Lancaster University

Economics Department

PhD thesis

Impact of Oil Boom in Texas

Author:
Jingjing "Stephanie" Cai

Supervisor:
Prof. Dakshina G. De Silva
Dr. Aurelie Slechten

Acknowledgments

I want to thank my outstanding supervisors, Prof. Dakshina G. De Silva and Dr. Aurelie Slechten who have been more than supportive. It is a true privilege to have them be a part of my Ph.D. journey. I would like to thank my parents for they are always behind me no matter what. I want to thank my husband Andrew Lamb who has been with me in the darkest days of my life and always believed in me. I would like to express my sincere appreciation to Lancaster University and Economics Department as their support and help made my time in England really special. Last but not least, I would like to Thank God for leading me to the light and not giving up on me.

Declaration

I hereby declare that except where specific reference is made to the work of others, the contents of this dissertation are original and have not been submitted in whole or in part for consideration for any other degree or qualifications in this, or any other university. Chapter Two and Three were co-authored with my supervisors.

Contents

[1] This paper is published in Energy Economics in 2021

Chapter 1

Introduction

1.1 Motivation and importance of the thesis

Upon the rising of green new energy, the traditional fossil fuel industry is still the main player in the energy industry. The development of oil and gas extracting technology has accelerated fossil fuel production, hence the oil boom in the 21st century. The oil and gas industry not only plays a vital role at the national level but also heavily influences the local economy and public service. The oil boom heavily affects the region where the local economy relies on oil extraction. In the United States, in particular, the production of crude oil has been rising since 2008 and the US became a net oil exporter in 2019. The increase in oil production has drastic impacts on oil production regions such as the biggest oil-producing state - Texas.

Oil industries generate income for the federal government and local governments.

However, the industry is not without its faults. The controversy of the fossil fuel industry comes from its commonly known pollution. The oil and gas industry has been studied at the national level; however, it is essential to examine and understand the effect of the oil boom locally. In the oil rich area, the local economy experiences the most direct impact brought by the oil industry, either environmentally or economically. Also, local governments have autonomy over taxation which influences oil production. Therefore, it is important to understand the impact of the oil boom from an environmental point of view, from a local taxation point of view, and from a local public good provision point of view.

1.2 Format of thesis

This thesis provides an analysis of the local impact of the oil boom in the State of Texas. The analysis takes 3 different perspectives: the local environmental impact and spillover economy effect of existing oil companies; the taxation of the oil industry and its allocation in the education sector; oil boom and education outcome.

There are five chapters. Chapter One is the general introduction which outlines the motivation, format, and limitations of the thesis. Chapter Two examines the effect of the oil boom on the local environment. In Chapter Two, I analyze the impact of oil and gas booms on local environmental quality in school districts in Texas between 2010 and 2014. Specifically, this research assesses whether the activity and employment spillovers generated by oil and gas booms are associated with indirect adverse environmental effects on local communities. Using data from the Toxic Release

Inventory (TRI) and County Business Patterns, the first chapter distinguishes economic activity associated with potential and actual polluters. TRI reporting firms responsible for toxic chemical releases to the environment that exceed TRI limits are identified and treated in this paper as TRI polluters. A potentially polluting firm (or TRI-type firm) is then defined as any firm, regardless of size or reporting requirements, in a NAICS code identified by the TRI. This study firstly investigates whether oil and gas revenue influences the location choices of potentially polluting firms from all sectors covered by the TRI program. In order to find out actual environmental costs, I then estimate the effect of oil and gas revenue on the number and proportion of TRI polluters.

Chapter Three analyzes the effects of the oil boom on local government behavior. This chapter investigates the impact of the oil boom on local taxation and educational expenditure at the tax unit level. Using data from Texas, I evaluate how oil and gas revenue affects the local tax base, local tax revenue, and local tax rates. This study also looks into the impact of oil production on the different sources of revenues; most importantly, the impact of oil abundance on the actual educational operating expenditure and how the additional local revenue is allocated among the different categories of educational expenditure.

Chapter Four evaluates the effects of school choice and the oil boom on education outcomes. Within the public school system, there are two types of public schools in Texas - traditional public schools and charter schools. The former is publicly managed by the school districts and the latter is privately managed. This chapter presents how school choice and oil production influence school performance. Specifically, this chapter first focuses on all charter schools and investigates whether or not whether or not locating in oil-producing districts benefits charter schools. Secondly, the chapter looks into all the schools in oil-rich areas, and examines whether or not charter schools have better outcomes than traditional schools within oil-rich districts. Chapter Five concludes the thesis.

1.3 Limitation of study

The data from Chapter Two and Three are based on school districts in Texas. School district-level data is useful because school districts in Texas have the autonomy to set their own tax regulations and school board policies; however, the limitation of the school district level data is that I am not able to investigate the further impact of the oil boom at an individual level. For the second chapter, the firm-level data would contain how much pollutants each potential and actual polluters releases, and hence that would give a detailed analysis on the environmental costs of the oil extraction. For the fourth chapter, I use school-level data because it includes the characteristics of each school. e.g. number of students, number of teachers, number of economic disadvantage students, etc. However, the limitation of data for Chapter Four is that individual student-level data is not publicly available; student-level data would reveal a detailed analysis of how each student changes when they transfer from one school to another.

1.4 Findings

In Chapter Two where I analyze the environmental effect of the oil boom, I find that the presence of oil and gas resources in a school district has spillover effects in terms of economic activity by attracting more potentially polluting firms. The presence of oil and gas extraction attracts more potentially polluting firms to both metropolitan and rural school districts. Oil abundance also generates an actual environmental burden for school districts located in metropolitan areas as the proportion of firms that actually report a release of toxic chemicals to the TRI increases with oil revenue. This has serious consequences as metropolitan school districts are more densely populated than rural areas.

Chapter Three dives into the impact of oil boom on tax revenue and education expenditures. Results of Chapter Three show that the presence of oil and gas resources enlarges the local tax base. These revenues from the oil industry contribute to higher local education expenditure per student; however, extra oil income contributes to the local tax base with a crowding-out effect on the federal revenue. Additionally, I find out that an increase in oil and gas revenue leads to higher educational expenditure in different categories. Oil revenue contributes the most to instructional expenditure which would benefit the classroom learning environment of students and teachers.

Chapter Four evaluates the impact of the oil abundance with the presence of school choices. The research in Chapter Four reveals that charter schools in oil-rich districts perform better than traditional public schools. The advantage holds even for economically disadvantaged students. In addition, the overall effect of the oil boom is negative, suggesting that schools in oil districts seem to have lower test scores generally. However, within the oil-producing districts, charter schools have an advantage over traditional public schools. Lastly, the estimation results show that traditional public schools are advantageous only in oil-scarce districts.

Chapter 2

Effects of Oil Booms on the Local Environment [1]

2.1 Introduction

New oil and gas drilling brings economic activity to the local communities, but there are substantial concerns about potential impacts on the quality of life of local residents, including pollution, traffic congestion, and crime. In this paper, we contribute to the debate by investigating whether the activity and employment spillovers generated by oil and gas booms are associated with indirect adverse environmental effects on local communities. In most countries, local governments have some degree of autonomy when it comes to the decision to allow new resource extraction activities. With the development of hydraulic fracturing (fracking) technologies and the existence of vast shale deposits around the world, providing a broad picture of

[1] This paper is published in Energy Economics in 2021

the costs associated with these activities is important. It will help local governments design complementary policies that ensure that the local benefits of oil and gas development outweigh any potential cost.

This paper uses school district-level data from the state of Texas for the period 2010-2014. Texas is an ideal setting in which to observe the impacts of oil and gas operations on local environmental quality. This state has experienced an oil and gas boom over the last 10 years due to the development of extracting technology. Annual crude oil production nearly tripled between 2009 and 2015. Texas is the biggest crude oil-producing state and it produces one-third of U.S. crude oil and one-fourth of U.S. natural gas (U.S. EIA, 2015). The Permian Basin in West Texas has become the world's most productive oil field (U.S. EIA, 2019). The Texan economy relies heavily on the oil and gas sector.[2] Further, there are few local environmental restrictions imposed in the state of Texas beyond local zoning laws, and the state itself takes a relatively light hand to regulation in general. Thus, jurisdictions (school districts in our case) in the state are largely subject to a practically identical regulatory environment.

This study makes use of the unique features of the data from the Toxic Release Inventory (TRI) to study the local environmental effects of oil and gas exploitation. The TRI is a mandatory reporting program that requires private and government facilities from a set of industries to report annually how they manage certain toxic chemicals. The chemicals covered by the TRI Program are typically local and are

[2]The value of oil and gas production in Texas represented 13.5% of its GDP in 2014 (*https://businessintexas.com/sites/default/files/txoil.pdf*).

known to have harmful health effects.[3] More importantly, TRI data allow us to distinguish between potential polluters and actual polluters.

Under the TRI Program, only firms in a subset of the North American Industry Classification System (NAICS) that employ at least 10 full-time employees (FTEs) and exceed the Environmental Protection Agency (EPA) threshold limits in terms of their processing or usage of designated hazardous or toxic chemicals are subject to mandatory reporting within the TRI.[4] The firms subject to mandatory reporting are denoted in this paper as TRI reporting firms. TRI reporting firms responsible for toxic chemical releases to the environment that exceed TRI limits are identified and treated in this paper as TRI polluters. A potentially polluting firm (or TRI-type firm) is then defined as any firm, regardless of size or reporting requirements, in a NAICS code identified by the TRI. So, TRI polluters are a subset of TRI reporting firms and TRI reporting firms are a subset of TRI-type (potentially polluting) firms.

Our analysis proceeds in two steps. We first investigate whether oil and gas revenue influences the location choices of potentially polluting firms from all sectors covered by the TRI program. A larger number of TRI-type firms shouldn't necessarily be seen as a negative effect because more potentially polluting firms implies more economic activity and more job opportunities for local residents. However, if this additional economic activity generates toxic chemical releases, then oil booms result in actual environmental costs for the local community. We examine this possibility in the second step of our analysis by estimating the impact of oil and gas revenue

[3] See Currie et al. (2015) or Aizer et al. (2018).

[4] https://www.epa.gov/toxics-release-inventory-tri-program

on the number and proportion of TRI polluters.

To deal with a potential endogeneity between firms' location decisions and oil and gas revenue and accurately estimate the environmental impact of oil abundance, we use an Instrumental Variable (IV) approach. We create an indicator that equals 1 if this school district is in an oil/gas basin county (defined as a county located in any of the Texan oil/gas basins). As the boundaries of Texan counties were defined before the discovery of oil, the location of oil resources does not directly affect our dependent variables.[5] The school district oil and gas revenue is then instrumented by the interaction between our basin dummy and year indicators to allow for temporal variation (as in Feyrer et al., 2017 or Jacobsen, 2019).

To ensure that our results are not driven by the most rural school districts, we estimate our empirical models separately for school districts located in a Metropolitan Statistical Area (MSA) and those located outside MSA boundaries. Our findings suggest that the presence of oil and gas resources attracts more potentially polluting firms to both MSA and non-MSA school districts. We also find that oil abundance generates an actual environmental burden for school districts located in MSAs as the proportion of firms that actually report a release of toxic chemicals to the TRI Program is higher in MSA school districts experiencing an oil boom. This is problematic as MSA school districts are more densely populated than rural areas.

These findings provide new insights into the impact of resource abundance on local amenities by identifying indirect environmental effects at the local level. Papers by

[5]This is similar to the approach used by Michaels (2010), who proxies oil abundance with a dummy variable for whether a county lies on a large existing oilfield.

Bartik et al. (2019), Muehlenbachs et al. (2015), and Jacobsen (2019) study the impacts of the recent fracking booms on various measures of local amenities, including crime, noise, traffic, and housing values. The effects of natural resource abundance on local public goods provision and local finance have also been explored (Caselli and Michaels, 2013; Borges et al., 2015; James, 2015; James, 2017; Marchand and Weber, 2019).

Further, our results contribute to the strand of the literature studying the effects of resource booms on the local economy and local labor markets. Expanded oil and gas exploitation has been shown to create jobs and increase wages (Weber, 2012; Feyrer et al., 2017; Wang, 2018; Allcott and Keniston, 2018; De Silva et al., 2020). This literature has also identified employment spillover effects of oil and gas abundance. However, there is no consensus on the size or on the sectors benefiting from these effects. Some papers document the existence of employment spillover effects in traded goods industries, e.g., manufacturing (Michaels, 2010; Weber, 2014; Allcott and Keniston, 2018), while other studies show that these effects are found only in local sectors, e.g., retail or construction (Black et al., 2005; Marchand, 2012; Brown, 2014). By and large, the potentially polluting activities considered in our paper (and not related to oil and gas extraction) result from industrial activities whose output is not dependent on the local market, i.e., production of tradeables. Our findings therefore provide some evidence supporting the existence of spillover effects in traded goods sectors.

The remainder of the paper is organized as follows. Section 2 describes the data and variables used in the empirical analysis. In Section 3, we evaluate the environmental costs associated with oil and gas booms. Section 4 concludes the study.

2.2 Data

In this section, we describe the data sources, explain the construction of our variables, and provide summary statistics. We use data at the school district level from Texas over a five-year period (2010 to 2014). School districts constitute a good institutional framework to study local environmental impacts of oil booms. They are relatively small areas and closely represent the population that would bear the immediate environmental impact of increased economy activity due to oil abundance. Moreover, a school district (as opposed to a census tract) is an independent government with some fiscal autonomy for the purpose of operating public schools that are situated within that area. In particular, every school district is authorized to set its own property tax and oil and gas companies pay a property tax based on the value of their production. A school district is therefore a small area that might benefit from oil and gas extraction but may also bear the potential environmental costs. During our sample period, there were 1024 school districts in Texas.

2.2.1 Oil and gas production and revenue

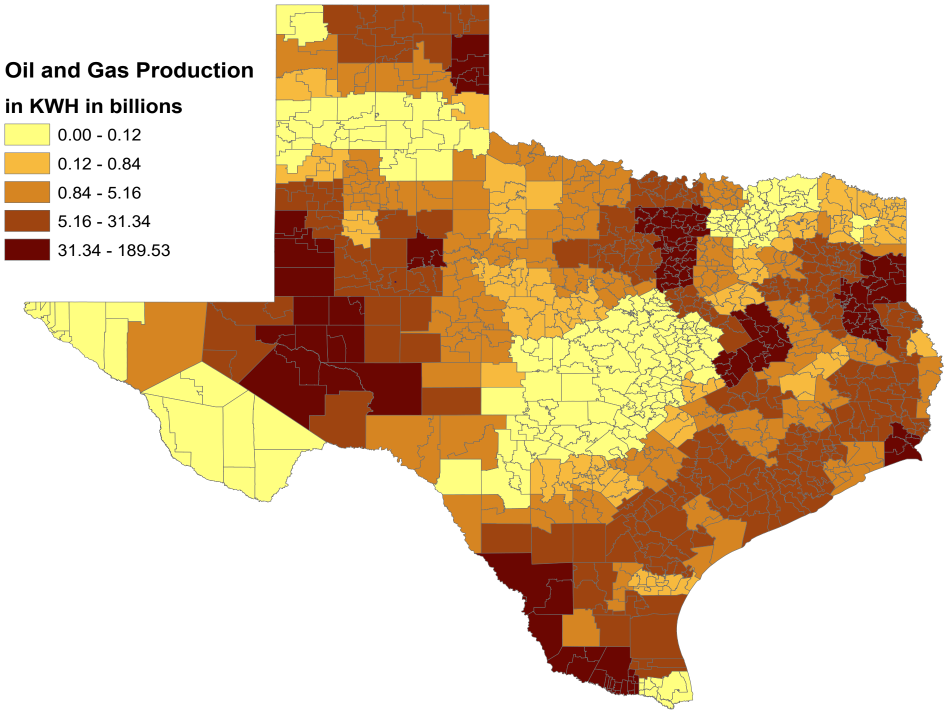
To measure oil abundance at the school district level, we use two alternative explanatory variables: oil and gas production and oil and gas revenue. The data on oil and gas production comes from the Railroad Commission of Texas (RRC). It includes county-level crude oil production in thousands of barrels, condensate oil production in thousands of barrels, gas-well gas production in thousands of cubic feet, and casing-head gas production in thousands of cubic feet. To derive the total level of oil and gas production at the county level, we convert all four types of oil and gas production into kilowatt hours (kWh) and add them up. As our analysis is at the school district level and all school districts are contained within a single county, we level down the county-level production using the proportion of the school district area contained in the county area. Based on the average yearly price of oil in dollars per barrel and gas in dollars per thousand cubic feet (data from U.S. Energy Information Administration), we calculate the revenue generated by oil and gas extraction.

Figure 1 shows school district-level oil and gas production in 2010. The distribution of oil and gas activity in Texas is consistent with the location of the main oil and gas resources. There are four principal zones: the Permian Basin in West Texas, the Eagle Ford shale formation located in the Gulf Coast Basin in South Texas, the Barnett shale formation in North Texas, and the Haynesville/Bossier shale formation in East Texas. For example, the majority of school districts in the Gulf Coast Basin had a production level higher than five billion kWh in 2010 compared to less than 0.12 billion kWh in Central Texas.

2.2.2 Sample generation

The objective of this paper is to compare school districts that have witnessed an oil boom over the sample period with those that have no specialization in oil and gas

Figure 1: **School district-level oil and natural gas production in Texas in 2010**



production. It is, therefore, important to narrow the analysis to school districts that have some degree of similarity. To this end, we restrict our sample in two different ways.

First, we identify the areas that are specialized in oil and gas production. Because the original data of oil and gas production is at the county level, we identify oil (and gas) counties in Texas. If oil and gas revenue at any time is greater than ten percent of a county's total revenue, that county is treated as an "oil county"; otherwise, it is a "non-oil county". Our first restriction on the sample of school districts is based on population and median income in school districts located in oil counties; the former signals the size of a school district and the latter indicates local living standards. Our analysis excludes school districts with a population less than 69 or larger than

164,642 (the smallest and the largest school districts in terms of population in the oil counties), or a median income less than \$15,917 or greater than \$92,917 (the lowest and the highest school district median incomes in the oil counties). This restriction reduces the number of school districts under study from 1024 to 980.

