective sales tax b)	0.513**	0.166	-0.149
	(0.203)	(0.279)	(0.265)
Personal income tax c)	1.787***	0.053	-1.059**
	(0.286)	(0.581)	(0.442)
Corporate income tax d)	3.613***	-0.509	-1.354
	(0.748)	(1.192)	(1.281)

Notes: This table shows coefficients from regressions of revenue cyclicality of state revenues prior to fracking boom (Panel A: FY 2000-2007), and during fracking boom (Panel B: FY 2008-2015). The dependent variable is the changes in the growth rates of major revenue sources. The main independent variable is the changes in the growth rates of state personal income. Column (1) shows the coefficients of short run elasticities of revenues for non-oil and gas states. Column (2) shows the estimate differences between non-fracking oil and gas states and non-oil and gas states. Column (3) shows the estimate differences between fracking states and non-oil and gas states. a) General sales tax rates are included as an independent variable, and the state regressions include dummies for food exemptions and prescription drug exemptions. b) The changes in the tax rates for gasoline and cigarettes are included as independent variables. c) The changes in the highest marginal personal income tax rate are included as independent variables. d) The changes in the highest marginal corporate tax rate are included as independent variables. All monetary figures are adjusted to 2010 dollars using the consumer price index from the Bureau of Labor Statistics. Robust standard errors are reported in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

In contrast, during the fracking boom (column 1 in panel B), non-oil and gas states experienced more volatile revenues, with corporate income tax as the most volatile revenue source. In these states, total tax collection, personal and corporate income taxes have grown at a faster rate than state personal income as indicated by coefficients greater than 1. The estimate of state personal income tax of 1.8 is interpreted that a one percentage point increase in the growth rate of state personal income would lead to a 1.8 percentage point increase in that of personal income tax, controlling for changes in the highest marginal personal income tax rate.

Column 2 reports the comparison of regression coefficients of revenue cyclicality between non-fracking oil and gas states and non-oil and gas states. Prior to the fracking boom that began in 2008 (column 2 in Panel A), non-fracking oil and gas states had more volatile own-source and tax revenues compared with those without the oil and gas sector indicated by positive and statistically significant coefficients. Non-fracking oil and gas states also had more volatile general sales and corporate income taxes as the coefficient of these revenues are positive and statistically significant. The most pronounced difference in coefficients of corporate income tax is estimated to be 4.4, suggesting that corporate income tax in non-fracking oil and gas states is four times more pro-cyclical than non-oil and gas states. During the fracking boom (Panel B), however, the cyclicality of revenues of the oil and gas states was not statistically different from that of non-oil and gas states.

Column 3 reports the comparison of revenue cyclicality between fracking states and non-oil and gas states. Most of the coefficients before and during the fracking boom were not statistically significant, suggesting that fracking states are not different from non-oil and gas states in terms of revenue cyclicality. The only differences are in the cyclicality of tax revenues prior to the development of fracking and that of personal income tax during the fracking boom.

Overall, the results indicate that the revenue cyclicality of the energy states, regardless they allow fracking or not, are not statistically different from that of non-energy states in the period of 2008-2015. This finding implies that the resource boom does not affect the revenue cyclicality of the energy states. The period of the fracking boom overlaps with the Great Recession, which has negatively affected state revenue collection. While the composition of state revenue plays an important role in determining the stability of state tax revenues during the business cycle (Felix 2008), the recession hit the energy states as much as it affected non-energy states. In the aftermath of the Great Recession, state revenues remained below the pre-recession level, after accounting for inflation. Even a few years after the recession, NASBO (2013) reports that aggregate state general fund revenues did not surpass nominal fiscal 2008 peak levels until fiscal 2013.

7. CONCLUSION

7.1 Discussion and Policy Implications

This paper investigates the effects of the recent oil and gas boom on four dimensions of state fiscal affairs: state revenues, residents' tax burden, the oil and gas industry's tax burden, and revenue cyclicality. Three broad conclusions can be drawn from the analysis of the previous chapters in respect of: (i) the flypaper effect, (ii) the size of fiscal effects of the recent resource boom, and (iii) the changes in residents' and the industry's tax burden, given the changes in the exportability of state taxes.

A first conclusion is that revenues from resource extraction have similar characteristics to intergovernmental grants. Using a theoretical model to predict state behavior as a response to an increase in oil and gas tax revenues, I find that the behavior of the states appears to be at least consistent with some outcomes predicted by the flypaper effect. The results from regression analyses indicate that states treat revenues from resource extraction similar to how they treat intergovernmental grants. The development of oil and gas in the states results in additional revenues to the states over the nominal value of revenues collected from oil and gas production, suggesting that oil and gas revenues have crowd-in effects on state revenues. As hypothesized in the flypaper effect, instead of reducing the residents' tax burden, the states use oil and gas revenues to increase state revenues.

The finding also provides an insight that revenues earned from a resource boom act as a driving factor for higher growth in government revenues. Analogous to lump-sum grants to a recipient government, states would treat oil and gas revenues as a supplement to existing revenue sources. The results are relevant to other industrial booms, not only from resource extraction like coal, iron, and industrial minerals, but also from non-extractive industries such as real estate, software, and semi-conductor industries. Additional revenues from fast-growing industries would be considered as extra money to government coffers.