Second, it would not be appropriate to compare the impact of an oil boom between rural and urban school districts as they widely differ in terms of population growth, employment, etc. We, therefore, split our sample into two subsets: school districts located in an MSA and school districts outside MSA boundaries. There are 25 MSAs in Texas, corresponding to 455 school districts in our sample.

Table 1 displays the summary statistics. We provide three categories of data. "Sample SD" refers to our restricted sample of 980 school districts in Texas. "MSA SD" and "non-MSA SD" refer to MSA school districts and non-MSA school districts. For each category, we compare school districts located in oil counties and non-oil counties. The definitions of all the variables are in Table A.1 in the Appendix.

2.2.3 TRI data

Production and transport of coal, natural gas, and oil provide many opportunities for the release of air pollutants (e.g. carbon dioxide, methane...) which may be hazardous to the health of local residents and speed up climate change. Local opposition to fracking has also emerged due to the potential damage from methane leakages or water contamination. However, in this paper, we are interested in the broader environmental impact of oil and gas production. Oil booms bring in more economic activity from other industries which can potentially result in adverse environmental effects on local communities.

To measure this indirect environmental impact of oil booms, we use data from the TRI. The TRI is a U.S. database established by law which requires private and government facilities to report annually how much of certain chemicals is released to the environment or managed through recycling, energy recovery and treatment. It covers a specific subset of NAICS codes and around 600 different toxic chemicals. We believe the data from the TRI Program constitute a good proxy for local environmental quality. First, most chemicals included in the TRI Program have very localized impacts. Using individual level data, Currie et al. (2015) show that the openings or closings of toxic plants (i.e., plants reporting a release to the TRI Program) have an impact on housing prices and birth outcomes within a 1-mile radius of the plant location.

Second, some of these chemicals have been shown to pose a threat to human health and the environment. For example, Currie et al. (2015) show that a reporting plant's operation is associated with a roughly 3 percent increase in the probability of low birth weight within a mile. Working at the county level, Currie and Schmieder (2009) find strong evidence that fetal exposure to most reported TRI-chemicals has a negative effect on health at birth and subsequent infant mortality. Aizer et al. (2018) show that there might also be long-term health effects.[6]

We define three subsets of TRI-related facilities: TRI reporters, TRI polluters and

[6]In particular, they show that one unit decrease in average blood-lead levels (a TRI-listed chemical) reduces the probability of being substantially below proficient in reading.

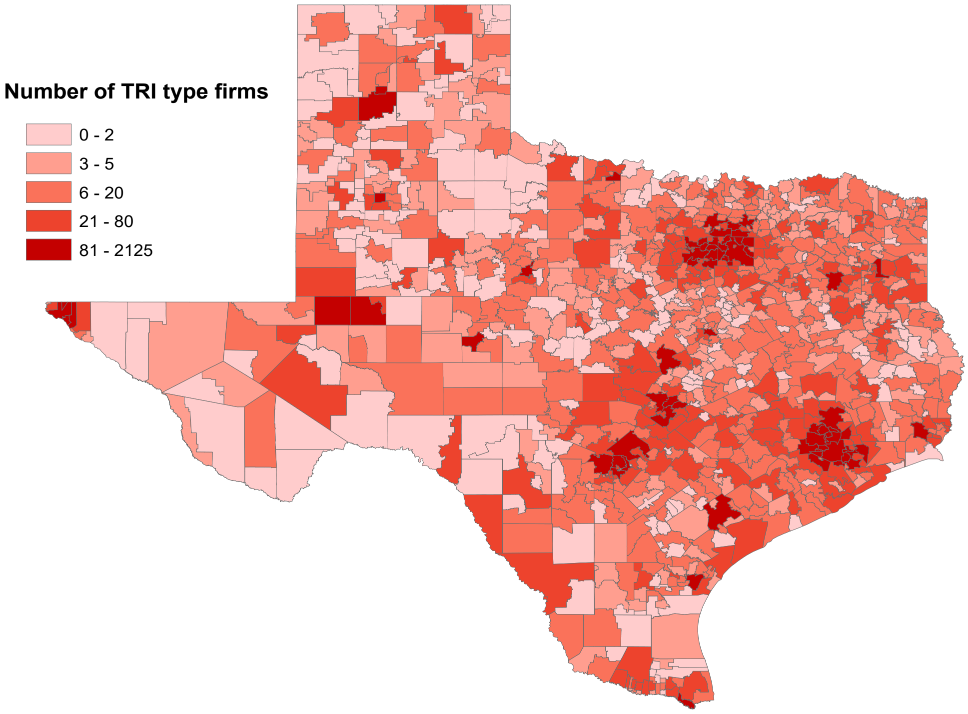
TRI-type firms. The EPCRA (Emergency Planning and Community Right to Know Act) Section 313 requires TRI reports to be filed by owners and operators of facilities that meet all of the following criteria:

- The facility has 10 or more full-time employee equivalents (FTE);
- The facility is included in a given subset of the NAICS. These NAICS codes are at the 6-digit level. This is the most detailed classification one can get; and
- The facility manufactures (defined to include importing), processes, or otherwise uses any EPCRA Section 313 chemical in quantities greater than the established threshold in the course of a calendar year.[7]

Facilities that meet all these requirements are classified as TRI reporters. When these firms exceed the toxic release limits set by the EPA (25,000 toxic pounds), they are considered TRI polluters for the year a release is reported. A facility located in a NAICS code covered by the TRI Program, regardless of whether it meets the other two requirements for mandatory reporting, is denoted as a TRI-type firm. To count the number of TRI-type firms at the school district level, we use data from the County Business Patterns (CBP). CBP data contain the number of establishments in each NAICS code at the county level. We select the establishments located in a NAICS code subject to TRI reporting in each county. This gives us the number of TRI-type firms at the county level, which we level down to the school district using the population distribution. Figure 2 shows the distribution of TRI-type firms in

[7] See https://www.epa.gov/toxics-release-inventory-tri-program for details on on NAICS codes, listed chemicals, and chemical thresholds required for reporting.

Figure 2: **TRI type firms in Texas in 2010**



Texas in 2010. A higher number of TRI-type firms can be observed in the school districts near Dallas and Houston.

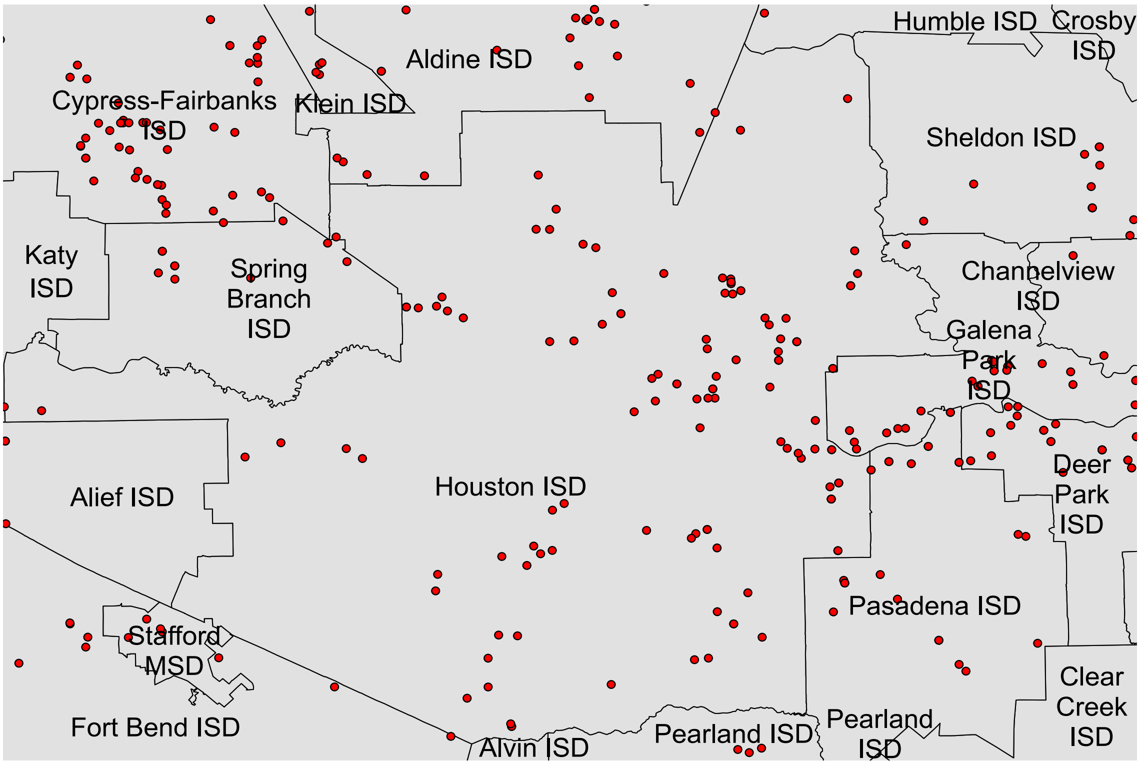
The number of TRI-type firms is an indicator of economic activity associated with potential polluters. We are working at sufficient industry detail (six-digit NAICS codes) that a reasonable level of homogeneity in activity can be assumed. If establishments in a given industry have been identified as having experienced a release via TRI reporting, we assume that other establishments in that same industry have largely similar activities and could potentially experience a similar release. In that respect, the number of TRI-type firms is also a proxy for potential environmental risks (as it affects the likelihood of toxic releases in the school district). A larger number of TRI-type firms in a school district can be seen as a positive effect, as it brings in more economic activity. At the same time, a larger number of potentially polluting firms also implies that the likelihood of toxic releases is higher.

Some oil and gas facilities are included in the TRI Program because they deal with around 25 different TRI-listed chemicals, including hydrogen sulfide, benzene, toluene, ethylbenzene, and xylene.[8] Table A.2 in the Appendix provides a list of oil-based TRI NAICS codes, i.e., NAICS codes covered by the TRI Program and related to oil and gas exploitation. As the focus of our paper is the indirect environmental costs associated with oil abundance, we divide TRI-type firms into two categories. The first category, "oil-based TRI-type firms", refers to TRI-type firms that extract oil and gas or produce oil- and gas-related products (NAICS codes listed in Table A.2). The second category, "non-oil-based TRI-type firms," covers the remaining TRI-type firms that do not relate to the oil and gas industry. This classification allows us to analyze whether the presence of oil resources attracts firms from other potentially polluting industries. The average number of TRI-type firms in non-oil counties is higher than in oil counties (see Table 1). The difference is the largest in MSA school districts: an average of 62 TRI-type firms in non-oil counties compared to 20 in oil counties.

The number of TRI-type firms is related to potential pollution. To obtain a measure of the actual environmental cost, we use the number of TRI polluters and the proportion of TRI polluters to TRI-type firms. As TRI data provide the address of reporting facilities, we can easily compute the number of TRI polluters at the school district level. Over our sample period, MSA school districts have, on average, more

[8] https://www.reginfo.gov/public/do/eAgendaViewRule?pubId=201610& RIN=2070-AK16.

Figure 3: **TRI polluters in Houston Independent School District in 2010**



TRI polluters than non-MSA school districts. Figure 3 shows the distribution of the 114 TRI polluters in the Houston Independent School District in 2010. This is the largest number of TRI polluters at the school district level in our sample.

2.2.4 Other controls

The literature on firm location decisions postulates that, in a profit maximization framework, a firm considering the location of a new plant will choose the area with attributes that allow this plant to operate at the lowest cost (Keller and Levinson, 2002; De Silva et al., 2016). Therefore, in our analysis of the environmental cost induced by an oil boom, we include a set of input factors at the school district level that may affect firm location decisions: unemployment rates and population to capture labor availability, median income to account for living conditions, house rental ratio to explain house-occupying status, transportation costs (such as the number of roads and railways), and the size of the school district to measure land availability. To incorporate insights from the environmental justice literature, we also include the non-white ratio, defined as the proportion of non-white residents in the school district.

School district-level data comes from the American Community Survey (ACS), except for the information regarding number of roads and railways that are computed using the U.S. Census Bureau's Census Feature Class Codes (CFCC) and ESRI Data & Maps (2000). The ACS is a series of survey databases including detailed demographic and economic information at the school district level. The highest median income is in MSA school districts within non-oil counties, with an average of \$55,100 (see Table 1). The highest non-white ratio (18 percent) is also observed in these school districts. Finally, we control for other businesses that are not covered by the TRI Program to account for local amenities. From CPB data, we obtain the number of all businesses at the school district level. We then deduct the number of TRI-type firms from the total number of businesses to compute the number of other businesses.

2.2.5 Identification Strategy and Instrument

The number of potentially polluting firms and oil and gas production/revenue can evolve simultaneously because of unobserved geographical characteristics or because companies from both oil/gas and other industries respond to policies implemented by local governments. To deal with this issue and accurately estimate the impact of oil and gas production on local environmental quality, we use an Instrumental Variable (IV) approach.

One approach to address the endogeneity of resource booms is to classify counties based on geological characteristics such as reserves of oil and gas (Michaels, 2010). We identify the major oil and gas basins in Texas, i.e., the Permian Basin in West Texas, the Eagle Ford shale formation in South Texas, the Barnett shale formation in North Texas, and the Haynesville/Bossier shale formation in East Texas. Counties located in any part of one of these basins are basin counties whereas the others are non-basin counties. We then create an indicator, D_i, that equals 1 if this school district is in an oil/gas basin county.

The school district oil and gas production/revenue is instrumented by the interaction between D_i and year indicators. The year indicator variable within the interaction allows us to capture the timing of the booms or changes in the world oil and gas prices (James, 2017; Feyrer et al., 2017).

Due to the uneven distribution of oil and gas resources in Texas, there is enough variation between school districts to identify the local effect of oil and gas production/revenue. Moreover, the location of the oil resources in Texas does not directly affect our dependent variables and vice-versa because the boundaries of Texan counties were defined before the discovery of oil and, thus, are not based on the presence of oil resources. The only possible indirect impact of oil and gas basins on these dependent variables must be through current oil and gas extraction.

2.3 Empirical analysis

2.3.1 Economic Activity and Environmental risk

To examine the impact of an oil boom on local economic activity associated with potential polluters, we estimate an empirical model that takes the following form:

$$y_{it} = \beta \ log \ p_{it} + s_{it}'\gamma + z_i'\delta + \tau_t + \varepsilon_{it} \tag{2.1}$$

Our dependent variable (y) is the log of the number of TRI-type firms, oil-based TRI-type firms, or non-oil TRI-type firms in a given school district i in a given year t. The explanatory variables can be divided into four groups: school district-level oil and gas production or oil and gas revenue (p, instrumented by the interaction between D_i and year indicators); school district-level characteristics (s) that vary with time, such as median income and population; time-invariant school district attributes (z) such as number of roads; and year effects (τ). The last term ε_{it} is an error term.

We estimate this model using two different approaches. The first approach is a linear IV regression specification. Estimation results are presented in Table 2 and Table 4 for MSA and non-MSA school districts, respectively. However, our dependent variables are left-censored. In this case, a linear model may provide inconsistent estimates of the parameters. It will also predict values of the dependent variables below zero. Therefore, we estimate equation (2.1) using a censored IV specification.

Estimation results are presented in Table 3 and Table 5 for MSA and non-MSA school districts, respectively.

For both specifications, oil and gas operations have a significant and positive effect on the number of TRI-type firms in MSA and non-MSA school districts. A higher level of oil and gas production or revenue attracts more potential polluters. Not surprisingly, in all cases, the effect of oil and gas production or revenue is larger for TRI-type firms in TRI NAICS codes related to the oil and gas industry. The effect on the number of non-oil TRI-type firms is still positive in all specifications for both MSA and non-MSA school districts. However, the effect is statistically significant for MSA school districts only (in the censored IV regression). This suggests the existence of spillover effects in terms of economic activity. The fact that this effect is present in MSA school districts only might be due to the attractiveness (in terms of infrastructure, proximity to consumers, etc.) of these areas compared to remote rural neighborhoods in non-MSA school districts.

In MSA and non-MSA school districts, the presence of other businesses is positively associated with the number of TRI-type firms (oil-based or not). This is also the case for median income, except for oil-based TRI-type firms in MSA school districts. The percentage of non-white residents has a positive correlation with the number of TRI-type firms in MSA school districts only. This is consistent with the environmental justice literature (De Silva et al., 2016). Finally, a larger number of roads in a school district attracts more potential polluters.

Note that, in Table 2 and Table 4 (linear IV specification), all our models pass the Weak-identification test (F-test reported in the tables). In Table 3 and Table 5 (censored IV specification), we report the p-value for the Hausman test. For all TRI-type and oil-based TRI firms (columns 1, 2, 4, and 5), we can reject the null hypothesis that both censored and IV censored regressions produce consistent results. The Hausman test of columns 3 and 6 (non-oil TRI-type firms) shows that IV and non-IV regressions yield similar results.

As a robustness check, we also estimate equation (2.1) using the Poisson Quasi-Maximum Likelihood (PQML) method with year fixed effects, which allows us to account for the count structure of our data. Note that in this case, our dependent variable is the number of TRI-type firms, oil-based TRI-type firms, or non-oil TRI-type firms in a given school district i in a given year t. Compared to the standard Poisson estimation, the PQML estimation does not assume that the data are distributed with the mean equal to the variance of the event count. The data need not even come from a Poisson process and may be either under or over-dispersed. It requires only that the conditional mean function is correctly specified. As shown in Table 6, the IV Poisson regression results are very similar to the results of the Censored IV specification (Tables 3 and 5).[9]

Given these findings, one could question whether our results are driven by school district-level infrastructure and other demographic characteristics. Hence, we estimate a parsimonious empirical model controlling only for number of other businesses

[9]One advantage of the PQML estimator is that it allows for fixed effects (unlike censored regressions). However, given that we have a short sample period (5 years) and the within variation for most variables is relatively small, taking school district and time fixed effects eliminates all the variation. For example, on average, the mean of the number of TRI-type firms in an MSA school district is 27 with a standard deviation of 1. For non-MSA school districts, the mean of the number of TRI-type firms is 8, on average, with a standard deviation less than 1.

and year effects. We use the number of other businesses to control for the size/scale of the school district. We present the linear IV regression results in Tables A.3 (for MSAs) and A.4 (for non-MSAs) and the IV Poisson regression results in Table A.5. The interpretation of the findings in these tables is qualitatively the same as for the results we discussed in Tables 2, 4 and 6.[10]

2.3.2 Actual Environmental Costs

As shown in the previous section, oil abundance increases economic activity associated with potential polluters. The next question is whether the higher potential environmental risk resulting from this activity leads to a higher actual environmental cost. To investigate this question, we estimate equation (2.1), where y_{it} is either the number of TRI polluters or the proportion of TRI polluters (defined as the number of TRI polluters divided by the number of TRI-type firms).[11] The number of school districts that have TRI polluters is a small fraction of all school districts: over 50 percent of MSA school districts and over 75 percent of non-MSA school districts do not have TRI polluters. The average proportion of TRI polluters in MSA school districts is 0.08 compared to 0.05 in non-MSA school districts.