From a policy perspective, this is certainly a potential finding about the benefits of oil and gas investment for state revenues. Additionally, an investment in oil and gas industry has secondary effect to the state economy. As pointed by Feyrer, Mansur, and Sacerdote (2017), local and regional economies benefit from oil and gas investment through employment and wages in the extraction and transportation industries, royalties and lease payment received by the landowners, and a multiplier effect on other industries.

The second conclusion is the sizes of fiscal effects of recent oil and gas booms vary across states. Some states enjoyed substantial gain in oil and gas revenues, while others did not see much increase in state revenues. For the states that depend on oil and gas revenues, their revenues would be exposed to external pressure because the production value is subject to the volatility of oil and gas prices in the market. With the continuous battle between OPEC, Russia, and the United States to control oil prices, state revenues in the states would be affected by changes in oil and gas prices. While the rise in oil and gas prices would have a positive impact on state revenues, declining prices would substantially hurt revenue collections. State policy makers should consider ways to respond. First, states that have abundant oil and gas reserve could set up trust fund to save some portion of oil and gas revenues for future use. Currently, there are only 5 out of 31 states that have oil and gas revenues have trust funds. Second, states could increase the amount of revenues deposited into trust funds during oil and gas booms and draw down balances when revenues fall.

The third conclusion is that windfall gains from a resource boom do not necessarily lead to a decrease in residents' tax burden. The theoretical model outlined in this study predicts that residents in the states that experience a resource boom would experience an increase in the amount of taxes paid to own-state and local governments. While my hypothesis suggests otherwise, the regression results confirm this prediction, indicating that the residents of energy states would experience a slight increase in tax burden.

The small increase in residents' tax burden is associated with the fact that part of oil and gas production is consumed by residents of producing states. In estimating state-local tax burden, the Tax Foundation (2016) allocates the total amount of state severance taxes collected from oil and gas production to each state based on the states' share of oil and gas consumption. Then states' share of oil and gas consumption is divided further into five sectors including the residential sector.[23] Accordingly, residents of the producing states also take on a fraction of oil and gas tax burden because they also purchase oil and gas products extracted within the states.

A resource boom also increases the ability of producing states to further shift the cost of public goods to the booming industry. Empirical analyses in this study indicate that when a resource boom happens in a state, the state's extractive industry would likely pay a greater share of state tax revenues. There are two plausible explanations to this finding. First, the growth of extractive industry convinces state policymakers to collect more taxes from the industry, justified by the argument that incidence of the taxes would fall on non-residents. And second, the industry's officials suffer from the complexity of state tax system making calculation of tax burden difficult.

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[23] The other four sectors are electricity sector, commercial sector, industrial sector, and transportation sector.

7.2 Limitations and Future Research

Although this study offers a view of the effects of oil and gas booms on state government fiscal affairs, some limitations do exist, and future research is needed to better establish the theoretical model and estimates on the effects of natural resource boom.

First, the results of this study are preliminary due to data limitations. Oil and gas revenues in the study do not include corporate income taxes on the oil and gas firms, and indirect taxes that are often affected by changes in economic activity or population induced by the oil and gas industry, such as sales tax and individual income tax. In result, the estimates are conservative and lower than what the actual results actually are. More comprehensive data collection is necessary to improve our understanding of the effects of oil and gas development on state revenues in general and of the magnitude of revenue substitution driven by windfall gains in particular.

Second, this study does not control for the spending side of state budget. While this study focuses on the revenue side of state budget, it could be argued that revenue also interacts with spending as the state budget decision-making process happens simultaneously for both the revenue and expenditure sides of the state budget. Despite the consistency of the results with the flypaper effect, caution must be exercised in reaching the conclusion that states are using windfall gains for budgetary expansion - a fundamental proposition of this model. While analysis on the effect of oil and gas boom on state spending is beyond the scope of this study, future research on this study should better control for the spending side of state budget.

And third, this study is silent regarding whether dependence on oil and gas revenues improves state's fiscal performance and whether public services are better in oil and gas producing states. In some states, oil and gas revenues are earmarked for specific expenditures in order to improve public services associated with these expenditures. Texas and Montana, for example, allocate some portion of oil and gas revenues for public primary and secondary education. Accordingly, further study should investigate whether earmarked oil and gas revenues improve educational attainment in the states. Testing the fungibility of education expenditures in the states would also be of particular interest for future research.