As in the previous section, when the dependent variable y_{it} in equation (2.1) is the number of TRI polluters, we use three empirical approaches: a linear IV specification, a censored IV specification and an IV Poisson specification. When the

[10] We also estimate these specifications using a censored IV regression technique. The results are qualitatively similar to what we observe in Tables 3 and 5. In the interest of brevity, we don't report those results, but we can provide them upon request.

[11] The results for production and revenue are very similar. This is why, in this section, we focus only on oil and gas revenue.

dependent variable y_{it} is the proportion of TRI polluters, we use a Wooldridge's two-step probit model (Wooldridge, 2010). The results in Table 7 indicate that oil and gas revenue has an impact on the total number of TRI polluters and the proportion of TRI polluters in MSA school districts only.[12]

Beyond these observations of interest to us, we see that the median income and the non-white ratio have a positive effect on the number and proportion of TRI polluters. The number of other businesses has a positive impact on the number of TRI polluters, but a negative effect on the proportion of TRI polluters. The number of rail roads positively affects the number and proportion of TRI polluters, while the number of roads matters only for the number of TRI polluters. As before, we estimate a parsimonious empirical model controlling only for number of other businesses and year effects. We present these IV regression results in Table A.6.

The coefficients presented for the censored regressions in Table 3 (all columns) and Table 7 (columns 3 and 4) are the average marginal effects. For an average school district in an MSA, a 1% increase in oil and gas revenue implies an increase in the number of TRI-type firms (non-oil related) of 0.012% (see column 3 in Table 3) and an increase in the number of TRI polluters of 0.016% (see column 3 in Table 7). Over our sample period, oil and gas revenue in those school districts has increased by 41%. The average MSA school district had 25 TRI-type firms and 2.35 TRI polluters in 2010. As a result, the oil and gas boom in Texas has attracted 0.123

[12] In columns 1 and 2 (linear specification), we show that both models pass the weak-identification test. In columns 3 and 4, we report the Hausman test and show that we cannot reject the null hypothesis of no endogeneity. For the fractional probit, we use the Chi-square Wald test of exogeneity. We can reject the null hypothesis of no endogeneity in column 8, but not in column 7 (note that the test statistic in column 7 is very close to the critical value).

new TRI-type firms (non-oil related) in the average MSA school district between 2010 and 2014. It has also increased the number of firms reporting a release to the TRI by 0.0154. Even though the magnitude of those effects seems small, we have to bear in mind that school districts are relatively small areas (especially in MSAs) and even one additional TRI polluter might generate adverse environmental effects. The literature has indeed shown that the TRI-listed chemicals have serious effects on human health (Currie et al., 2015; Currie and Schmieder, 2009).

This suggests that, even though oil booms in Texan counties brought in more economic activity, they also resulted in a degradation of local environmental quality (measured as an increase in reported toxic releases) in MSA school districts. This last result raises some environmental justice concerns (Hamilton, 1995; De Silva et al., 2016) because MSAs seem to bear more environmental costs than non-MSAs and they are more densely populated areas. Any chemical release from these additional polluting firms would adversely affect a larger number of people than in rural areas.

2.4 Conclusion

In this paper, we analyze the impact of oil booms on local environmental quality using school district-level data from Texas between 2010 and 2014. Because school districts are relatively small areas, they constitute a good proxy for the locality adjacent to any potentially polluting firm located in the school district. To deal with the potential endogeneity between our dependent variables and oil and gas production, we use an IV approach in which school district oil and gas revenue is instrumented by the interaction of an indicator that equals 1 if this school district is in an oil basin county and an indicator of year.

We show that an increase in oil and gas revenue attracts more potentially polluting firms from various sectors covered by the TRI Program (i.e., firms that use toxic chemicals, but not necessarily report releases). While this might be seen as a positive impact in terms of economic activity, we also find that the proportion of firms that actually report a release is higher in school districts experiencing an oil boom. This negative environmental effect is stronger in MSA school districts, which are also more densely populated.

The pollutants covered by the TRI Program are toxic chemicals that pose a serious threat to human health and the environment. Our analysis, therefore, suggests that encouraging oil and gas exploitation might lead to substantial local environmental degradation. Given the recent oil discoveries in the US Gulf of Mexico and the existence of important shale deposits around the world, the issue of the local impacts of oil abundance is politically relevant. If the attainment of greater environmental quality is a policy goal, serious thought should then be given to complementary environmental regulations or to new regulations on compensation schemes designed to offset the costs of a higher environmental burden.

Bibliography

[1] Allcott, H., and Keniston, D. (2018). Dutch Disease or Agglomeration? The Local Economic Effects of Natural Resource Booms in Modern America. *The Review of Economic Studies*, 85 (2): 695-731.

[2] Aizer, A., Currie, J., Simon, P., and Vivier, P. (2018). Do Low Levels of Blood Lead Reduce Children's Future Test Scores? *American Economic Journal: Applied Economics*, 10(1): 307-41.

[3] Bartik, A. W., Currie, J., Greenstone, M., and Knittel, C. R. (2019). The local economic and welfare consequences of hydraulic fracturing. *American Economic Journal: Applied Economics*, 11(4): 105-55.

[4] Black, D., McKinnish, T., and Sanders, S. (2005). The economic impact of the coal boom and bust. *The Economic Journal*, 115(503): 449-476.

[5] Borge, L., Parmer, P., and Torvik, R. (2015). Local natural resource curse?. *Journal of Public Economics*, 131: 101-114.

[6] Brown, J. P. (2014). Production of natural gas from shale in local economies: A resource blessing or curse? *Economic Review*, Federal Reserve Bank of Kansas

City, 1-29.

[7] Caselli, F., and Michaels, G. (2013). Do Oil Windfalls Improve Living Standards? Evidence from Brazil. *American Economic Journal: Applied Economics*, 5(1): 208-238.

[8] Currie, J., and Schmieder, J. F. (2009). Fetal exposures to toxic releases and infant health. *American Economic Review*, 99(2): 177-83.

[9] Currie, J., Davis, L., Greenstone, M., and Walker, R. (2015). Environmental health risks and housing values: evidence from 1,600 toxic plant openings and closings. *American Economic Review*, 105(2): 678-709.

[10] De Silva, D.G., Hubbard,T.P., and Schiller, A.R. (2016). Entry and Exit Patterns of "Toxic" Firms, *American Journal of Agricultural Economics*, 98(3): 881-909.

[11] De Silva, D.G., McComb, R.P., and Schiller, A.R. (2020). Do localities benefit from natural resource extraction.*Energy Journal*, 41(5): 185-211.

[12] EPA (2011). Toxic Chemical Release Inventory Reporting Forms and Instructions. *Revised 2011 Version.* EPA 260-R-10-001.

[13] Feyrer, J., Mansur, E. T., and Sacerdote, B. (2017). Geographic dispersion of economic shocks: Evidence from the fracking revolution. *American Economic Review*, 107(4): 1313-34.

[14] Hamilton, J.T. (1995). Testing for Environmental Racism: Prejudice, Profits, Political Power? *Journal of Policy Analysis and Management*, 14: 107-132.

[15] Jacobsen, G. D. (2019). Who wins in an energy boom? Evidence from wage rates and housing. *Economic Inquiry*, 57(1): 9-32.

[16] James, A. (2015). US state fiscal policy and natural resources. *American Economic Journal: Economic Policy*, 7(3):238-57.

[17] James, A. (2017). Natural resources and education outcomes in the United States. *Resource and Energy Economics*, 49: 150-164.

[18] Keller, W., and Levinson A. (2002). Pollution Abatement Costs and Foreign Direct Investment Inflows to U.S. States. *Review of Economics and Statistics*, 84: 691-703.

[19] Marchand, J. (2012). Local labor market impacts of energy boom-bust-boom in Western Canada. *Journal of Urban Economics*, 71(1): 165-174.

[20] Marchand, J., and Weber, J. (2019). The Local Effects of the Texas Shale Boom on Schools, Students, and Teachers. *Working Paper No. 2017-12*.

[21] Michaels, G. (2010). The long term consequences of resource-based specialisation. *The Economic Journal*, 121(551): 31-57.

[22] Muehlenbachs, L., Spiller, E., and Timmins, C. (2015). The housing market impacts of shale gas development. *American Economic Review*, 105(12): 3633-59.

[23] U.S. EIA, (2015). Texas Profile State Profile and Energy Estimates (https://www.eia.gov/state/?sid=TX).

[24] U.S. EIA, (2019). Drilling Productivity Report (https://www.eia.gov/petroleum/drilling/pdf/dpr-full.pdf).

[25] Weber, J. G. (2012). The effects of a natural gas boom on employment and income in Colorado, Texas, and Wyoming. *Energy Economics*, 34(5): 1580-158.

[26] Weber, J. G. (2014). A decade of natural gas development: the makings of a resource curse. *Resource and Energy Economics*, 37: 168-183.

[27] Wang, H. (2018). An Economic Impact Analysis of Oil and Natural Gas Development in the Permian Basin. *Working Paper*.

[28] Wooldridge, J.,M. (2010). Econometric Analysis of Cross Section and Panel Data. The MIT Press.

Table 1: School district level summary statistics

Variable	School District					
	Sample		MSA		Non-MSA	
	Oil	Non oil	Oil	Non oil	Oil	Non oil
Number of Schools	3.43	6.42	5.10	14.51	2.93	3.31
Population[a]	6.52	17.66	11.98	51.92	4.92	6.46
Number of Students[a]	1.28	3.46	2.53	9.95	0.92	1.16
University Ratio	0.12	0.14	0.12	0.16	0.12	0.13
Oil and gas revenue[b]	2.45	0.18	2.11	0.25	2.58	0.09
Oil and gas production[c]	8.10	0.88	8.31	1.32	8.16	0.42
Income[d]	4.51	4.87	4.88	5.51	4.40	4.30
Number of TRI type firms	10.93	20.94	19.94	62.32	8.15	9.20
Number of oil TRI firms	3.28	2.29	6.15	5.65	2.38	1.17
Number of non oil TRI firms	7.66	18.65	13.79	56.66	5.77	8.03
Number of TRI polluters	0.73	1.97	1.24	4.09	0.57	0.82
Number of other businesses	123.91	338.38	234.20	1,055.22	91.41	121.95
Nonwhite ratio	0.14	0.14	0.13	0.18	0.14	0.11
Unemployment rate	0.07	0.07	0.07	0.07	0.06	0.07
Number of rail roads	7.08	12.87	11.52	25.72	5.75	8.04
Number of roads	18.75	20.90	21.77	26.94	17.86	18.39
Area (in Km^2)	949.84	551.51	654.60	366.62	1,046.74	804.87
House rental ratio	0.24	0.25	0.24	0.26	0.24	0.24

[a] in 1,000, [b] in \$100 million, [c] in billions of KwH, and [d] in \$10,000.

Table 2: IV Regression results for TRI-type firms in MSA school districts

Variable	Log of TRI-type firms					
	All TRI	Oil TRI	Non oil TRI	All TRI	Oil TRI	Non oil TRI
	(1)	(2)	(3)	(4)	(5)	(6)
Log of oil and gas revenue	0.028***	0.055***	0.014			
	(0.009)	(0.018)	(0.009)			
Log of oil and gas production				0.022***	0.043***	0.011
				(0.007)	(0.014)	(0.007)
Log of income	0.270***	-0.082	0.384***	0.278***	-0.066	0.388***
	(0.081)	(0.120)	(0.086)	(0.080)	(0.118)	(0.085)
Log of population	0.184	-0.734***	0.337**	0.181	-0.740***	0.336**
	(0.151)	(0.177)	(0.149)	(0.151)	(0.176)	(0.149)
Log of number of other businesses	0.649***	1.040***	0.545***	0.651***	1.044***	0.546***
	(0.149)	(0.177)	(0.146)	(0.149)	(0.177)	(0.146)
Non white ratio	0.455***	0.434*	0.452***	0.463***	0.451*	0.456***
	(0.124)	(0.257)	(0.135)	(0.124)	(0.254)	(0.135)
Unemployment rate	-0.934*	-3.046***	-0.263	-0.919*	-3.017***	-0.256
	(0.498)	(0.970)	(0.564)	(0.492)	(0.962)	(0.561)
Log number of rail roads	-0.002	-0.013	0.003	-0.003	-0.014	0.003
	(0.012)	(0.024)	(0.013)	(0.012)	(0.024)	(0.013)
Log number of roads	0.041**	0.065**	0.019	0.043**	0.069**	0.020
	(0.018)	(0.033)	(0.020)	(0.018)	(0.033)	(0.020)
Log of land area	0.016	0.039	0.020	0.023	0.052	0.023
	(0.022)	(0.038)	(0.023)	(0.022)	(0.036)	(0.023)
House rental ratio	0.110	0.397	0.317	0.116	0.408	0.320
	(0.261)	(0.259)	(0.299)	(0.261)	(0.259)	(0.299)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,227	2,227	2,227	2,227	2,227	2,227
R^2	0.941	0.500	0.933	0.941	0.500	0.933
Weak identification F - test	26.43	26.43	26.43	31.09	31.09	31.09

Stock-Yogo weak ID test critical values: 10% maximal IV size 16.38.

Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Censored IV regression results for TRI-type firms in MSA school districts

Variable	Log of TRI-type firms					
	All TRI	Oil TRI	Non oil TRI	All TRI	Oil TRI	Non oil TRI
	(1)	(2)	(3)	(4)	(5)	(6)
Log of oil and gas revenue	0.027***	0.049***	0.012**			
	(0.005)	(0.007)	(0.006)			
Log of oil and gas production				0.021***	0.038***	0.010**
				(0.004)	(0.006)	(0.004)
Log of income	0.262***	-0.003	0.321***	0.269***	0.008	0.325***
	(0.030)	(0.045)	(0.033)	(0.030)	(0.045)	(0.033)
Log of population	0.178***	-0.586***	0.361***	0.176***	-0.590***	0.360***
	(0.028)	(0.041)	(0.031)	(0.028)	(0.041)	(0.030)
Log of number of other businesses	0.629***	0.836***	0.503***	0.630***	0.837***	0.504***
	(0.027)	(0.039)	(0.029)	(0.027)	(0.039)	(0.029)
Non white ratio	0.440***	0.309***	0.397***	0.449***	0.323***	0.401***
	(0.066)	(0.095)	(0.072)	(0.066)	(0.095)	(0.072)
Unemployment rate	-0.904***	-1.925***	-0.255	-0.890***	-1.907***	-0.249
	(0.249)	(0.372)	(0.276)	(0.248)	(0.373)	(0.275)
Log number of rail roads	-0.002	-0.016*	-0.007	-0.002	-0.017**	-0.007
	(0.006)	(0.008)	(0.006)	(0.006)	(0.008)	(0.006)
Log number of roads	0.040***	0.053***	0.027***	0.042***	0.056***	0.028***
	(0.009)	(0.013)	(0.009)	(0.009)	(0.013)	(0.009)
Log of land area	0.016*	0.009	0.017*	0.022***	0.021*	0.020**
	(0.008)	(0.012)	(0.009)	(0.008)	(0.012)	(0.009)
House rental ratio	0.106	0.144	0.190***	0.112*	0.154	0.192***
	(0.066)	(0.099)	(0.073)	(0.066)	(0.100)	(0.073)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,227	2,227	2,227	2,227	2,227	2,227
Log likelihood	-593.851	-2,010.388	-834.101	-598.412	-2,024.923	-834.403
Hausman Test	0.016	0.006	0.413	0.024	0.007	0.417
Left-censored observations	0	252	80	0	252	80

Robust standard errors are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4: IV Regression results for TRI-type firms in non-MSA school districts

Variable	Log of TRI-type firms					
	All TRI	Oil TRI	Non oil TRI	All TRI	Oil TRI	Non oil TRI
	(1)	(2)	(3)	(4)	(5)	(6)
Log of oil and gas revenue	0.022***	0.052***	0.004			
	(0.007)	(0.009)	(0.008)			
Log of oil and gas production				0.018***	0.043***	0.003
				(0.006)	(0.007)	(0.006)
Log of income	0.291***	0.164*	0.260***	0.300***	0.186*	0.262***
	(0.093)	(0.099)	(0.100)	(0.092)	(0.098)	(0.100)
Log of population	0.018	-0.293***	0.135	0.017	-0.295***	0.134
	(0.089)	(0.087)	(0.091)	(0.089)	(0.087)	(0.091)
Log of number of other businesses	0.774***	0.540***	0.665***	0.774***	0.540***	0.665***
	(0.093)	(0.091)	(0.095)	(0.093)	(0.092)	(0.095)
Non white ratio	-0.156	-0.466*	0.001	-0.121	-0.382	0.006
	(0.197)	(0.269)	(0.218)	(0.190)	(0.263)	(0.212)
Unemployment rate	-0.143	-0.427	-0.208	-0.154	-0.453	-0.210
	(0.414)	(0.519)	(0.448)	(0.413)	(0.518)	(0.448)
Log number of rail roads	0.000	-0.014	0.017	-0.001	-0.016	0.017
	(0.015)	(0.026)	(0.016)	(0.015)	(0.026)	(0.016)
Log number of roads	0.056**	0.021	0.061**	0.056***	0.022	0.061**
	(0.022)	(0.030)	(0.025)	(0.022)	(0.030)	(0.025)
Log of land area	-0.043**	0.074**	-0.028	-0.040*	0.083**	-0.027
	(0.021)	(0.033)	(0.023)	(0.021)	(0.033)	(0.023)
House rental ratio	0.471**	0.689***	0.665***	0.471**	0.689***	0.665***
	(0.210)	(0.227)	(0.235)	(0.210)	(0.229)	(0.234)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,629	2,629	2,629	2,629	2,629	2,629
R^2	0.864	0.308	0.847	0.864	0.302	0.847
Weak identification F - test	68.69	68.69	68.69	72.25	72.25	72.25

Stock-Yogo weak ID test critical values: 10% maximal IV size 16.38.

Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Censored IV regression results for TRI-type firms in non-MSA school districts

Variable	Log of TRI-type firms					
	All TRI	Oil TRI	Non oil TRI	All TRI	Oil TRI	Non oil TRI
	(1)	(2)	(3)	(4)	(5)	(6)
Log of oil and gas revenue	0.020***	0.039***	0.002			
	(0.003)	(0.003)	(0.003)			
Log of oil and gas production				0.017***	0.032***	0.001
				(0.003)	(0.003)	(0.003)
Log of income	0.219***	0.176***	0.151***	0.228***	0.191***	0.151***
	(0.036)	(0.041)	(0.037)	(0.035)	(0.041)	(0.037)
Log of population	-0.056**	-0.241***	0.093***	-0.057**	-0.246***	0.093***
	(0.026)	(0.030)	(0.027)	(0.026)	(0.030)	(0.027)
Log of number of other businesses	0.815***	0.435***	0.687***	0.816***	0.437***	0.687***
	(0.026)	(0.030)	(0.027)	(0.026)	(0.030)	(0.027)
Non white ratio	-0.101	-0.192*	0.013	-0.068	-0.128	0.015
	(0.094)	(0.105)	(0.097)	(0.092)	(0.102)	(0.095)
Unemployment rate	-0.085	-0.217	-0.245	-0.095	-0.236	-0.247
	(0.203)	(0.231)	(0.213)	(0.203)	(0.232)	(0.213)
Log number of rail roads	0.001	-0.013*	0.003	0.000	-0.014*	0.003
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
Log number of roads	0.042***	0.012	0.036***	0.043***	0.012	0.036***
	(0.009)	(0.011)	(0.010)	(0.009)	(0.011)	(0.010)
Log of land area	-0.044***	-0.008	-0.012	-0.041***	-0.000	-0.012
	(0.009)	(0.010)	(0.009)	(0.008)	(0.010)	(0.009)
House rental ratio	0.287***	0.345***	0.249***	0.287***	0.341***	0.250***
	(0.082)	(0.095)	(0.091)	(0.083)	(0.095)	(0.091)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,629	2,629	2,629	2,629	2,629	2,629
Log likelihood	-1,093.696	-2,263.696	-1,301.546	-1,094.315	-2,279.457	-1304.508
Hausman Test	0.016	0.006	0.413	0.024	0.007	0.417
Left-censored observations	15	553	195	15	553	195

Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 6: IV Poisson regression results for TRI-type firms in school districts

Variable	Number of TRI-type firms					
	All TRI	Oil TRI	Non oil TRI	All TRI	Oil TRI	Non oil TRI
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: School districts in MSAs						
Log of oil and gas revenue	0.025***	0.088***	0.015***			
	(0.003)	(0.013)	(0.003)			
Log of oil and gas production				0.020***	0.073***	0.012***
				(0.003)	(0.012)	(0.003)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,227	2,227	2,227	2,227	2,227	2,227
Panel B: School districts in non-MSAs						
Log of oil and gas revenue	0.019***	0.280***	-0.006			
	(0.004)	(0.064)	(0.004)			
Log of oil and gas production				0.015***	0.231***	-0.005
				(0.003)	(0.055)	(0.003)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,629	2,629	2,629	2,629	2,629	2,629

Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

All regressions include log of income, log of population, log of number of other businesses, non white ratio, unemployment rate, log number of rail roads, log number of roads, log of land area, and house rental ratio.

Table 7: Regression results for TRI polluters

Variable	Log of TRI-polluting firms				TRI-polluting firms		Proportion of TRI-polluting firms	
	IV		Censored-IV		IV-Poisson		Fractional Response IV Probit	
	MSA	Non-MSA	MSA	Non-MSA	MSA	Non-MSA	MSA	Non-MSA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log of oil and gas revenue	0.033*	0.007	0.016*	-0.002	0.085***	-0.013	0.045***	-0.002
	(0.019)	(0.007)	(0.008)	(0.004)	(0.028)	(0.014)	(0.015)	(0.010)
Log of income	0.422***	0.227***	0.342***	0.240***	1.630***	1.713***	0.295***	0.446***
	(0.126)	(0.066)	(0.053)	(0.039)	(0.204)	(0.241)	(0.112)	(0.129)
Log of population	0.027	0.008	0.020	0.037	-0.254*	0.281**	0.172*	0.267***
	(0.114)	(0.044)	(0.047)	(0.028)	(0.149)	(0.133)	(0.091)	(0.071)
Log of number of other businesses	0.079	0.103**	0.115**	0.082***	0.513***	0.455***	-0.319***	-0.209***
	(0.106)	(0.046)	(0.045)	(0.028)	(0.141)	(0.148)	(0.083)	(0.071)
Non white ratio	1.246***	0.151	1.002***	0.275***	2.122***	2.370***	1.091***	0.995***
	(0.330)	(0.214)	(0.100)	(0.071)	(0.221)	(0.549)	(0.192)	(0.301)
Unemployment rate	-1.084	-0.196	-0.829*	-0.317	4.391**	-1.602	-2.137**	-1.124
	(0.891)	(0.328)	(0.450)	(0.229)	(1.724)	(1.292)	(0.910)	(0.801)
Log number of rail roads	0.275***	0.144***	0.180***	0.072***	0.629***	0.471***	0.332***	0.279***
	(0.033)	(0.022)	(0.009)	(0.005)	(0.041)	(0.034)	(0.021)	(0.026)
Log number of roads	0.035	0.021	0.039***	0.042***	0.027	0.248***	-0.041	0.060
	(0.035)	(0.021)	(0.014)	(0.010)	(0.052)	(0.072)	(0.035)	(0.045)
Log of land area	0.015	-0.043**	0.014	-0.022***	-0.095*	-0.082**	-0.044*	-0.034
	(0.038)	(0.021)	(0.014)	(0.008)	(0.051)	(0.036)	(0.026)	(0.028)
House rental ratio	0.168	0.508***	-0.034	0.008	-0.310	-0.631	-0.390	-0.814***
	(0.271)	(0.163)	(0.123)	(0.092)	(0.361)	(0.484)	(0.239)	(0.263)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,227	2,629	2,227	2,629	2,227	2,629	2,227	2,629
R^2	0.479	0.350						
Log likelihood			-1,786.499	1,263.253			-7,469.00	-8,553.00
Hausman Test			0.785	0.934				
Weak identification F - test	26.43	68.69						
Wald test of exogeneity χ^2							6.17	1.40
Left-censored observations			1,253	1,998				

Stock-Yogo weak ID test critical values: 10% maximal IV size 16.38.

Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix

Table A.1: Variable Descriptions

Variable	Description
Number of Schools	Number of schools in the school district
Population	School district level total population
Number of Students	Total number of students in the school district
University Ratio	Percentage of the population who holds a university degree in the school district
Number of TRI type firms	School district level number of TRI type firms
Number of oil TRI firms	School district level number of TRI type firms that belong to one of the NAICS codes listed in Table A.2
Number of non oil TRI firms	School district level number of TRI type firms that do not belong to one of the NAICS codes listed in Table A.2
Number of TRI polluters	School district level number of firms that reported a release above the EPA threshold (25,000 pounds) to the TRI in at least one year
Oil and gas revenue	Total market value of oil and gas production at school district level
Oil and gas production	Total production of oil and gas in kwh at school district level
Number of other businesses	Number of firms that do not belong to a NAICS code covered by the TRI Program in the school district
Median income	School district level median income in $
Non white ratio	School district level share of non white population
Unemployment rate	School district level unemployment rate
Number of roads	We use the U.S. Census Bureau's Census Feature Class Codes (CFCC) to identify roads. These road maps are provided by ESRI Data & Maps (2000) and we combine them with maps of school districts boundaries. We use all major highways to small roads that provide access to businesses, facilities, and rest areas along limited-access highways
Number of rail roads	As in roads we use the U.S. Census Bureau's Census Feature Class Codes (CFCC) and ESRI Data & Maps (2000) to identify rail roads. We use all major and minor rail tracks identified by ESRI Data & Maps
Area	School district level land area in square kilometers
House rental ratio	Number of rented houses divided by the total number of owned houses

Table A.2: Oil based TRI NAICS codes

TRI NAICS	Description
211111 :	Crude Petroleum and Natural Gas Extraction
211112 :	Natural Gas Liquid Extraction
212112 :	Bituminous Coal Underground Mining
211130 :	Natural Gas Extraction
324xxx :	Petroleum and Coal Products Manufacturing
424710 :	Petroleum Bulk Stations and Terminals

Table A.3: IV Regression results for TRI-type firms in MSA school districts: alternate specification

Variable	Log of TRI-type firms					
	All TRI	Oil TRI	Non oil TRI	All TRI	Oil TRI	Non oil TRI
	(1)	(2)	(3)	(4)	(5)	(6)
Log of oil and gas revenue	0.028**	0.044**	0.012			
	(0.011)	(0.021)	(0.012)			
Log of oil and gas production				0.022**	0.034**	0.010
				(0.008)	(0.016)	(0.009)
Log of number of other businesses	0.861***	0.380***	0.906***	0.861***	0.381***	0.906***
	(0.015)	(0.027)	(0.017)	(0.015)	(0.027)	(0.017)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,227	2,227	2,227	2,227	2,227	2,227
R^2	0.935	0.451	0.925	0.935	0.447	0.925
Weak identification F - test	20.60	20.60	20.60	24.27	24.27	24.27

Stock-Yogo weak ID test critical values: 10% maximal IV size 16.38.

Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A.4: IV Regression results for TRI-type firms in non-MSA school districts: alternate specification

Variable	Log of TRI-type firms					
	All TRI	Oil TRI	Non oil TRI	All TRI	Oil TRI	Non oil TRI
	(1)	(2)	(3)	(4)	(5)	(6)
Log of oil and gas revenue	0.022***	0.058***	0.004			
	(0.007)	(0.010)	(0.008)			
Log of oil and gas production				0.019***	0.048***	0.003
				(0.006)	(0.008)	(0.006)
Log of number of other businesses	0.809***	0.259***	0.838***	0.809***	0.260***	0.838***
	(0.017)	(0.024)	(0.021)	(0.017)	(0.024)	(0.021)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,629	2,629	2,629	2,629	2,629	2,629
R^2	0.857	0.220	0.839	0.857	0.208	0.839
Weak identification F - test	68.12	68.12	68.12	70.08	70.08	70.08

Stock-Yogo weak ID test critical values: 10% maximal IV size 16.38.

Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A.5: IV Poisson regression results for TRI-type firms in school districts: alternate specification

Variable	Number of TRI-type firms					
	All TRI	Oil TRI	Non oil TRI	All TRI	Oil TRI	Non oil TRI
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: School districts in MSAs						
Log of oil and gas revenue	0.020***	0.074***	0.014***			
	(0.004)	(0.021)	(0.004)			
Log of oil and gas production				0.016***	0.059***	0.011***
				(0.003)	(0.017)	(0.003)
Log of number of other businesses	0.935***	0.905***	0.938***	0.936***	0.911***	0.939***
	(0.015)	(0.083)	(0.011)	(0.015)	(0.086)	(0.011)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,227	2,227	2,227	2,227	2,227	2,227
Panel B: School districts in non-MSAs						
Log of oil and gas revenue	0.020***	0.321***	-0.004			
	(0.004)	(0.051)	(0.004)			
Log of oil and gas production				0.017***	0.294***	-0.004
				(0.004)	(0.051)	(0.003)
Log of number of other businesses	0.877***	0.542***	0.947***	0.877***	0.537***	0.947***
	(0.009)	(0.028)	(0.009)	(0.009)	(0.028)	(0.009)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,629	2,629	2,629	2,629	2,629	2,629

Robust standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A.6: Regression results for TRI polluters: alternate specification

Variable	Log of TRI-polluting firms				TRI-polluting firms		Proportion of TRI-polluting firms	
	IV		Censored-IV		IV-Poisson		Fractional Response IV Probit	
	MSA	Non-MSA	MSA	Non-MSA	MSA	Non-MSA	MSA	Non-MSA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log of oil and gas revenue	0.055**	0.005	0.056***	-0.000	0.053***	0.004	0.073***	-0.002
	(0.024)	(0.007)	(0.008)	(0.004)	(0.019)	(0.016)	(0.014)	(0.010)
Log of number of other businesses	0.320***	0.192***	0.312***	0.194***	0.738***	1.219***	0.050***	0.228***
	(0.028)	(0.023)	(0.010)	(0.008)	(0.023)	(0.046)	(0.017)	(0.026)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,227	2,629	2,227	2,629	2,227	2,629	2,227	2,629
R^2	0.227	0.219						
Log likelihood			-2072.469	-1430.831			-7,572.00	-8,679.00
Hausman Test			0.000	0.239				
Weak identification F - test	20.60	68.12						
Wald test of exogeneity χ^2							15.25	1.79
Left-censored observations			1,253	1,998				

Stock-Yogo weak ID test critical values: 10% maximal IV size 16.38.

Robust standard errors are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Chapter 3

Effects of Oil Boom on Local Government Behavior

3.1 Introduction

The natural resource curse refers to the observed negative correlation between economic growth and the abundance of natural resources, as defined by Auty (1993). Most studies that emerged late in the 20th century, have investigated oil booms and economic development at an aggregate level (Sachs and Warner, 1997, 2001). This research is interested in understanding the impacts of oil and gas abundance at the local level; specifically, this study explores the influence of the oil boom on government behavior at the tax unit level. Oil and gas resources are unevenly spread within a country or a state and, in most countries, local governments have some degree of fiscal autonomy. This implies that their revenues will be affected by new drilling activities which might influence their local public good provision, including education.

From the perspective of a local government, the questions are: "Should oil and gas exploitation be encouraged based on their impact on local revenues?" and " How does the local government allocate the oil income within their tax unit?" Using data from the State of Texas, this paper contributes to this debate in two ways. First, this research investigates how oil and gas revenue affects the local tax base and local tax revenue. This study also looks into the impact of the oil boom on the different sources of revenues, i.e. federal-, state- and district revenues. Second, to assess how the oil boom influences the local public good provision, this paper evaluates the impact of oil abundance on the actual educational operating expenditure and how the additional local revenue is allocated among the different categories of educational expenditure.

This study is based on data from Texas from 2010 to 2014 due to its unique characteristics. Texas has experienced an oil and gas boom over the last 10 years due to the development of extracting technology. Annual crude oil production nearly tripled between 2009 and 2015. Texas is the biggest crude oil-producing state, producing one-third of U.S. crude oil and one-fourth of U.S. natural gas (U.S. EIA, 2015). The Permian Basin in West Texas has become the world's most productive oil field (U.S. EIA, 2019). The Texan economy relies heavily on the oil and gas sector.

School districts' governments constitute a good institutional framework to study the impact of oil boom on local public provision. On the one hand, a school district is an independent local government for the purpose of operating local public schools and virtually all local revenues are generated by means of property taxation. Every school district is authorized to set its own property tax. All properties are taxable based on their appraised value and oil and gas companies pay a property tax based on the value of their production. We can therefore estimate the effect of oil wealth on local taxation and local school expenditure. The value of oil and gas production in Texas represents 13.5% of its GDP in 2014. [1].

Local government behavior and oil and gas production can evolve simultaneously, either because of unobserved geographical characteristics or because oil and gas companies respond to policies implemented by local governments. To deal with this potential endogeneity and accurately estimate the impact of oil and gas production on school districts' taxation behavior and public good provision, we use an Instrumental Variable (IV) approach. The school district oil and gas production is instrumented by the interaction between a year indicator and an indicator that equals 1 if this school district is in an oil/gas basin county (where a basin county is defined as a county located in any of the Texan oil/gas basins). As the boundaries of Texan counties were defined before the discovery of oil, the location of oil resources does not directly affect our dependent variables.

Using IV specifications, the results of this research identify different channels through which oil abundance affects school districts in Texas. The presence of oil and gas resources enlarges the local tax base, and property tax rates are found to be associated with the oil boom. In particular, the estimation shows that lower tax rates are

[1] https://businessintexas.com/sites/default/files/txoil.pdf

correlated with increased local revenue. These new revenues contribute to higher local education expenditure per student. Additionally, we decompose the impact of oil and gas activities by categories of education expenditure and show that an increase in oil and gas revenue leads to higher expenditure in categories, which directly benefits the teaching experience of both students and teachers.

Badeeb et al. (2017) comprehensively survey the natural resources curse literature. Our paper contributes to a line of research that considers the natural resources curse at the local level. Using local level data from Norway, Borge et al. (2015) analyze the efficiency of public good provision and revenues from hydro-power production. This study does not find any evidence of reduced efficiency in the provision of public goods with natural resources revenues. Caselli and Michaels (2013) investigate the influence of resources from oil windfalls in Brazil. Their result indicates that total oil output has a positive effect on local government revenue. Oil-related revenue increases public goods spending on transportation, education, health, etc. Wang (2018) adopts a fixed-effect panel data regression and analyzes the effect of oil and gas production on local employment and annual income in New Mexico. Wang (2018) identifies a positive effect of oil and gas revenue on state revenue, per job annual income, and the number of jobs.

Michaels (2011) evaluates the long-term impacts of oil abundance and finds out that oil production contributed to local employment in the mining industry and the overall size of manufacturing. Oil rich counties had higher population growth, higher per capita income and advanced infrastructure. studies from Allcott and Keniston

(2014, 2018) reach a similar conclusion - oil productions increase population, income and wages without imposing a negative effect on the manufacturing industry. However, oil discoveries do not have a significant impact on overall factor productivity. Caselli and Michaels (2013) investigate the influence of resources from oil windfalls in Brazil. Their result indicates that total oil output has a positive effect on local government revenue. De Silva et al. (2020) investigate whether localities benefit from natural resource extraction in Texas. They find little or no evidence of the natural resources curse in the long run. This study (i.e. third chapter of my thesis) contributes to this branch of literature by comparing the oil contribution in metropolitan and rural districts. Also, this paper looks into the impact of oil production on local tax rates.

Research focusing on the impact of oil production on education spending provides mixed evidence. Black et al (2005) assess the influence of the coal boom and bust on education and reveal that high school enrolment dropped dramatically in the coal-abundance counties during the coal boom period. Their results indicate that long-term wage growth in low-skilled work could decrease high school enrolment. Bartik et al (2016) conclude that local governments experience an increase in revenue that is larger than the average growth in total expenditures. Using local public financial data, Raimi and Newell (2016) find that oil and gas income contributes to the local government revenue or expands the local tax base, which can be redistributed to the school funds or school districts. Ratledge and Zachery (2017), however, find no statistically significant impact on tax revenue or expenditure per student from the oil and gas development in the state of Pennsylvania. One of the explanations for such results is the crowding out effect: a rise in revenue in school districts may crowd out funding from state or federal sources (Gordon 2004). James (2017) investigates the relationship between oil and gas production and both public and private education expenditure. Using the state level data, the study finds that public education spending in oil-abundant states exceeds that in oil-scarce states; consequently, private education expenditures are imperfectly crowded out. Marchand and Weber (2020) examine how shale oil production (also known as unconventional oil) affects education in Texas, using shale depth as a proxy. Their paper reveals a higher increase in spending per student in shale boom school districts. This research (i.e. the third chapter of my thesis) extends this strand of literature by examining how an oil boom affects different components within operational education expenditure at a local tax unit level.

The remainder of the paper is organized as follows. Section 2 describes the data and variables used in the empirical analysis. In Section 3, we evaluate the effects of oil and gas operations on local taxation. Section 4 focuses on education expenditure. Section 5 concludes.

3.2 Data

In this section, we describe the sources of data, explain the construction of our variables, and provide summary statistics. We use data at the school district level from Texas over a five-year period–2010 to 2014. A school district is an independent government with some fiscal autonomy for the purpose of operating public schools that are situated within that area. During our sample period, there were 1024 school districts in Texas.

3.2.1 Oil and gas production and revenue

To measure oil abundance at the school district level, we use the explanatory variable of oil and gas revenue based on oil and gas production. The data on oil and gas production comes from the Railroad Commission of Texas (RRC). It includes county-level crude oil production in thousands of barrels, condensate oil production in thousands of barrels, gas-well gas production in thousands of cubic feet, and casing-head gas production in thousands of cubic feet. To derive the total level of oil and gas production at the county level, we convert all four types of oil and gas production into kilowatt hours (kWh) and add them up. As the analysis is at the school district level and all school districts are contained within a single county, this study levels down the county-level production, using the proportion of the school district area contained in the county area. Based on the average yearly price of oil in dollars per barrel and gas in dollars per thousand cubic feet (data from the US Energy Information Administration), the revenue generated by oil and gas extraction is calculated.

3.2.2 Sample generation

The objective of this paper is to compare school districts that have witnessed an oil boom over the sample period with school districts that have no specialization in oil and gas production. It is therefore important to narrow the analysis to school districts that have some degrees of similarity. To this end, we restrict our sample in two different ways.

First, we identify the areas that are specialized in oil and gas production. Because the original data on oil and gas production is at the county level, we identify oil (and gas) counties in Texas. If oil and gas revenue at any time is greater than ten percent of a county's total revenue, that county is treated as an "oil county"; otherwise, it is a "non-oil county". Our first restriction on the sample of school districts is based on population and median income in school districts located in oil counties; the former signals the size of a school district and the latter indicates local living standards. To be precise, our analysis excludes school districts with a population less than 69 or larger than 164,642 (the largest school district in the oil counties), or a median income less than 15,917 dollars or greater than 92,917 dollars (the highest median income of the school districts in the oil counties). This restriction reduces the number of school districts from 1024 to 980.

Second, it would not be appropriate to compare the impact of an oil boom between rural and urban school districts as they widely differ in terms of population growth, employment, etc. We, therefore, divide the 980 school districts of our sample into two subsets using the definition of the Metropolitan Statistical Area (MSA). There are 25 MSA counties in Texas, corresponding to 455 school districts in our sample.

Table 1 displays the summary statistics. We provide three categories of data. "Sample SD" refers to our restricted sample of 980 school districts in Texas. "MSA SD" and "non-MSA SD" refer to MSA school districts and non-MSA school districts.

For each category, we compare school districts located in oil counties and non-oil counties. The definition of all the variables can be found in Table A.1 in the Appendix.

3.2.3 School district property tax

School districts' governments (called school boards) have powers similar to that of a town or a county, including taxation. Locally elected school boards make policy decisions regarding public education. School district revenue comes from three sources: local tax revenue (44 %), revenue from the state government (46%) and revenue from the federal government (10%). The school district-level revenue data comes from the Texas Education Agency (TEA).

Local source. Local governments heavily depend on property tax revenues to finance public services provision. In Texas, every school district has the leverage to set up its own property tax rate and there is no state-level property tax. All properties are taxable and each property must have one appraised value unless it is provided an exemption by the law. Mineral profits are considered real property and, therefore, oil and gas firms pay the property tax based on their production revenue. The school district property tax revenue is the property tax rate multiplied by the district's total property taxable value and it forms the local share of school funding. As school districts must guarantee a basic education funding level per student (determined by the State), school boards will set tax rates taking into account the total taxable value in the district. School districts have however the opportunity to raise the property tax rate up to 17 cents/$100 valuation to finance educational enhancement above the basic level determined by the State.

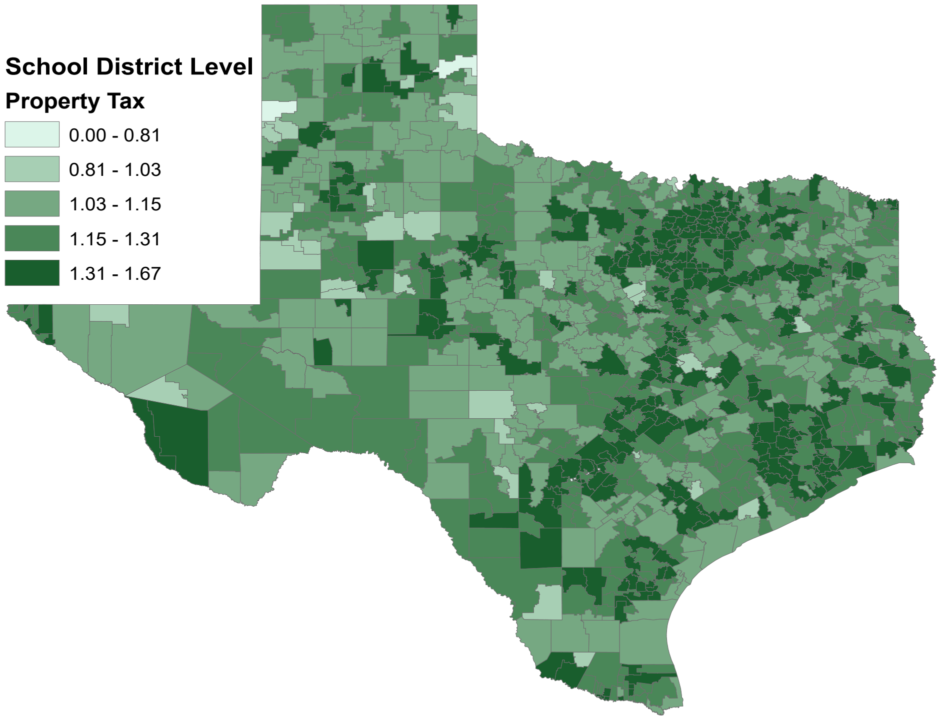
Our data contains school district-level property tax rates and property tax revenues over a five-year period. Figure 1 shows the school district-level property tax rate in 2010. School districts in Eastern Texas had higher property tax rates than those in the West, especially around big cities in metropolitan areas. Property tax rates at the school district level contain two components: maintenance and operation (MO) tax and interest and sunk (IS) tax. The upper limit on the MO tax rate is 1.50 dollars per 100 dollars of assessed property value. The MO tax is used to fund local public school expenditures. Our analysis will therefore primarily focus on that rate. The IS tax is designed to fund debt service, such as providing interest and creating a sinking fund for obligation bonds. In 2010, the average MO tax rate in Texas was 1.06 and the average IS tax rate was 0.17.[2]

In Table 1, it is interesting to note that MSA school districts in oil counties have a lower property tax rate than MSA districts in non-oil counties. Property tax rates in non-MSA districts show the opposite effect. The average MO tax rates are lower in school districts in oil counties across categories.

State source. If the property tax revenues are insufficient to cover the pre-determined basic funding level per student, the Sate government covers the difference. An

[2] It is worth mentioning that there are four school districts that have a zero school district-level property tax base due to special regulations. Joint Base San Antonio is located at Fort Sam Huston, Randolph Field, and Lackland independence school districts; hence, these three school districts have a zero tax base as they host a military installation. The Boys Ranch school district is a non-profit special district established for students with special needs. In addition, if a school district is rated "academically unacceptable", that school district is merged with its neighbor. Merging school districts also leads to a zero property tax rate in our dataset. For example, Kendleton school district was merged with Lamar school district in 2010, so the tax rates for Kendleton after 2010 are shown as 0.

Figure 1: SD property tax



increase of the taxable value leading to higher local revenues (induced by an oil boom for example) might then be offset by a reduction of State's transfers.

In Texas, there is also financial legislation aimed at preventing wealthy school districts from raising tax revenue to provide services that poorer school districts cannot. If a school district's MO tax revenue exceeds a state-wide rate per student, the excess will be recaptured by the state government and redistributed to poor school districts. This is known as the Robin Hood policy, which can result in a wealth transfer from the school district to the State and could potentially offset the benefits of an oil boom in terms of local revenues. However, it does not influence our results because of the crowding out effect.

Finally, the State of Texas still imposes a state oil and gas tax. The severance tax on oil extraction is 4.6 percent of the market value of oil production while the severance tax on gas extraction is 7.5 percent of the market value of gas production. These tax rates remained unchanged since the 1950s. By granting tax exemptions or reductions, the state government provides severance tax incentives to lower the cost of oil and gas production. For instance, "*Severance Tax Relief for Marginal Wells*" offers tax relief to businesses of marginal oil and gas wells when oil and gas prices drop below certain levels. The total state oil and gas production tax in 2014 was 5.774 billion dollars. The State tax revenue goes to fund highway construction and school education [3].

Federal source. Federal funding consists of direct payments to individuals and tends to target low-income students or other distinct groups.

3.2.4 Education expenditure

TEA provides detailed data on education expenditure at the school-district level. As Texas's economy expands, local property tax revenues fund a bigger percentage of public education. [4] In this study, we use the total actual operating expenditure per student, which is the sum of the actual operating expenses excluding debt service and capital outlay. There are five categories of operational expenses: total actual expenditure on school district-level administration, educational instruction, school-level administration, physical plant services, and on other operating costs (such as

[3] i.e. *"Foundation School Program, a Texas Education Agency-administered fund used for expenses such as teacher salaries, bilingual education and special education".* See details at https://www.texastribune.org/2018/01/05/hey-texplainer-how-does-texas-budget-use-taxes-oil-and-natural-gas-pro/

[4] *Source: https://www.texastribune.org/2019/02/15/texas-school-funding-how-it-works/*

food services).

When investigating the impact of oil and gas production on local government decisions about property tax and school expenditure, we control for potential confounding factors. We use data from the American Community Survey to account for local attributes (e.g. income, population) that affect local taxation and provision of public goods. Median income measures the local living conditions, and population captures the size of the school districts.

3.2.5 Identification Strategy and the Instrument

Local government behavior and oil and gas production can evolve in simultaneity, either because of unobserved geographical characteristics or because oil and gas companies respond to policies implemented by local government. To deal with this issue and accurately estimate the impact of oil and gas production on school districts' governments' behavior, we use an Instrumental Variable (IV) approach.

We use the interaction of major oil and gas basins in Texas (i.e. the Permian Basin in West Texas, the Eagle Ford shale formation in South Texas, the Barnett shale formation in North Texas, and the Haynesville/Bossier shale formation in East Texas)and year indicators as an instrument. The year indicator variable within the interaction allows us to capture the timing of the booms or changes in world oil and gas prices (James, 2017; Feyrer et al., 2017). Counties located in any part of one of these basins are considered basin counties whereas the other counties are treated as non-basin counties. School districts that are located in a basin county are basin school districts. Due to the uneven distribution of oil and gas resources in Texas, there is enough variation to identify the local effect of oil and gas production. Moreover, the location of the oil resources in Texas does not affect directly our dependent variables (school expenditure, or local taxation) and vice-versa because the boundaries of Texan counties were defined before the discovery of oil, and thus are not based on the presence of oil resources. The only possible indirect impact of oil and gas basins on these dependent variables must be through current oil and gas extractions.

3.3 Impact on local taxation

We now turn to the analysis of local government behavior. In this section, we first examine how energy production affects school districts' revenues. In the next section, we analyze how this revenue is used to fund education expenditures.

As mentioned in the data section, school districts' revenues come from different sources. At the local level, the main source of revenues is property taxation and so depends on the tax rate set by the school board and the total taxable value (or tax base). We have seen previously that school boards will set tax rates taking into account the total taxable value in the district as they have to meet some basic education funding per student. To obtain the impact of oil and gas production on local tax revenues, we, therefore, need to estimate the total taxable value as a function of oil and gas production and property tax rates as a function of total taxable value. This leads to an empirical challenge because the taxable value of the oil and gas industry depends on market values, which are also determined by tax rates. Property tax rates and total taxable values are therefore jointly determined and OLS estimations will be biased.

To identify the separate effects of oil abundance on school districts' property tax rates and total taxable value, we follow three steps used by De Silva et al. (2016). First, we regress the total taxable value as a function of the oil and gas revenues and other school district attributes e.g. income and population (from the previous year), as shown in equation (3.1). Second, we strip out the impact of energy production. We compute the total predicted taxable value, denoted by $\hat{v}_{it}*$, from equation (3.4) omitting energy production. Finally, we evaluate the school district-level tax rates, and tax revenue as a function of oil and gas revenues and the taxable value in the absence of energy production $\hat{v}_{it}*$, as shown in Equation (3.2) and (3.3). We estimate these models using two-stage least squares, where oil and gas revenue is instrumented by oil and gas basins.

$$log(v)_{it} = \overline{\mu}_1 \, log\,(E)_{it-1} \; + s'_{it-1}\overline{\mu}_2 + t + \varepsilon_{it} \tag{3.1}$$

$$tax\,rate_{it} = \rho \, ln\,(\hat{v}_{it-1}*) + \gamma_1 \, lnE_{it-1} + s'_{it-1}\gamma_2 + t + e_{it} \tag{3.2}$$

$$ln\,(tax\,revenue)_{it} = \kappa_1 \, ln\,(\hat{v}_{it-1}*) + \kappa_2 \, lnE_{it-1} + s'_{it-1}\kappa_3 + t + \eta_{it} \tag{3.3}$$

$$where\ \hat{v}_{it-1}* = ln\, \hat{v_{it-1}} - \overline{\mu}_1\, ln\, E_{it-1} \tag{3.4}$$

Tables 2 and 3 present the results for MSA and non-MSA school districts respectively. Column (1) in both Tables estimate equation (3.1). Not surprisingly, higher oil and gas revenues enlarge the tax base. From the results in column (1), we extract $\hat{v}_{it}*$ (the tax base without energy production) and estimate equations (3.2) and (3.3) in columns (2), (3), (4) and (5).

We estimate the relationship between oil and gas revenues and the total tax rate, IS tax rate, and MO tax rate. Of particular interest is the MO tax rate because it is the tax rate used to fund school expenditures, including facility maintenance and public service operations. In Table 2, revenues from the oil and gas industry are negatively correlated with the property tax rate and IS tax rates in metropolitan school districts. There is also a negative correlation with the MO tax rate, but it is not significant. Table 3 shows that oil and gas revenues have a negative correlation with the MO tax rate in non-MSA school districts, but it is not significant. In Column (5) of Tables 2 and 3, the effect of oil and gas revenues on the total revenue per student is positive and significant. This suggests that, even though oil and gas revenues are negatively correlated with the MO tax rate, the positive effect on the tax base is proportionally larger.

We then analyze how oil and gas wealth affects local revenues from other sources such as state sources and federal sources. Our results in Column (6) of Table 2 and 3 are consistent with our initial hypothesis that a higher level of local tax revenues caused by oil and gas production is crowding out revenues from the state source in Column (7). Oil and gas production also brings in additional federal revenues in MSA school districts as shown in column (8). One potential explanation is that federal grants include direct payments to individuals and these grants are driven by population (Texas Comptroller, 2019). Column (5) shows that the overall impact on school districts' revenues is significantly positive, despite the reduction in state transfers.

3.4 Impact on education expenditures

As the main role of school district governments is to operate public schools that are situated within that area, the next question is: what do school district governments do with these additional revenues? The model specification and methodology adopted in the section are the same as in the last section (two-stage least squares). We focus on actual operating expenditure, as it is a better and more accurate measure to assess actual public services provision.

First, in both metropolitan and rural areas, the presence of the oil and gas industry is associated with an increase in actual operational expenditure (in total and per student). A 1% increase in oil and gas revenues contributes to a 0.114% increase in education expenditure per pupil in MSA school districts as in column (2) of Table 4. In non-MSA school districts, the elasticity of per pupil spending with respect to oil and gas revenues is only 0.01 from Column (2) in Table 5. Next, we investigate how school boards allocate these additional funds between the different categories of education expenditure.

In MSA school districts (Table 4), oil and gas revenues have a similar impact on all categories of education spending, except for the school administration category, where the impact is slightly lower. In contrast with the impacts in metropolitan areas, the effects of oil and gas revenues in non-MSA school districts vary among the different categories of school expenditure (Table 5). The elasticity of plant service expenditure with respect to oil and gas revenues is larger than the elasticity of other categories of spending.