APPENDIX A
STATE TAXES ON OIL AND GAS PRODUCTION

State	Tax Name	Rate	Source
Alaska	Production Tax	In 2013, Senate Bill 21 (commonly known as the More Alaska Production Act or "MAPA") set the current tax rate of 35% (AS 43.55). The tax base is the net value of oil and gas, which is the value at the point of production, less all qualified lease expenditures.	Alaska Department of Revenue – Tax Division http://www.tax.alaska.gov/programs/programs/index.aspx?60650
	Conservation Surcharges	The current rate is $0.01 per barrel (AS 43.55.201).	Alaska Department of Revenue – Tax Division http://tax.alaska.gov/programs/programs/reports/Annual.aspx?60655
Alabama	Oil and Gas Privilege Tax	8 percent of gross value of gas or oil at point of production. Some exceptions apply: - 6% for production from offshore wells producing greater than 200 MCF or 25 barrels per day at depths less than 8,000 feet and wells permitted 7/01/88 or later. - 4 % production from offshore wells producing 200 Mcf or 25 BBLs or less per day at depths less than 8,000 feet, oil wells producing 25 barrels or less per day, gas wells producing 200 Mcf or less per day, and incremental production from qualified enhanced recovery projects and supplemental enhanced recovery projects approved by the State Oil and Gas Board. - 3.65% for gross proceeds from offshore production from depths greater than 8,000 feet below mean sea level.	Alabama Department of Revenue https://revenue.alabama.gov/business-license/oil-gas-tax

State	Tax Name	Rate	Source
		Title 40, Chapter 20 Article 1 & 1a, Sections 2 & 21	
	Oil and Gas Production Tax	2 percent of gross value of gas or oil at point of production. Some exceptions apply: - 1.66% for gross proceeds from offshore production from depths greater than 8,000 feet below mean sea level. - 1% for production from wells permitted from 7/01/96 thru 6/30/2002 for five years from first production. Title 9, Chapter 17 Sections 25-35	Alabama Department of Revenue https://revenue.alabama.gov/business-license/oil-gas-tax
	Oil and Gas Reduced Privilege Tax	- 2% for wells normally qualifying for the 4% privilege tax rate and permitted from 7/01/96 thru 7/01/2002 for five years from first production - 3% for wells normally qualifying for the 6% privilege tax rate and permitted from 7/01/96 thru 7/01/2002 for five years from first production Title 40, Chapter 20 Article 1, Section 2(a)(6)	Alabama Department of Revenue https://revenue.alabama.gov/business-license/oil-gas-tax
Arkansas	Oil Revenue Tax	• 4% of the market value when production averages 10 barrels or less per well per day. ---- §26-58-111(6)(b) • 5% of the market value when production averages more than 10 barrels per well per day. ---- §26-58-111(6)(a)	Arkansas Department of Finance and Administration http://www.dfa.arkansas.gov/offices/exciseTax/MiscTax/Pages/oil.aspx
	Natural Gas Severance Tax	The applicable tax rates of 1.25%, 1.5%, and 5.0% are dependent on the well classification by the Arkansas Oil and Gas	Arkansas Department of Finance and Administration http://www.dfa.arkansas.gov/offices/exciseTax/MiscTa

State	Tax Name	Rate	Source
		Commission. Applicable Statutes: AR Code Ann. §26-58-101 et seq., §26-58-201 et seq.	x/Pages/naturalGasSeverance.aspx
Arizona	Transaction Privilege Tax	3.125 percent for oil and gas production and nonmetal mining. Statute 42-5072	Joint Legislative Budget Committee, State of Arizona 2016 Tax Handbook https://www.azleg.gov/jlbc/16taxbook/16taxbk.pdf
California	Oil and Gas Production Assessment	The rate is $0.3243123 on each barrel of oil and each 10,000 cubic feet of natural gas produced.	State of California Department of Conservation http://www.conservation.ca.gov/dog/for_operators/Pages/assessments.aspx
Colorado	Severance Tax	The current rates are: • 2% for GI under $25,000 • $500 and 3% of the excess over $24,999 for GI between $25,000–$99,999 • $2,750 and 4% of the excess over $99,999 for GI between $100,000–$299,999 • $10,750 and 5% of excess over $299,99 for GI above $300,000	Colorado Department of Revenue Annual Report 2016 https://www.colorado.gov/pacific/sites/default/files/2016%20Annual%20Report.pdf
Florida	Oil Production Tax	The tax is based on the value of the oil produced and saved or sold during a month. Oil is taxed at the following rates: • 12.5% of gross value for escaped oil. • 8% of gross value for ordinary oil production. • 5% of gross value for small well oil. • Excise tax rate based on tiered formula for tertiary oil. Reference Chapter 211, Part I, Florida Statutes	Florida Department of Revenue http://floridarevenue.com/taxes/taxesfees/Pages/severance.aspx
	Gas Production Tax	Gas production tax rates for 2017-2018 is $0.172 per 1,000 cubic feet	Florida Department of Revenue http://floridarevenue.com/taxes/taxesfees/Pages/severan

State	Tax Name	Rate	Source
		Reference Chapter 211, Part I, Florida Statutes	ce.aspx, https://revenuelaw.floridarevenue.com/LawLibraryDocuments/2017/05/TIP-121140_TIP%2017B07-02%20FINAL%20RLL.pdf
Kansas	Mineral Tax	8% of gross value of oil and gas, less property tax credit of 3.67 percent K.S.A. 79-4217, 4219	Kansas Department of Revenue 2016 Annual Report https://www.ksrevenue.org/pdf/ar16a.pdf
Kentucky	Oil Production Tax	4.5 percent of the gross value less the transportation expense KRS 42.450(2) and 42.470(2)	Office of State Budget Director https://osbd.ky.gov/Publications/Documents/Special%20Reports/Natural%20Resources%20Severance%20and%20Processing%20Tax.pdf
	Minerals and Natural Gas Tax	4.5 percent of the gross value less the transportation expense KRS 42.450(2) and 42.470(2)	Office of State Budget Director https://osbd.ky.gov/Publications/Documents/Special%20Reports/Natural%20Resources%20Severance%20and%20Processing%20Tax.pdf
Louisiana	Oilfield Site Restoration Fee-Gas, Oilfield Site Restoration Fee-Oil, Natural Resources-Severance Tax, Oil Production and Cash Collections, and Natural Gas Production and Cash Collections	Oil – Full rate is 12.5% of its value at time and place of severance. Gas – Full rate 9.8 cents per Mcf for FYE 16, 16.3 cents per Mcf for FYE 15, 11.8 cents per Mcf for FYE 14, 14.8 cents per Mcf for FYE 13, and 16.4 cents per Mcf for FYE 12.	Louisiana Department of Revenue 2016 Annual Report http://revenue.louisiana.gov/Publications/AR(15-16).pdf
Maryland		The State of Maryland does not collect tax on oil and gas.	
Michigan	Gas & oil privilege fee	1.00% of gross cash market value	Michigan Department of Treasury

State	Tax Name	Rate	Source
		The Michigan Severance Tax Act, MCL 205.301	http://www.michigan.gov/taxes/0,4676,7-238-43519_43545---,00.html
	Gas & oil severance tax	• 6.6% of gross cash market value for oil • 4% of gross cash market value for Marginal/Stripper Oil Well • 5% of gross cash market value for gas The Michigan Severance Tax Act, MCL 205.301	Michigan Department of Treasury http://www.michigan.gov/taxes/0,4676,7-238-43519_43545---,00.html
Mississippi	Oil and gas severance tax	6% of the value at the point of production of oil and gas. Oil wells that meet Enhanced Oil Recovery (E.O.R.) production criteria qualify for a reduced rate of 3% for as long as the well maintains its production by the EOR method. Miss. Code Ann. Sections 27-25-703, 27-25-503	Mississippi Department of Revenue http://www.dor.ms.gov/Business/Pages/Miscellaneous-Taxes.aspx
Missouri		The State of Missouri does not collect tax on oil and gas.	

Montana	Oil and Gas Production Tax	Gas rates (percent of gross production value), working interest:
		• First 12 months of qualifying production: 0.8%
		• After 12 months:
		  • Pre-1999 wells: 15.1%
		  • Post-1999 wells: 9.3%
		  • Stripper natural gas pre-1999 wells: 11.3%
		  • Horizontally completed well production:
		    • First 18 months of qualifying production: 0.8%
		    • After 18 months: N/A
		
		Oil rates (percent of gross production value), working interest:
			Montana Department of Revenue, Natural Resource Taxes, https://revenue.mt.gov/home/businesses/naturalresource_taxes

State	Tax Name	Rate	Source

		• Primary recovery production:
		  • First 12 months of qualifying production: 0.8%
		  • After 12 months:
		    • Pre-1999 wells: 12.8%
		    • Post-1999 wells: 9.3%
		• Stripper oil production:
		  • First 1 through 10 barrels a day production: 5.8%
		  • More than 10 barrels a day production: 9.3%
		  • Stripper well exemption production: 0.8%
		  • Stripper well bonus production: 6.3%
		• Horizontally drilled:
		  • Pre-1999 & post-1999 wells first 18 months: 0.8%
		• Incremental Production:
		  • New or expanded secondary recovery production: 8.8%
		  • New or expanded tertiary production: 6.1%
		• Horizontally recompleted well:
		  • Pre-1999 & post-1999 wells first 18 months: 5.8%
		
		• Non-working interest: oil and gas wells subject to 15.1% tax	

Nebraska	Severance Tax	The tax is based on the value of the oil and gas produced at the following rates: • 3% of the value of non-stripper oil and natural gas • 2% of the value of stripper oil	Nebraska Department of Revenue, http://www.revenue.nebraska.gov/tax/current/fill-in/f_61.pdf.
	Conservation Tax	The conservation tax rate is set by the Oil and Gas Conservation Commission. Effective April 1, 2017, the tax rate is 0.7% based on the value of the oil and gas. Revenue from the conservation tax is deposited in the Oil and Gas Conservation Fund.	Nebraska Department of Revenue, http://www.revenue.nebraska.gov/tax/current/fill-in/f_61.pdf.