To discuss the economic significance of our results, we compute the contribution of oil and gas revenues to expenditure per pupil in dollar terms (Table 6). Panel A and Panel B refer to MSA and non-MSA school districts, respectively. In each Panel, the first row reports how total education expenditure per student is allocated among the different categories, while the second row gives the average expenditure per student in each category. Using the coefficient of oil and gas revenues (i.e. 0.114) in Table 4, we compute the effect in dollar terms of a 1 % rise in oil and gas revenue in MSA school districts (Panel A). Instructional expenditure per student captures the biggest share of the contribution, i.e. \$428. The second largest education expenditure category (other educational purposes) accounts for \$146. Using the coefficient of oil and gas revenues in column 2 of Table 5, we find that a 1% increase in oil and gas revenues in non-MSA school districts (Panel B) contributes to an increase in expenditure of approximately \$644 per student, from which \$358 is devoted to instructional purposes. The second category to benefit the most from the oil boom (in dollar terms) is the other educational spending, whereas plant service expenses increase by $75 per student.

In dollar terms, oil and gas revenues contribute the most to instructional expenditure. This category includes expenses for classroom instruction and other teaching activities which enhance the learning environment for students. The second largest contribution from oil and gas revenues is towards other educational operating expenditures, including expenses to provide physical health services, food services, transportation, counseling services, etc. An increase in such expenditure benefits students outside the classroom. In non-MSA school districts, plant service spending accounts for the third largest contribution. A boost in plant service and facilities operation expenditure may lead to better property insurance, a safer security system (e.g. smoke detectors, etc.), and improved facilities for the entire school district such as athletic equipment. Overall, the results suggest that an increase in oil and gas revenues raises the level of expenditure in categories that directly benefit students and teachers both in and outside the classroom.

3.5 Conclusion

This research examines the effects of oil and gas production from two aspects: local property taxation and expenditures on education. We contribute to the literature on natural resources in ways. The findings on taxation suggest that oil and gas production generates a significant increase in the school district property tax base and total revenue per student for both MSA and non-MSA school districts. Revenues received from oil and gas operations are partially offset by a reduction of state government transfers, but overall per student remains positive. The negative correlation between the MO tax rate and energy production proves our initial hypothesis in the rural area. Overall, the results provide evidence of a positive impact of oil booms, i.e. boosting local tax revenues.

This paper estimates the expenditure on education. School districts with oil and gas operations are more likely to have a higher level of total actual operational expenditure on education and it still holds true at the per-pupil level. Within operational expenditure, those school districts spend their budget mostly on instrumental educational expenditures and other expenditures (such as well-being and food services).

The paper provides avenues for future research. First, the analysis shows that tax rates are negatively correlated with production of oil and gas. A possible extension of this study would be to investigate the mechanisms behind this effect, in particular the role of special interest groups. Second, the investigation finds a positive impact on local education expenditure; however, expenditure on education does not represent real learning quality. Another possible extension would be to look into how oil revenue affects the learning experience.

Bibliography

[1] Allcott,H., Keniston, D. (2018) Dutch Disease or Agglomeration? The Local Economic Effects of Natural Resource Booms in Modern America, *The Review of Economic Studies*, 85(2): 695–731.

[2] Auty, R. (1993). Sustaining development in mineral economies. London: Routledge.

[3] Badeeb, R., Lean, H. and Clark, J. (2017). The evolution of the natural resource curse thesis: A critical literature survey. *Resources Policy*, 51: 123-134.

[4] Bartik, A. W., Currie, J., Greenstone, M., and Knittel, C. R. (2019). The local economic and welfare consequences of hydraulic fracturing. *American Economic Journal*: Applied Economics, 11(4): 105-55.

[5] Black, D., McKinnish, T., and Sanders, S. (2005). The economic impact of the coal boom and bust. *The Economic Journal*, 115(503): 449-476.

[6] Borge, L., Parmer, P. and Torvik, R. (2015). Local natural resource curse? *Journal of Public Economics*, 131: 101-114.

[7] Caselli, F. and Michaels, G. (2013). Do Oil Windfalls Improve Living Standards? Evidence from Brazil. *American Economic Journal: Applied Economics*, 5(1): 208-238.

[8] De Silva, D. G., Hubbard,T.P., Schiller A.R., (2016) Entry and Exit Patterns of “Toxic” Firms, *American Journal of Agricultural Economics*, 98(3): 881–909.

[9] De Silva, D. G., McComb, RP., and Schiller A.R., (2020) Do localities benefit from natural resource extraction? *The Energy Journal* . 41(5) : 184 -212.

[10] Feyrer, J., Mansur, E. T., and Sacerdote, B. (2017). Geographic dispersion of economic shocks: Evidence from the fracking revolution. American Economic Review, 107(4): 1313-34.

[11] Gordon, N. (2004). Do federal grants boost school spending? Evidence from Title I. *Journal of Public Economics*, 88(9-10): 1771-1792.

[12] James, A. (2017). Natural resources and education outcomes in the United States. *Resource and Energy Economics*, (49): 150-164.

[13] Marchand., J. and Weber., J. G. (2020). ”How Local Economic Conditions Affect School Finances, Teacher Quality, and Student Achievement: Evidence from the Texas Shale Boom,” *Journal of Policy Analysis and Management.* 39(1): 36-63.

[14] Michaels, G. (2011). The long term consequences of resource-based specialisation. *The Economic Journal*, 121(551): 31-57.

[15] Raimi, D. and Newell, R. G., (2016) US State and Local Oil and Gas Rev-

enues. *Resources for the Future Discussion Paper* 16-50, Available at SSRN: https://ssrn.com/abstract=2891365

[16] Ratledge, N. and Zachary, L., . (2017). Public education impacts of unconventional oil and gas development. *Resources for the future report.*

[17] Sachs, J.D., Warner, A.M., 1997. Natural Resource Abundance and Economic Growth. *Technical Report.* Center for International Development and Harvard Institute for International Development.

[18] Sachs, J.D., Warner, A.M., 2001. The curse of natural resources. *European Economics Review.* (45): 827–838.

[19] Texas comptroller (2019) Federal funding in Texas https://comptroller.texas.gov/economy/fiscal-notes/2017/november/federal-funding.php

[20] U.S. EIA, (2015) Texas Profile State Profile and Energy Estimates https://www.eia.gov/state/?sid=TX (Access: 10 Mar 2018)

[21] U.S. EIA, (2019) Drilling Productivity Report. https://www.eia.gov/petroleum/drilling/pdf/dpr-full.pdf (Access: 15 Mar 2019)

[22] Wang, H. (2018). An Economic Impact Analysis of Oil and Natural Gas Development in the Permian Basin. Available at SSRN 3254814.

[23] Wooldridge, J.,M. (2010). "Econometric Analysis of Cross Section and Panel Data," MIT Press Books, The MIT Press, edition 2, volume 1.

Table 1: School District Level Summary Statistics

	Sample SD		MSA SD		Non MSA SD	
	Oil	Non oil	Oil	Non oil	Oil	Non oil
Number of Schools	3.424	6.438	5.110	14.61	2.927	3.307
Population [a]	6.543	17.73	12.11	52.31	4.923	6.465
Number of Students [a]	1.287	3.468	2.554	10.01	0.923	1.158
Oil and gas revenue [b]	2.458	0.179	2.140	0.251	2.582	0.0927
Oil and gas production[c]	8.128	0.885	8.409	1.328	8.163	0.421
Income [d]	4.505	4.867	4.852	5.504	4.398	4.301
Area (in Km^2)	952.7	554.5	662.2	369.5	1047.1	804.9
Property tax rate	1.198	1.272	1.231	1.336	1.188	1.184
MO tax rate *	1.065	1.075	1.067	1.079	1.064	1.066
IS tax rate ◇	0.134	0.197	0.164	0.257	0.124	0.119
Taxable base [e]	0.685	1.127	1.011	3.609	0.594	0.397
Tax revenue [f]	0.654	1.540	1.119	4.765	0.519	0.473
Total education expenditure[f]	1.187	2.922	2.174	8.291	0.903	1.039
		The variables below are at per student level				
Total revenue[d]	1.367	1.133	1.224	1.075	1.411	1.206
Education expenditure [g]	11.07	9.600	10.28	8.911	11.31	10.44
Federal source revenue [g]	1.290	1.221	1.305	1.119	1.285	1.324
State source revenue [g]	5.263	5.450	5.429	4.823	5.210	6.087
Local Tax revenue [g]	7.045	4.641	5.510	4.703	7.520	4.737
Instructional expenditure [g]	6.015	5.355	5.703	4.996	6.111	5.842
Central admin expenditure [g]	1.062	0.817	0.875	0.661	1.120	1.005
Plant expenditure [g]	1.370	1.116	1.204	1.068	1.421	1.145
School admin expenditure [g]	0.580	0.524	0.568	0.487	0.584	0.571
Other expenditure [g]	2.047	1.789	1.932	1.701	2.083	1.883

[a] in 1000, [b] in $ 100 million , [c] in 1 billion KwH, [d] in $10,000 , [e] in $1 billion ,

[f] in $10 million , [g] in $1000 ,

* Maintenance and operation tax rates , ◇ Interest and Sunk tax rates

Table 2: IV regression of taxation on sample MSA school districts

Variables	Log of Tax Base	Tax Rate	MO Tax	IS Tax	Log of Revenue Per student			
					Total	Local	State	Federal
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log of oil and gas revenue	0.055***	-0.010***	-0.002	-0.008***	0.015***	0.036***	-0.027***	0.040***
	(0.010)	(0.003)	(0.001)	(0.003)	(0.003)	(0.009)	(0.007)	(0.011)
Log of income	0.881***							
	(0.050)							
Log of population	0.886***							
	(0.011)							
v*		0.052***	-0.003**	0.056***	-0.096***	0.794***	-0.570***	-0.680***
		(0.003)	(0.002)	(0.003)	(0.013)	(0.035)	(0.029)	(0.042)
Log of students					0.018	-0.762***	0.410***	0.594***
					(0.012)	(0.032)	(0.027)	(0.039)
Constant	1.820***	0.449***	1.171***	-0.734***	10.782***	-1.827***	16.714***	14.974***
	(0.546)	(0.069)	(0.031)	(0.060)	(0.166)	(0.448)	(0.373)	(0.537)
Observations	1,758	1,314	1,314	1,314	1,314	1,314	1,314	1,314
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: IV Regression of taxation on sample non MSA school districts

Variables	Log of Tax Base	Tax Rate	MO Tax	IS Tax	Log of Revenue Per Student			
					Total	Local	State	Federal
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log of oil and gas revenue	0.065***	0.002	-0.002***	0.004***	0.017***	0.045***	-0.015***	0.010
	(0.007)	(0.001)	(0.001)	(0.001)	(0.003)	(0.006)	(0.006)	(0.006)
Log of income	1.121***							
	(0.080)							
Log of population	0.705***							
	(0.015)							
v*		0.041***	-0.004*	0.044***	0.019	0.477***	-0.318***	-0.219***
		(0.004)	(0.002)	(0.003)	(0.019)	(0.043)	(0.040)	(0.045)
Log of students					-0.157***	-0.513***	0.124***	0.231***
					(0.014)	(0.033)	(0.031)	(0.035)
Constant	0.905	0.431***	1.173***	-0.738***	9.831***	2.409***	13.660***	9.326***
	(0.887)	(0.074)	(0.041)	(0.065)	(0.276)	(0.635)	(0.598)	(0.670)
Observations	2,103	1,574	1,574	1,574	1,574	1,574	1,574	1,574
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 4: IV Regression of educational expenditure on sample MSA school districts

Variables	Log of Actual Operating Expenditure		Log of Expenditure Per Pupil				
	Total	Per Pupil	Instructional	Central Admin	Plant Service	Schools admin	Other
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log of oil and gas revenue	0.187***	0.114***	0.101***	0.104***	0.102***	0.073***	0.106***
	(0.035)	(0.020)	(0.019)	(0.017)	(0.017)	(0.014)	(0.018)
Log of students		-0.221***	-0.223***	-0.221***	-0.115*	-0.224***	-0.091
		(0.072)	(0.067)	(0.062)	(0.060)	(0.050)	(0.063)
v*	0.998***	0.175**	0.189***	0.006	0.042	0.179***	0.082
	(0.039)	(0.078)	(0.072)	(0.067)	(0.065)	(0.054)	(0.068)
Constant	-5.515***	5.678***	4.995***	6.496***	5.491***	3.342***	5.001***
	(0.813)	(0.987)	(0.907)	(0.842)	(0.815)	(0.681)	(0.857)
Observations	1,326	1,326	1,326	1,326	1,326	1,326	1,326
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 5: IV regression of educational expenditure on sample non MSA school districts

Variables	Log of Actual Operating Expenditure		Log of Expenditure Per Pupil				
	Total	Per Pupil	Instructional	Central Admin	Plant Service	Schools admin	Other
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log of oil and gas revenue	0.009**	0.010***	0.005**	0.015***	0.030***	0.010	0.015***
	(0.005)	(0.002)	(0.002)	(0.004)	(0.003)	(0.007)	(0.003)
Log of students		-0.144***	-0.135***	-0.340***	-0.140***	-0.026	-0.043***
		(0.012)	(0.011)	(0.020)	(0.020)	(0.037)	(0.015)
v*	1.052***	0.005	0.022	-0.035	-0.014	-0.026	-0.021
	(0.014)	(0.016)	(0.014)	(0.027)	(0.026)	(0.049)	(0.020)
Constant	-3.946***	9.908***	9.019***	9.416***	7.775***	6.766***	8.007***
	(0.252)	(0.235)	(0.209)	(0.397)	(0.379)	(0.719)	(0.297)
Observations	1,574	1,574	1,574	1,574	1,574	1,574	1,574
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Average Contribution from Oil Revenue to Education Expenditure

Panel A: MSA school districts

	Total Expenditure	Instructional	Central Admin	Plant Service	School Admin	Other
Percentage	100%	56.1%	7.4%	11.8%	5.5%	19.2%
Average Expenditure per student	$9256	$5149	$725	$1116	$505	$1763
Contribution from oil industry per student	$762	$428	$56	$90	$42	$146

Panel B: Non MSA school districts

	Total Expenditure	Instructional	Central Admin	Plant Service	School Admin	Other
Percentage	100%	55.5%	9.1%	11.6%	5.3%	18.3%
Average Expenditure per student	$10897	$5982	$1062	$1290	$577	$1988
Contribution from oil industry	$644	$358	$59	$75	$34	$118

We use coefficient 0.114 from Table 4 to compute contribution from oil industry from 1 % increase in oil and gas revenue in MSA school districts and coefficient 0.01 from Table 5 for non MSA school districts

Average oil revenue (from previous year) is 55 million for sample MSA school districts and 124.4 million for sample non MSA school districts.

Appendix

Table A.1. The table below explains the variables and their definitions:

Variable name	Explanation
Schools:	Number of school in the school district
Population :	Total population in the school district
Student number :	Total student number in the school district
Energy production value :	Total market value of oil and gas production at county level
Energy production :	Total production of oil and gas in kwh at county level
Median income :	Median income in the school district
Area :	The surface of the school district
SD property tax rate :	Property tax rate levied by the school district government
SD MO property tax rate :	Property tax rate for maintenance and operation purpose, as a part of SD property tax rate,
Tax Base :	Also called taxable value, School district taxable value after the loss to the additional $10,000 homestead exemption and the tax ceiling reduction
Total tax revenue:	Total tax revenue from property tax rate at school district level
Tax revenue per student:	Total tax revenue divided by the number of students in the school districts
State revenue per student :	Actual revenue from state sources divided by number of students

Local revenue per student:	Actual revenue from local taxes, other local sources divided by the number of students
Instructional expenditure per student :	Actual instructional expenditures divided by total students
Central Admin expenditure per student :	Total actual expenditures for central administration in the district divided by total students
Plant expenditure per student :	Total actual expenditures for keeping the physical plant and grounds in effective working condition divided by total students
School Admin expenditure per student :	Total actual expenditures for the administration of the schools in the district divided by total students
Other Expenditure per student:	Total actual expenditures for all other operating costs in the district divided by total students

Chapter 4

Effects of School Choice and Oil Boom on Education Outcome

4.1 Introduction

The recent political debate about school choice has brought charter schools under the spotlight. As privately-managed public schools, charter schools aim to give parents and students an opportunity to find the school that is right for them. The existence of charter schools benefits those students who are low-income or racial minorities. In addition to providing families with more school options, charter schools may also generate competition between traditional public schools, leading to improved efficiency in education quality and better performance for all students.

When it comes to the evaluation of charter and traditional public schools, the existing literature compares the academic performance of the two types of schools

(Holmes et al, 2006; Booker et al, 2008). However, the location and other local factors also influence the result of the schools. In the oil-rich areas, the oil-producing companies bring in workers and their children; consequently, they add strains on the resources of local schools. To solve the problem, oil companies widen the school choices and directly invest in the local charter schools which act as major competitors of traditional schools. Under the context of school choice and the oil boom, my research answers key questions. The first question focuses on charter schools only: "do charter schools in an oil-producing district achieve better education outcomes, compared with charter schools in oil-scarce districts?" The second question focus on all school in oil-abundant districts only. The second question: "in oil-rich districts, do charter schools achieve better test scores, compared with rival traditional schools?" In the presence of oil production, To my knowledge, my paper is the first paper to link oil dependency with school choice.

In this paper, I use a school-level dataset in Texas to evaluate the impact of school choice and the oil boom on school performance. First of all, this research finds that school choice benefits school academic outcomes for charter schools in energy-rich districts. Charter schools in oil districts achieve better student outcomes than traditional public schools, although charter schools have lower overall performance statewide. It is worth mentioning that the superior outcome of charter schools in oil-producing districts still remains true for economically disadvantaged students. The estimates also suggest that traditional schools have a general advantage, but further analysis shows that such an advantage only holds in oil-scarce districts.

Lastly, the overall effect of the oil boom on academic performance is negative. Schools in oil districts seem to have a lower score generally. An in-depth investigation, however, shows a different story. In oil districts, being a charter school has an advantage; that is, charter schools have significantly better academic results compared with their rival traditional schools.

This study is based on data from Texas from 2016 to 2019 for several reasons. Texas has been playing an important role in expanding the charter school industry. In 1995, Texas Legislature authorized the State Board of Education to establish charter schools in the states. The first seventeen charter schools were established in 1996 with 2498 students enrolled. By 2020, there were more than 700 charter school campuses in Texas, serving nearly 300,000 students, with 141,000 students on the waiting list due to the limited spots. Charter schools in Texas are exempt from many rules and regulations that apply to traditional public schools. For example, charter schools do not require teachers to have traditional teacher certificates. Charter schools are operated on a system of open enrolment by non-profit organizations; the schools must let any student enroll although they can establish zoned enrolment at the campus level based on zip code. The funding of charter schools primarily comes from state government aid called Foundation School Program (FSP), with an average of 80 percent of revenue. Unlike traditional public schools in independent School districts, open-enrolment charter schools are not allowed to receive school district-level property tax revenue. This condition allows us to observe the impact of charter competition on traditional public schools at a school district level.