State	Tax Name	Rate	Source
Nevada	Oil and Gas Conservation Fee	Up to $0.20 per 50,000 cubic feet of natural gas or barrel of oil	Brown (2013)
New Mexico	Oil and Gas Severance Tax	The tax is based on the value of the oil and gas produced at the following rates: • 3.75% of taxable value of oil or gas severed and sold • 1.875 % of taxable value for enhanced recovery project oil and gas • 2.45% of taxable value for well workover projects in excess of production projection • 1.85% or 2.8125% of taxable value for stripper wells NM Stat § 7-29-4	Brown (2013) and The Taxation and Revenue Department New Mexico http://www.tax.newmexico.gov/all-nm-taxes.aspx?9674a2e28c1442ce8b25e81c6d015418blogPostId=ba1c6d6acfa244f78ea15f5a3edfc50f#/BlogContent
	Oil and Gas Conservation Tax	$0.19% of taxable value of sold oil or gas NM Stat § 7-30-4	Brown (2013) and The Taxation and Revenue Department New Mexico http://www.tax.newmexico.gov/all-nm-taxes.aspx?9674a2e28c1442ce8b25e81c6d015418blogPostId=ba1c6d6acfa244f78ea15f5a3edfc50f#/BlogContent
	Oil and Gas Emergency School Tax	The tax is based on the value of the oil and gas produced at the following rates: • Oil: 3.15% of taxable value • Gas: 4% of taxable value NM Stat § 7-31-4	Brown (2013) and The Taxation and Revenue Department New Mexico http://www.tax.newmexico.gov/all-nm-taxes.aspx?9674a2e28c1442ce8b25e81c6d015418blogPostId=ba1c6d6acfa244f78ea15f5a3edfc50f#/BlogContent
	Oil and Gas Ad Valorem Production Tax	Rate based on assessed value of property NM Stat § 7-32-1	Brown (2013) and The Taxation and Revenue Department New Mexico http://www.tax.newmexico.gov/all-nm-taxes.aspx?9674a2e28c1442ce8b25e81c6d015418blogPostId=ba1c6d6acfa244f78ea

State	Tax Name	Rate	Source
			15f5a3edfc50f#/BlogContent
	Natural Gas Processor Tax	0.0065 per mmbtu of natural gas multiplied by adjustment factor. Adjustment factor equal to the annual taxable value per MCF of natural gas divided by $1.33 NM Stat § 7-33-2	Brown (2013)
New York		The State of New York does not collect tax on oil and gas.	
North Dakota	Oil Extraction Tax	The tax is based on the value of the oil a produced at the following rates: - 5%, if oil prices are below $90 per barrel - In the event of sustained oil prices above $90 per barrel, the oil extraction tax would increase to 6%.	Office of State Tax Commissioner 52nd Biennial Report 2013-2015 http://www.nd.gov/tax/data/upfiles/media/45thbiennialreport.pdf
	Oil & Gas Gross Production Tax	The gross value of oil production at the well is taxed at a rate of 5% in lieu of property taxes on the oil and gas producing properties. Gas is taxed on a volume basis at a rate determined by the movement of a fuels cost index. During FY 2014, gas production tax rate was 8.33¢ per MCF. In FY 2015, the tax rate was 9.82¢ per MCF.	Office of State Tax Commissioner 52nd Biennial Report 2013-2015 http://www.nd.gov/tax/data/upfiles/media/45thbiennialreport.pdf
Ohio	Oil and gas severance tax	The tax is based on the volume of the oil a produced at the following rates: • Oil: 10 ¢ per barrel • Natural gas: 2.5 ¢ per MCF Ohio Rev. Code § 5749.02	Ohio Department of Taxation 2016 Annual Report https://www.tax.ohio.gov/Portals/0/communications/publications/annual_reports/2016AnnualReport/2016AnnualReport.pdf
Oklahoma	Oil and gas severance tax	The tax is based on the value of the oil and gas produced: • The base gross production tax rate: 7%.	Oklahoma Tax Commission Annual Report Fiscal Year Ended June 30, 2016

State	Tax Name	Rate	Source
		• Qualified horizontally drilled wells: 1% • New wells drilled beginning July 1, 2015: 2% • Qualified deep wells: 4%.	https://www.ok.gov/tax/documents/AR2016.pdf
	Petroleum excise tax	Oil and gas excise taxes are collected at 0.095 of 1% of gross value.	Oklahoma Tax Commission Annual Report Fiscal Year Ended June 30, 2016 https://www.ok.gov/tax/documents/AR2016.pdf
Oregon	Oil and gas production tax	The tax is based on the value of the oil and gas produced. • 6% of gross value of oil or gas well production	Brown (2013), Department of Geology and Mineral Industries Oregon http://www.oregon.gov/DOGAMI/Pages/oil/oilhome.aspx
Pennsylvania	Impact fee	The fee is calculated based upon the average price of natural gas for the year. For example, the fees for horizontal well in 2013 were: Year 1: $50,000 Year 2: $40,000 Year 3: $30,000 The fees for vertical well are 20% of the applicable horizontal well fees. Act 13 of 2012	Pennsylvania Public Utility Commission http://www.puc.state.pa.us/filing_resources/issues_laws_regulations/act_13_impact_fee_.aspx, http://www.puc.state.pa.us/NaturalGas/pdf/MarcellusShale/Act13_Producer_Fees-CY2013.pdf
South Dakota	Energy Minerals Severance Tax	The tax is based on the taxable value of any energy minerals severed and saved by or for the owner or operator. The rate is 4.5%. Statute 10-39A-1	South Dakota Legislature, http://www.sdlegislature.gov/Statutes/Codified_Laws/DisplayStatute.aspx?Type=Statute&Statute=10-39A-1
Tennessee	Severance tax	The tax is based on the sales price of oil and gas produced. The rate is 3%.	Tennessee Department of Revenue https://www.tn.gov/revenue/taxes/severance-taxes/due-dates-and-tax-rates.html
Texas	Severance tax	The baseline Texas severance tax on oil and gas is: • 7.5% of gas market value	Railroad Commission of Texas

State	Tax Name	Rate	Source
		• 4.6% of oil market value • 4.6% of gas condensate	http://www.rrc.state.tx.us/oil-gas/publications-and-notices/texas-severance-tax-incentives-past-and-present/
Utah	Conservation fee	The conservation fee rate is 0.2% of the value of oil and gas produced and saved, sold, or transported from the field in Utah. Statutory Reference: § 40-6-14.	Utah State Tax Commission https://oilgas.ogm.utah.gov/pub/Publications/Lists/prod_tax_sumry.pdf
	Severance tax	The tax rates for oil: • 3% of the value of the oil up to and including the first $13 per barrel for oil • 5% of the value of the oil from $13.01 and above per barrel for oil. The tax rates for natural gas: • 3% of the value up to and including the first $1.50 per MCF for gas • 5% of the value from $1.51 and above per MCF for gas Statutory Reference: § 59-5-102	Utah State Tax Commission https://oilgas.ogm.utah.gov/pub/Publications/Lists/prod_tax_sumry.pdf
Virginia		The Commonwealth of Virginia does not collect tax on oil and gas.	
West Virginia	Severance tax	5% on gross receipts at the well-head attributable to the production of oil and natural gas.	West Virginia State Tax Department http://tax.wv.gov/ResearchAndGovernment/Research/SeveranceTaxHistoryAndData/Pages/SeveranceTaxHistoryAndData.aspx
Wyoming	Oil and Natural Gas Severance Tax	• 6% of based on the assessed value of gross product of crude oil and natural gas • 4% of based on the assessed value of gross product of stripper oil	State of Wyoming 2015 Comprehensive Annual Financial Report http://sao.wyo.gov/publications

APPENDIX B
ESTIMATES OF THE EFFECTS OF OIL AND GAS BOOMS ON STATE OWN SOURCE REVENUE

	Dependent variable: State own-source revenues as share of state personal income				
	Model 1	Model 2	Model 3	Model 4	Model 5
State oil and gas revenues as share of state personal income	1.067*** (0.071)	1.068*** (0.071)	1.074*** (0.070)	1.076*** (0.071)	1.077*** (0.072)
Presence of fracking well		0.003*** (0.001)	0.003** (0.001)		
Fracking intensity				-0.001 (0.001)	-0.001 (0.001)
Oil and gas revenues (t-1)	-0.022 (0.091)	-0.022 (0.091)	-0.018 (0.091)	-0.031 (0.093)	-0.030 (0.095)
Republican legislators as share of state legislators	-0.022*** (0.003)	-0.022*** (0.003)	-0.022*** (0.003)	-0.023*** (0.004)	-0.023*** (0.004)
Republican governor	-0.0002 (0.0004)	-0.0002 (0.0004)	-0.0002 (0.0004)	-0.0004 (0.001)	-0.0004 (0.001)
Log (population)	-0.024*** (0.007)	-0.023*** (0.007)	-0.022*** (0.007)	-0.016* (0.009)	-0.015* (0.009)
Population aged 65 or over as share of total population	0.042 (0.055)	0.056 (0.055)	0.031 (0.057)	0.124* (0.073)	0.115 (0.083)
Poverty rate	-0.023* (0.013)	-0.022* (0.013)	-0.023* (0.013)	-0.038** (0.015)	-0.038** (0.015)
Oil and gas revenues x Presence of fracking well			-0.054 (0.078)		
Oil and gas revenues x Fracking intensity					-0.012 (0.089)
Constant	0.379*** (0.095)	0.367*** (0.095)	0.356*** (0.094)	0.266** (0.123)	0.262** (0.121)
State fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	711	706	706	421	421
R^2 with the fixed effects	0.961	0.961	0.961	0.966	0.966
R^2 without the fixed effects	0.512	0.704	0.705	0.628	0.645
F Statistic	227.269***	221.747***	218.689***	198.909***	194.645***

Notes: This table shows regressions of state's own-source revenues on state's oil and gas revenues between 2000 and 2015 with presence of fracking well and fracking intensity as moderating variables, and lagged oil and gas revenues as an independent variable. All monetary figures are adjusted to 2010 dollars using the consumer price index from the Bureau of Labor Statistics. Robust standard errors are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01.