Texas has experienced an oil and gas boom over the last 10 years due to the development of extracting technology. Texas is the biggest crude oil-producing State, and it produces one-third of U.S. crude oil and one-fourth of U.S. natural gas (U.S. EIA, 2019).

The oil industry in Texas creates an interesting case. On the one hand, the oil industry directly supports Texas charter schools. For example, a number of shale firms donate $16.5 million to build charter schools in West Texas in 2020 as an influx of oil and gas workers strained schools and other public services. The oil industry also plays a role of a fundraiser for charter schools. A group of shale producers pledges to raise $100 million to deal with civic strains, 38.5 million of which will eventually create 14 schools with a capacity for 10,000 students at seven sites in Midland and Odessa, Texas. Therefore, oil revenue directly contributes to the increasing number of charter school campuses or expansion of existing charter schools, hence directing resources to charters and attracting more students, which poses a potential risk of lowered budget and worsened education outcomes for traditional public schools. On the other hand, oil production contributes to local revenue, and higher revenue per student means high education expenditure, which could hypothetically provide a better education outcome for local public schools.

A growing literature has been investigating the impacts of oil production on education spending are divergent. James (2017) studies how natural-resource endowments affect education expenditures using panel data of 48 U.S. states for the year 1970–2008. He finds that resource-abundant states spend more on education than their resource-scarce counterparts. His analysis also reveals that education outcomes change pro-cyclically with resource booms and busts. Whereas the resource boom benefits families with young children, it may cause high school students to drop out. Black et al (2005) also support such findings. They assess the influence of the coal boom and bust on education in Kentucky and Pennsylvania. High school enrolment dropped dramatically in the coal-abundance counties during the coal boom period. Their results indicate that a long-term 10 percent wage growth in low-skilled work could decrease high school enrolment by 5 percent. The effects are reversed during the coal bust. Marchand and Weber(2020) examine how shale oil production (also known as unconventional oil) affects education in Texas, using shale depth as a proxy. The paper reveals a higher increase in spending per student in shale boom school districts. However, students in oil-rich school districts tend to have weaker academic achievement, despite the tax base tripled. The authors explain that an increasing wage gap between private and education sectors leads to a greater teacher turnover and more inexperienced teachers, hence the reduced test scores. Caselli and Michaels (2013) investigate the local economic effect of oil-based fiscal windfall in Brazil. Using municipality-level data, they find that there is no significant improvement of educational quality. The authors suggest that oil revenues were used to fund political contributions, rent extraction, and embezzlement by public officials. A study from Brollo et al. (2013) supports the claim that oil royalties are associated with political corruption.

Besides the impact of the oil boom on education, my research also links to the literature on school choice. Policies for school choice aim to create healthy competition among the schools, leading to enhancement in education quality and better academic performance for students. An increasing number of researchers have investigated whether competition among schools improves education outcomes. The statistical studies testing this assumption produce mixed results (Jabbar et al, 2022; Holmes et al, 2006; Goldhaber and Elde, 2003; Gonnberg, 2012; Bettinger, 1999;).

Jabbar et al (2022) have done a systemic literature review on school choices. The authors point out that, in theory, when parents are able to choose from different schools, the market pressure faced by school administration improves their efficiency in terms of management and quality of education. Some findings support this argument. Holmes et al (2006) evaluate how the introduction of school choice, especially charter schools, influences student performance. Using the data from the state of North Carolina, the authors conclude that competition between traditional public schools and charter schools boosts test scores by one percent. Goldhaber and Elde (2003) suggest that increased competition is expected to enhance school and student outcomes, even when some parents are not actively choosing. Using campus-level data from Texas, Gronberg et al (2012) adopt a stochastic cost frontier approach and find that charter schools are more efficient than traditional public schools of comparable size. Charter schools provide the education outcome at a lower cost compared with transition public schools, especially when it comes to maths and reading. Using student-level panel data for 8 years in Texas, Booker et al (2008) find significantly positive effects of charter school competition on traditional public school student test scores, for both maths and reading tests.

Other studies find the adverse effect or little to no effects from the charter schools. Bifulco and Ladd (2006) estimate the effect of charter schools on students in charter schools and in nearby traditional public schools with student-level panel data from 1995 to 2002. The results indicate that the average charter school effects are negative, in the sense that students make considerably smaller gains on academic achievement in charter schools than they would in public schools. The authors attribute the negative impacts to the high student turnover rate. Carr and Ritter (2007) find a similar negative impact on the public schools in Ohio. Bettinger (1999), using school-level data from Michigan's standardized testing program, assesses the effect of charter schools on both charter students and students in traditional public schools. The author concludes that charter schools do not have strong effects on the test score of students attending them, and have had little or no effect on the academic achievement of nearby public schools.

My paper expands the literature by taking the oil boom into consideration when comparing traditional public schools and charter schools. The analysis of oil dependency would largely give the policymakers and administrators new perspectives regarding the education policy, especially those in the oil-abundant states.

The next section provides a comparison between charter schools and traditional public schools. Section 3 provides a description of the data. Section 4 explains the methodology used in this paper. Second 5 provides the results and analysis. Section 6 concludes the article.

4.2 The difference between charter schools and traditional public schools

In Texas, charter schools and traditional public schools are both publicly funded and subjected to same state testing program STAAR, but differ in key aspects. First, charter schools receive 100% of their funding from state sources, while traditional public schools receive funding from local property taxes (50%), state (44%), and federal sources (6%) [1]. In 2019, charter schools received $10,721 per student in funding, while traditional schools received $11,397. In addition, charter schools serve 10 % more low income students.[2] One distinctive feature of charter schools is their ability to receive donations from major contributors such as energy companies. These donations address overcrowding issues in public schools due to an influx of workers. Donations, as voluntary contributions, do not crowd out state funding hence directly contribute to charter operation. For instance, a partnership, comprising 20 energy companies, contributed $16.5 million in 2019 to support the establishment of 14 new charter schools in Permian Basin region. [3]

Second, the one-size-fits-all curriculum in traditional public schools is mandated by the school district. Charter schools, however, have the autonomy to determine their own curriculum through their school boards, enabling them to offer customized courses that meet the diverse educational needs of their students.

[1]Source: Texas Education Agency

[2]How Public Charter Schools Are Funded: https://txcharterschools.org/wp-content/uploads/2020/12/Charter-Funding-Memo-Final.pdf

[3]https://www.chron.com/business/energy/article/Permian-oil-companies-donate-16-5M-for-new-14097381.php

4.3 Data

Data in this paper is collected from multiple sources. School-level data from all public schools are obtained from Texas Education Agency (TEA) for a four-year period of time – from 2016 to 2019. The data describes the student outcomes for all pupils, student outcomes for economically disadvantaged pupils, the number of students, and the number of full-time teacher equivalent. The TEA data also includes specific demographic school features such as the percentage of nonwhite students, teacher experience, and indicators of the type of school (i.e. whether or not it is a charter school).

Variables of student outcomes are captured by the school-level grades at the State of Texas Assessment of Academic Readiness, also known as STAAR. This is the standardized test that assesses the academic progress of all students from 3rd grade to 8th grade in Texas. STAAR covers various basic subjects i.e. mathematics, science, reading, etc. STAAR is marked in percentage and there are four categories of grades:: Fail, Approach, Meet, and Masters Grade level [4]. Depending on the subject, students at the Approach level have at the minimum passing score of 25% to 35%; it is Fail if lower than that. Students who achieve grades between 55% and 85% have met the requirements and hence being categorized at Meet level. Finally, the Masters level grades cover from 85% to 100% . The variables of education outcomes at the school level measure the percentage of students who are at each

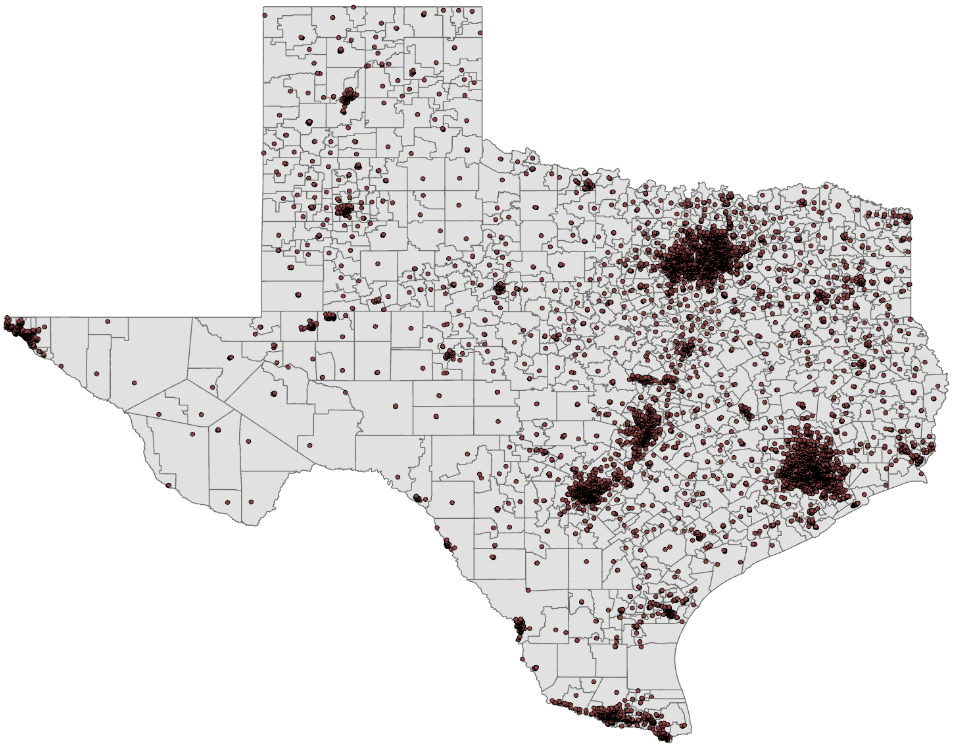
[4] The criterion scores are different among the subjects. For example, for mathematics, the "Approach" score can be 30%, "Meet" score can be 65%. Whereas, for reading, the "Approach" score can be 25%, "Meet" score can be 55%.

level of grade. The average percentage of students who are at Pass, Meet, and Masters are 75.66%, 45.54% and 20.86% respectively.

Table 1 shows the summary statistics. The first two columns provide an overview of two types of schools. Traditional public schools are larger than charter schools; the former has an average students number of 586 whereas the latter has 467 students. Traditional schools has slightly more economic disadvantage students (359 students) compared with charter schools (326 students). The average number of teachers in traditional public schools tops charter schools at 39 to 28. The last two columns compare all schools in oil-producing and non-oil-producing districts. Schools in oil districts are considerably smaller (367 students) than schools in oil-scarce districts (618 students). The number (215) and the percentage (18.54%) of economic disadvantage students are smaller in oil-rich districts, compared with schools in oil-scarce districts (385 and 21.25%). The average number of teachers in oil-rich districts is 27 whereas it is 41 in oil-scarce districts.

This paper looks into average causal effects on student outcomes from two perspectives. The first perspective regarding school choice - is whether the school is a public charter school or a traditional public school. This variable is included in TEA data. During the sample period, there were 8866 public schools across Texas, among which 782 were charter schools and 8084 were traditional public schools. To find out the number of schools per school district, I further incorporate the geo data of charter school locations containing latitude and longitude for each school campus. With GIS data of all the independent districts in Texas, I overlay the map of charter

Figure 1: Map of schools in Texas



schools with the map of school districts. Finally, I extract the number of charter schools within each school district from the overlaid map. Figure 1 shows the school distribution in Texas. In 2019, there were 62 schools on average in each school district. Houston Independent School District had the largest number of schools– 364 –in 2019.

The second perspective concerning the oil boom; that is, whether or not the school is located in an oil-producing district. A school district is defined as oil producing school district (oil district) if the county-level oil and gas share is greater than 10 %. Data regarding the oil and gas share of a school district's tax base is obtained from Texas Oil and Gas association. This data shows the dollar and percentage contribution from the oil and gas industry to the local property tax base in each school district.

4.4 Methodology

The empirical strategy of this chapter follows the basic setup based on Imbens (2000), and Guo and Fraser (2014). The main treatment of this paper is the charter school status – a school is considered as "treated" if it is an open-enrollment charter school; a school is in the "control" group if it is a traditional public school. Propensity scores are used to estimate the effects between these two groups. This paper employs propensity scores estimated by a logit model and then carries out the outcome analysis with the inverse of specific propensity score as the sampling weight. Lastly, I run the regression with subgroups. This approach has several steps.

Step 1: Estimate propensity score with a logit model. The logit model is specified as below:

$$\begin{aligned} log\frac{P(T=t|X)}{P(T=1|X)} &= \alpha_t + \beta_1 * students + \beta_2 * teachers + \beta_3 * OilDistrict \\ &+ \beta_4 * OilDistrict * students + \beta_5 * OilDistrict * teachers \end{aligned} \tag{4.1}$$

The covariant *students* represents the number of students which controls the size of the school. The covariant *teachers* is the number of full-time teachers and it evaluates the education quality of the school. Oil school district is added to the regression as a dummy variable so that I can fully capture the effect of locating in an oil-producing district and assess the impact of oil booms. Following the logit model, I then estimate the propensity score for both the treated group and control group using the predicted values from the model. The propensity score is the estimated probability of a school being a charter school, based on its characteristics like the number of students, teachers, oil district attributes, and interaction terms.

Step 2: Generate inverse of propensity scores as weights

Denoting $e(X_i, t) = pr(T = t|X)$ as the probability of receiving treatment(aka being a charter school) for school i with observed covariants X. Its inverse is defined as inverse propensity weight (ipw) for the school i. The ipw for charter schools is $\frac{1}{e(X_i t)}$ whereas the ipw for traditional schools is $1 - \frac{1}{1-e(X_i t)}$

IPW uses weighted means instead of simple unweighted means to disentangle the treatment effect and other covariants. The intuition is to make sure weights are inversely proportional to sampling probability. The weights come from the inverse of the treatment group's probability of being observed, which leads to an efficient estimate of the treatment effects. To avoid the extreme weight caused by small propensity scores, I adopt a common approach of trimming and remove schools with propensity scores greater than 0.99 or smaller than 0.01.

Step 3: Conduct regression analysis with the ipw weights. The treatment effect is estimated with a weighted linear regression model for the outcome. Robust standard errors are used to account for within-subject correlation due to the weighing process.

To examine the impact of charter schools and schools' location on students' academic performance, the following model is estimated:

$$
\begin{aligned}
Y_i = \alpha_t + \beta_0 * Charter + \beta_1 * students + \beta_2 * teachers + \beta_3 * OilDistrict \\
+ \beta_4 * OilDistrict * students + \beta_5 * OilDistrict * teachers + \epsilon_i \ with \ ipw
\end{aligned}
\tag{4.2}
$$

Y_i is school-level student grade; specifically, it measures the percentage of all students who have achieved the Masters level grades at each school. This paper uses Masters level grade because Masters level grades show Mastersy of the course content. With Masters grade, a student is on track for college and career readiness. It is the most accurate and realistic measurement of the STAAR. *Charter* is the treatment variable of whether or not the school is a charter school. *students* represents the number of students and it controls the size of the school. *OilDistrict* is the dummy variable that indicates whether a school locates in an oil-producing district. The term *OilDistrict* interacts with the two covariants. *teachers* is the number of teachers with one year lag. Because teachers' efforts are not directly reflected on the students' outcomes. It takes time for teachers to deliver academic results therefore I adopt the lagged value of the number of teachers. The regression is estimated with *ipw* weight generated from Step 2, after obtaining the propensity score from Equation (4.1). This study trims the schools with extreme propensity scores and removes the schools that have scores lower than 0.01 or higher than 0.99. This is a common approach to avoid proportionally large or small weights.

4.5 Results

Before analyzing the results, one needs to check the balance of covariants in order to determine the efficiency of the inverse probability weight from the propensity score. Table 2 shows the covariants before and after weighing. Without weights, the number of students in the treated group (Charters) is 407 compared with 538 in the control group (Traditionals). The weighted means of the two groups are a lot closer, 548 and 527 respectively. Without weights, the numbers of teachers for Charters and Traditional are 24 and 37 respectively. The weighted means of Charters and Traditionals are 32 and 37.

Table 3 presents the result of Equation (4.2). The results suggest that charter schools perform worse overall. Charter schools have 1.96% fewer students who have achieved Masters grade compared with Traditional schools. This result is in line with the finding of other literature (Bettinger,1999). In the context of Texas, charter schools do not receive school district funding that is from local property tax hence charter schools have less public resources. The coefficient of $oilsd$ reveals that locating in an oil-producing school district does not benefit students' educational outcomes overall. The reason is that oil districts have high level of student mobility, according to Ratledge and Zachary (2017), teachers experience physical and emotional fatigue from having to constantly integrate with new students, and that would reduce the teaching quality and hence negatively impact the academic results. However, the coefficient of the interaction term of $oilsd$ and $numberofstudents$ is positive, meaning that the negative effect of oil districts on student outcomes is offset when there are more students. Because larger schools have the capacity and resources to handle an influx of students. Compared with smaller schools, larger schools can accommodate these changes more effectively, ensuring that students' educational needs are met despite the challenges posed by the oil boom. When it comes to the impact of the number of teachers on educational outcomes, the estimation proves that a higher number of teachers is generally associated with better student outcomes and it is statistically significant (0.018 in the table). The result of the interaction term of oil district and the number of teachers cannot provide any conclusive result.

To investigate how charter schools and the oil boom impact the students' scores, I then estimate Yi for different categories of subgroups with weights *ipw*. I divide all the schools into two subgroups according to their location: schools in oil-producing districts and schools in non-oil-producing districts. Equation (4.3) and (4.4) estimate the impact of charter schools for the two subgroups. Equation (4.3) and (4.4) show whether charter schools have better test scores in oil-rich districts and oil-scarce districts respectively. I then re-divide all the schools into another two subgroups according to school type: charter schools and traditional public schools. Equation (4.5) and (4.6) estimate the impact of the oil boom on the two groups. Equation (4.5) and (4.6) show whether being in an oil-rich district contributes to higher test scores for charter schools and traditional schools respectively.