APPENDIX C
ESTIMATES OF THE EFFECTS OF OIL AND GAS BOOMS ON STATE TAX REVENUE

	Dependent variable: State tax collection as share of state personal income				
	Model 1	Model 2	Model 3	Model 4	Model 5
State oil and gas revenues as share of state personal income	1.083*** (0.061)	1.083*** (0.061)	1.076*** (0.065)	1.086*** (0.061)	1.075*** (0.066)
Presence of fracking well		-0.0003 (0.001)	-0.0002 (0.001)		
Fracking intensity				0.001 (0.001)	0.001 (0.001)
Oil and gas revenues (t-1)	0.008 (0.080)	0.008 (0.080)	0.004 (0.084)	0.003 (0.080)	-0.005 (0.086)
Republican legislators as share of state legislators	-0.018*** (0.003)	-0.018*** (0.003)	-0.018*** (0.003)	-0.017*** (0.004)	-0.017*** (0.004)
Republican governor	-0.0003 (0.0004)	-0.0003 (0.0004)	-0.0003 (0.0004)	-0.001 (0.0005)	-0.001 (0.0005)
Log (population)	-0.027*** (0.007)	-0.027*** (0.007)	-0.028*** (0.007)	-0.013 (0.008)	-0.016** (0.008)
Population aged 65 or over as share of total population	-0.017 (0.048)	-0.020 (0.049)	0.006 (0.052)	0.033 (0.061)	0.124* (0.066)
Poverty rate	-0.025** (0.012)	-0.025** (0.012)	-0.025** (0.012)	-0.042*** (0.014)	-0.042*** (0.014)
Oil and gas revenues x Presence of fracking well			0.057 (0.074)		
Oil and gas revenues x Fracking intensity					0.118 (0.084)
Constant	0.405*** (0.086)	0.410*** (0.086)	0.422*** (0.087)	0.215** (0.107)	0.255** (0.107)
State fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	711	706	706	421	421
R^2 with the fixed effects	0.960	0.960	0.960	0.966	0.967
R^2 without the fixed effects	0.577	0.758	0.766	0.719	0.734
F Statistic	220.338***	214.415***	211.589***	203.212***	201.175***

Notes: This table shows regressions of state's tax revenues on state's oil and gas revenues between 2000 and 2015 with presence of fracking well and fracking intensity as moderating variables, and lagged oil and gas revenues as an independent variable. All monetary figures are adjusted to 2010 dollars using the consumer price index from the Bureau of Labor Statistics. Robust standard errors are reported in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

APPENDIX D
ESTIMATES OF THE EFFECTS OF OIL AND GAS BOOMS ON STATE OWN-SOURCE AND TAX REVENUES

	Dependent variable: State own-source revenues as share of state personal income	Dependent variable: State tax collection as share of state personal income
State oil and gas revenues as share of state personal income	47.461 (149.985)	173.089 (171.039)
Oil and gas revenues x value-based tax system	-23.202 (74.991)	-85.999 (85.520)
Republican legislators as share of state legislators	-0.019*** (0.004)	-0.013*** (0.004)
Republican governor	-0.0003 (0.001)	-0.0003 (0.001)
Log (population)	-0.004 (0.008)	-0.002 (0.007)
Population aged 65 or over as share of total population	0.106 (0.070)	0.014 (0.059)
Poverty rate	-0.032* (0.016)	-0.038** (0.015)
Constant	0.111 (0.103)	0.072 (0.096)
State fixed effect	Yes	Yes
Year fixed effect	Yes	Yes
Observations	393	393
R^2 with the fixed effects	0.964	0.966
R^2 without the fixed effects	0.631	0.739
F Statistic	194.589***	202.577***

Notes: This table shows regressions of state's own-source and tax revenues on state's oil and gas revenues between 2000 and 2015 with state's value-based tax system as a moderating variable. Value-based tax system is a dichotomous variable indicating whether a state collects oil and gas taxes/fees based on the market value of total production. The number of observations in the models is reduced as these models only include the states that have oil and gas production. All monetary figures are adjusted to 2010 dollars using the consumer price index from the Bureau of Labor Statistics. Robust standard errors are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01.

APPENDIX E
ESTIMATES OF THE EFFECTS OF OIL AND GAS BOOMS ON RESIDENT'S TAX BURDEN

	Dependent variable: Taxes paid to own state and local taxes per capita				
	Model 1	Model 2	Model 3	Model 4	Model 5
State oil and gas revenues per capita	0.108*** (0.036)	0.108*** (0.036)	0.093*** (0.032)	0.108*** (0.038)	0.092*** (0.034)
Presence of fracking well		139.199** (59.464)	147.563** (59.836)		
Fracking intensity				6.301 (68.411)	-45.617 (64.952)
Republican legislators as share of state legislators	-528.107*** (113.447)	-523.022*** (113.660)	-535.518*** (111.996)	-436.061** (192.616)	-418.291** (183.762)
Republican governor	-5.689 (14.958)	-6.253 (14.981)	-2.890 (15.020)	-18.049 (19.269)	-16.898 (19.282)
Log (population)	-833.046*** (281.830)	-792.980*** (273.944)	-863.990*** (264.220)	-613.903 (398.960)	-696.719* (397.810)
Population aged 65 or over	-17,044*** (2,718)	-16,536*** (2,769)	-13,101*** (2,329)	-15,151*** (4,638)	-8,793** (3,708)
Poverty rate	-1,194*** (409)	-1,199*** (410)	-1,035** (405)	-1,491*** (520)	-1,286** (521)
Oil and gas revenue x Presence of fracking well			0.247*** (0.054)		
Oil and gas revenue x Fracking intensity					0.299*** (0.055)
Constant	13,683*** (3,699)	13,115*** (3,589)	13,891*** (3,480)	10,593** (5,338)	11,312** (5,345)
State fixed effect	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes
Observations	611	611	611	364	364
R^2 with the fixed effects	0.976	0.977	0.978	0.973	0.974
R^2 without the fixed effects	0.557	0.557	0.562	0.604	0.618
F Statistic	335.326***	335.137***	342.630***	227.000***	234.564***

Notes: This table shows regressions of own-state and local taxes paid by state residents on state's oil and gas revenues between 2000 and 2015 with presence of fracking well and fracking intensity as moderating variables. Both the dependent and independent variables are expressed in shares of state personal income. The number of observations in the models is reduced as these models only include the states that have oil and gas production. All monetary figures are adjusted to 2010 dollars using the consumer price index from the Bureau of Labor Statistics. Robust standard errors are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01.

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VITA

Dody Dharma Hutabarat

EDUCATION

PhD	Public Administration University of Illinois at Chicago	2018
M.Sc.	International Finance and Economic Policy University of Glasgow, U.K.	2008
B.A.	Accounting Muhammadiyah Asahan College of Economics, Indonesia	2002
Associate (Diploma III) Budget	State College of Accountancy, Indonesia	1998

PROFESSIONAL EXPERIENCES

Head of Business Process Improvement Section — 2009 - 2013
Directorate General of Treasury, Ministry of Finance, Jakarta, Indonesia

Project Manager — 2011 - 2012
Implementing the Electronic Signature on the Payment Instruction Documents
Directorate General of Treasury, Ministry of Finance, Jakarta, Indonesia

Project Manager — 2011 - 2012
Trial Use of Credit Card Scheme for Government Payment
Directorate of Treasury Transformation, Jakarta, Indonesia

Training Coordinator — 2008 - 2009
Directorate General of Treasury, Ministry of Finance, Jakarta, Indonesia

Supervisor — 2005 - 2007
State Treasury Office, Medan, North Sumatra, Indonesia

Budget Controller — 2003 – 2005
Regional Office of State Budget, Medan, North Sumatra, Indonesia

Treasury Officer — 2001 – 2002
State Treasury Office, Tanjungbalai, North Sumatra, Indonesia

RESEARCH EXPERIENCES

Graduate research assistant 2015 – present
Illinois Department of Revenue

Graduate research assistant Summer 2017
Professor Michael A. Pagano
NLC City Fiscal Condition Project
Department of Public Administration, University of Illinois at Chicago

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PUBLICATIONS FOR GENERAL AUDIENCE

Hutabarat, D. D. (2016). *Understanding Political Behavior in Indonesia*, Commentary, Tempo.
Hutabarat, D. D. (2011). *Electronic Signature: Securing Government Transactions*, Indonesian Treasury Magazine.
Hutabarat, D. D. (2010). *Government Credit Card: An Innovation in Government Payment System*, Indonesian Treasury Magazine.
Hutabarat, D. D. (2009). *Regulation and Supervision towards Financial Sector Stability*, Indonesian Treasury Magazine.

UNIVERSITY SERVICES

PhD Student Representative 2017 - 2018
Dean Student Advisory Committee

Public Administration Student Representative 2017 - 2018
Graduate Student Council, University of Illinois at Chicago

Representative of the University of Illinois at Chicago 2015
The National Student Simulation Competition
The Network of Schools of Public Policy, Affairs and Administration, in Indianapolis, IN

REVIEWER

Senior Editor 2011 – 2013
Indonesian Treasury Magazine

TEACHING EXPERIENCES

Trainer 2010 - 2012
Various trainings with the topic of Cash Forecasting for Central Government Entities in Indonesia

Speaker 2011
Several Cash Management seminars with the topic of "Cash Management under an Integrated State Budget and Treasury System"

Teaching Assistant 2009
State College of Accountancy

HONORS AND AWARDS

Innovation Award 2015 2015
The Minister of Finance, the Republic of Indonesia for innovation in digital signature for government electronic financial transactions

Scholarship award 2015 - 2018
American-Indonesian Cultural and Educational Foundation

Travel Award 2014 - 2016
Graduate Student Council, University of Illinois at Chicago

Travel award 2014 - 2015
Department of Public Administration, University of Illinois at Chicago

Travel Award 2015
NASPAA - National Student Simulation Competition in Indianapolis, IN

Scholarship award 2014 - 2015
Chicago Consular Corps

Scholarship award 2013 - 2018
The Ministry of Finance of the Republic of Indonesia

The British Chevening Award 2007 - 2008
The Foreign Commonwealth Office to pursue a Master degree in the U.K.

Scholarship award 1995 - 1998
The Ministry of Finance of the Republic of Indonesia to pursue an associate degree at the State College of Accountancy, Indonesia

PROFESSIONAL ASSOCIATIONS

The Indonesian Institute of Accountants
American Society for Public Administration
Association for Budgeting and Financial Management
American Economic Association