All the following equations are estimated with *ipw* weights.

$$Y_i = \alpha_t + \beta_0 * Charter + \beta_1 * students + \beta_2 * teachers + \epsilon_i \; if \; OilDistrict = 1 \quad (4.3)$$

$$Y_i = \alpha_t + \beta_0 * Charter + \beta_1 * students + \beta_2 * teachers + \epsilon_i \; if \; OilDistrict = 0 \quad (4.4)$$

$$Y_i = \alpha_t + \beta_0 * OilDistrict + \beta_1 * students + \beta_2 * teachers + \epsilon_i \; if \; Charter = 1 \quad (4.5)$$

$$Y_i = \alpha_t + \beta_0 * OilDistrict + \beta_1 * students + \beta_2 * teachers + \epsilon_i \; if \; Charter = 0 \quad (4.6)$$

Table 4 reveals particularly interesting results for regressions with subgroups. From Column (1), the coefficient of *charter* suggests that, in oil-producing districts, charter schools have 3.019% more students who have Masters level grades compared with rival traditional public schools. In oil-rich districts, charter schools perform better than traditional schools. Column (3) supports this finding. Among all charter schools in Texas, locating in an oil-abundant school district is positively correlated with student outcomes. That is, charter schools perform better than their rival traditional public schools in oil-rich districts. Column (2) shows that, in non-oil producing districts, charter schools perform worse than traditional public schools by 2.905%, and that traditional schools have better student achievement in non-oil districts. Column (4) is consistent with this result. For all traditional public schools, locating in an oil-rich district is negatively correlated with student scores. Traditional schools would do better if they were located in oil-scarce districts.

There are a few reasons why charter schools perform better than public schools in resource-rich districts whereas public schools only have an advantage in resource-scarce districts. The first reason concerns the issues of student mobility in oil-abundant districts. Oil workers and their families go wherever the oil jobs go; it's called "revolving poor" (Ratledge and Zachary, 2017). Because school districts do not know when a student might arrive or leave, it creates a great challenge for school districts' central budgeting and curriculum planning. The long bureaucratic process puts the traditional public school system at an even bigger disadvantage.

Funding of public schools is approved and coordinated by the board of school districts. When there is a big spike in the student population in traditional public schools, especially during the school year, school districts would have to re-budget education expenditure from local revenue, readjust state revenue and coordinate with federal funding. All of these processes are time-consuming. Whereas charter schools have direct supervision of their budget hence they are more flexible. When there is a surge in student population, charter schools have the autonomy to allocate resources accordingly at their own initiative in a timely manner. That would dramatically increase students' learning experience hence increasing the education outcome.

The second reason is that oil companies are directly funding and raising funds for charter schools. Due to the influx of oil and gas workers, energy producers raise and donate funds to expand existing charter schools or open new charter schools. New oil projects would bring in more families hence leading to overcrowding in public schools. The oil industry does not have authority over school districts on how and when resources would be allocated. Directing funding is the best solution for overcrowded schools hence more workers and their families could settle in. In some cases, oil companies have first-hand knowledge of when there would be an influx of workers; therefore, oil groups are able to prepare for the spike in student population by expanding or opening charter schools in advance. So when new workers moved in, their children would have enough resources in charter schools. However, when it comes to traditional public schools, the budget of each public school district is made according to the number of students in the previous year. Hence, public schools are unable to increase the funding until the spike of the student population has already happened. Students' outcomes will be negatively influenced when the classrooms are overcrowded.

The third reason originates from the existence of teacher unions. As a result of the increasing student population in oil-producing school districts, both charter schools and public schools need to hire more teachers. The difference is that teachers in public schools are unionized whereas teachers in charter schools are not. Public schools can only hire teachers with qualifications that teachers' unions approve of; however, charter schools are less restrictive on teacher qualifications. [5] When facing an influx of students, charter schools are not restricted by teacher unions' monopolistic requirements. Also, the salary of teachers in charter schools is merit-based. Public schools, on the other hand, have a smaller supply pool of teachers because they have to hire "qualified" teachers (who are later impossible to fire due to the teacher unions). Moreover, Traditional public school teachers' salaries will increase

[5]For example, a retired Physics professor with 30 years of university teaching experience cannot teach in public schools because he does not have a teaching qualification. However, a 22-year-old graduate with an Educator degree and 2.5 GPA can teach in public schools because her degree qualifies.

regardless of their teaching ability. Student outcomes are not linked with teachers' performance. Therefore, in oil-rich school districts where charter schools pose a valid competition for traditional public schools, students in charter schools achieve significantly better results.

I also estimate the academic performance of economically disadvantaged students. As shown in Table 5, for poor students, there is a strong correlation between student outcomes and locating in an oil-producing district. If a school was located in an oil school district, there would be 3.392% fewer poor students with Masters level grades. Compared with the outcomes of all students in Table 3, schools in oil-rich school districts create slightly worse outcomes for economically disadvantaged students, - 3.392%, compared with all students - 3.323%. Estimation with subgroups gives a more detailed result. Column (1) of Table 6 shows that, in oil-rich districts, charter schools' superior academic performance still holds even for economically disadvantaged students. Meaning that poor students in oil-abundant districts achieve better test scores in charter schools than in traditional public schools. Compared with the estimates of Column (1) in Table 6 and Table 4, the advantage of a charter school for poor students (2.61%) is not as large as their advantage for all students (3.019%). Column (4) in Table 6 suggests that poor students in traditional public schools would be doing worse off if the schools were located in oil districts. Comparing the estimates of Column (4) from Table 4 and Table 6, one would find out that traditional public schools generally achieve inferior academic performance in oil districts, (- 1.579%), but it is particularly worse for economically disadvantaged students (-1.975%).

4.6 Conclusion

This study reveals the complex relationship between student performance, school choice, and the oil boom. To determine the effectiveness of charter schools, it is not enough to simply compare charters with traditional schools; it is essential to take into account school location, especially in oil-producing states like Texas.

The results of this paper illustrate a particularly interesting pattern. Overall, it seems that, as previous studies suggest, charter schools are worse off for student performance (Bettinger, 1999). However, when considering the impact of the oil boom on charter schools and traditional schools, the estimation reveals that charter schools actually achieve better academic results in oil-rich districts. Hence charter schools have an advantage over traditional public schools in energy-producing districts. Traditional public schools, however, are only in a better position if they are located in oil-scarce districts.

The advantage of charter schools also applies to economic disadvantaged students in oil-abundant districts. Charter schools carry out a flexible curriculum so that they can select their course material to meet students' needs. Due to the flexibility of the curriculum, charter schools are able to effectively help students with a particular talent for arts, technology, or music. Public schools, however, are unable to do so. The critics of charter schools argue that a flexible curriculum would only leave poor students behind. My paper offers a more nuanced perspective.

When it comes to the impact of oil abundance on school performance overall, my results suggest that test scores of schools located in oil school districts are lower than the schools in non-oil school districts. The reason behind low performance in oil-rich districts could be the increased teacher turnover. Because oil production provides better economic opportunities, and expands the wage gap between the private and education sectors, which could have led teachers to leave schools (Marchand and Weber, 2020). Further investigation shows that, in oil-abundant districts, the oil boom positively contributes to charter schools whereas impacts traditional public schools negatively. Hence, charter schools have an academic advantage and better test scores over their rival traditional public schools in resource-rich districts.

A few policy implications can be derived from this research. First, this study provides evidence in support of charter schools in oil-producing districts. Due to the inflexibility of budgeting and planning of traditional public schools, public education policymakers should prioritize funding for charter schools in places where their economy heavily relies on oil extraction. Second, officials in public school boards ought to communicate with local oil and gas producers and plan their budget a few years ahead, in order to lessen the risk of overcrowding in public schools due to a potential spike in student population.

Bibliography

[1] Bettinger, E.P. (1999) The Effect of Charter Schools on Charter Students and Public Schools. Occasional Paper.

[2] Bifulco, R., and Ladd, H. F. (2006) The impacts of charter schools on student achievement Evidence from North Carolina. *Education Finance and Policy*, 1(1): 50-90.

[3] Black, D. A., McKinnish, T. G., Sander, S.G. (2005) Tight Labor Markets and the Demand for Education: Evidence from the Coal Boom and Bust. *Industrial and Labor Relations Review*, 59(1) 3-16.

[4] Booker, K., Gilpatric, S. M., Gronberg, T., and Jansen, D. (2008) The effect of charter schools on traditional public school students in Texas: Are children who stay behind left behind? *Journal of Urban Economics* (64): 123–145.

[5] Brollo, F, Tommaso N, Roberto P, and Guido T (2013). "The Political Resource Curse." *The American Economic Review*. 103 (5): 1759–1796.

[6] Carr, M., and Ritter, G. (2007) Measuring the Competitive Effect of Charter Schools on Student Achievement in Ohio's Traditional Public Schools. *National*

Center for the Study of Privatization in Education (Columbia University) Research Paper, 146.

[7] Caselli, F, and Michaels, G (2013). "Do Oil Windfalls Improve Living Standards? Evidence from Brazil." *American Economic Journal: Applied Economics*. 5 (1): 208–238.

[8] Goldhaber, D. D., and Eide, E. R. (2003) Methodological thoughts on measuring the impact of private sector competition on the educational marketplace. *Educational Evaluation and Policy Analysis*. (25): 217-232.

[9] Gronberg, T. J., Janson, D. W. And Taylor, L. L (2012) The relative efficiency of charter schools: A cost frontier approach. *Economics of Education Review.* (31) : 302–317

[10] Guo, S., and Fraser, M. W. (2014). Propensity score analysis: Statistical methods and applications (Vol. 11). SAGE publications.

[11] Holmes, G.M., DeSimone, J. and Rupp, N.G. (2006). Does School Choice Increase School Quality? Evidence from North Carolina Charter Schools. *Improving school accountability* (14) 131-155.

[12] Imbens, G. W. (2000) The role of the propensity score in estimating dose-response functions, *Biometrika*, (87) 706–710.

[13] Jabbar, H., Fong, C. J., Germain, E., Li, D., Sanchez, J., Sun, W., and Devall. M. (2022) The Competitive Effects of School Choice on Student Achievement: A Systematic Review. *Educational Policy* 36(2): 247-281.

[14] James, A. (2017), Natural resources and education outcomes in the United States. *Resource and Energy Economics.* (49):150–164

[15] Marchand, J., Weber, G. J (2020) How Local Economic Conditions Affect School Finances, Teacher Quality, and Student Achievement: Evidence from the Texas Shale Boom . *Journal of Policy Analysis and Management*, 39(1): 36–63.

[16] Ratledge, N ,. and Zachary, L.,(2017) Public Education Impacts of Unconventional Oil and Gas Development The community impacts of shale gas and oil development. *An RFF initiative.*

[17] U.S. EIA, (2019) Drilling Productivity Report. https://www.eia.gov/petroleum/drilling/pdf/dpr-full.pdf (Access: 15 Mar 2019)

Table 1: School level Summary statistics

	Charter schools	Traditional schools	In oil districts	In Non Oil districts
Number of students	467.8	586.1	367.6	618.1
	(295.1)	(321.9)	(183.7)	(326.7)
Number of economic	326.3	359.9	215.1	385.4
disadvantage students	(241.8)	(250.0)	(143.1)	(256.4)
Number of teachers	28.54	39.80	27.93	41.09
	(20.34)	(19.62)	(11.72)	(20.47)
Percentage of all students	17.54	21.07	18.52	21.25
with Master level grade	(10.41)	(11.69)	(9.302)	(11.99)
Percentage of econ disad students	14.89	15.62	13.54	15.97
with Master level grade	(9.059)	(8.190)	(7.077)	(8.420)
N	2072	24550	4386	22236

Table 2: Mean of covariants

	Without weights		With IPW weights	
	Charters	Traditionals	Charters	Traditionals
students	407.265	538.538	548.127	527.784
	(300.711)	(336.679)	(372.891)	(334.154)
teachers	24.637	37.595	32.358	37.023
	(19.767)	(20.148)	(24.180)	(19.963)

Table 3: Regression of Education Outcomes for All Students

	% of all pupils above master standard
charter	**-1.960*****
	(0.321)
students	0.005***
	(0.001)
teachers	0.018***
	(0.004)
oil sd	**-3.232*****
	(1.132)
oil sd $\times$ number of students	0.010***
	(0.002)
oil sd $\times$ teachers	0.019
	(0.015)
year	0.446***
	(0.153)
Constant	-883.5***
	(307.7)

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Regression of student Outcomes of All Students

	School level outcome: Percentage of students with Master level grade			
	(1)	(2)	(3)	(4)
	In Oil sd	In Non Oil sd	Charter Schools	Traditional Schools
charter	3.019***	-2.905***		
	(1.146)	(0.307)		
students	0.0170***	0.00581***	0.00687***	0.00578***
	(0.00291)	(0.000783)	(0.00135)	(0.000282)
teachers	0.0359**	0.0186***	0.0237***	0.0213***
	(0.0148)	(0.00438)	(0.00839)	(0.00267)
year	-0.123	0.500***	0.198	0.645***
	(0.530)	(0.147)	(0.298)	(0.0674)
oil sd			4.459***	-1.579***
			(1.191)	(0.172)
Constant	259.9	-990.8***	-385.9	-1283.8***
	(1068.5)	(295.8)	(600.7)	(135.9)

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: Regression of Education Outcomes for Economic Disadvantaged Students

	% of econ disad pupils above master standard
charter	**0.092**
	(0.245)
number of students	0.002^{***}
	(0.000)
teachers	0.0145^{***}
	(0.003)
oil_sd	**-3.392*****
	(0.916)
oil_sd × number of students	0.008^{***}
	(0.002)
oil_sd × teachers	0.001
	(0.011)
year	0.404^{***}
	(0.109)
Constant	-801.2^{***}
	(220.4)

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: Regression of student Outcomes of Economic Disadvantaged Students

	Percentage of econ. disad. students with Master level grade			
	(1)	(2)	(3)	(4)
	In Oil sd	In Non Oil sd	Charter Schools	Traditional Schools
charter	2.610***	-0.336		
	(0.997)	(0.228)		
number of students	0.010***	0.003***	0.004***	0.002***
	(0.002)	(0.000)	(0.000)	(0.000)
teachers	0.016	0.014***	0.016***	0.016***
	(0.010)	(0.003)	(0.006)	(0.001)
year	-0.095	0.453***	0.183	0.558***
	(0.431)	(0.105)	(0.223)	(0.046)
oil_sd			1.323	-1.975***
			(0.995)	(0.128)
Constant	201.1	-899.4***	-357.4	-1111.6***
	(870.7)	(210.8)	(449.9)	(93.30)

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Chapter 5

Conclusion

5.1 Conclusion

This thesis investigates the impact of the oil boom on local environmental quality, local taxation and education expenditure, and educational outcomes. Using district-level data in the second chapter, I show that growth in oil and gas extraction activities attracts potential polluting firms. Undoubtedly, the increasing number of firms positively affects the local economy; however, one must not overlook the environmental impact. I find that the proportion of firms that report pollutant release is higher in oil-rich school districts. The environmental cost is even higher in MSA school districts where there is a dense population. The findings reveal that oil and gas exploitation could lead to considerable local environmental degradation.

In Chapter Three, I find out that oil and gas extraction generates a significant increase in the school district property tax base and total revenue per student for both metropolitan and rural school districts. The tax revenues from the oil industry are consequently allocated to local school expenditures; as a result, school districts with higher oil income are likely to have a higher level of total actual operational expenditure. Within the operation expenses, those school districts spend their budget mostly on instrumental educational expenditures and other expenditures. That is, revenues from the oil boom enhance student education spending.

The oil industry in Texas is heavily involved in the investment of local charter schools since the influx of workers and their families overwhelms traditional public schools. With school-level data, chapter Four, therefore, dives into the impact of the oil industry on education outcomes for traditional public schools and charter schools in both oil-rich and oil-scarce school districts. Charter schools overall produce worse academic performance compared with traditional public schools; however, charter schools in oil-producing school districts achieve higher test scores than their rival traditional public schools. The reason is that, with direct donations and fundraising from the oil industry, charter schools in oil-abundant districts are able to tailor a flexible curriculum to meet students' needs better hence the better academic performance. Also, the hiring pool of teachers is larger due to the different qualification standards, therefore charter schools would be better equipped to deal with any potential turnovers.

In sum, the oil boom substantially boosts the local economy by attracting more firms and bringing in higher tax revenues. The tax income from oil extraction is then allocated to local education operational expenditures; consequently, oil abundance improves educational spending per student. In oil-producing school districts, especially, not only do oil firms contribute to public schools through taxation, but they also directly invest in local charter schools. Hence, charter schools in school districts with oil and gas have better educational outcomes than traditional public schools in the same area. However, behind all the contributions to public taxation and public goods is the environmental cost of oil extraction. Worse, metropolitan districts are disproportionally Influenced by the negative environmental impact.

5.2 Policy recommendations

For policy-makers in oil-rich areas, the goal is to ensure public good provision (through the oil income) and simultaneously protect the local environment from pollution. It is a hard balance to achieve. On one hand, politicians need to secure the oil tax revenue so that local public goods and services are properly provided. On other hand, regulators must protect the well-being of local people from all the pollution brought by the oil boom. Over-regulation would lead to a potential decline of tax revenue from oil and gas firms, which would reduce education expenditures and hence worsens educational outcomes. More, over-regulation could also disincentivize the fossil fuel industry in investing in local charter schools. However, the common understanding is that lack of regulation could potentially lead to environmental degradation which would jeopardize people's health.

The author thinks this dilemma might not be an issue that local or even federal officials can solve, especially when it comes to the environmental impact of oil-extracting activities. Government regulation might not be the best means of achieving environmental protection since any level of government will face the same dilemma - a choice between oil income and public well-being. Perhaps the government could try to return environmental protection to the private domain. The issue of pollution control could be solved by the protection of property rights. The lawmakers shall create liability for environmental harms through common law liability. Where property rights are protected, an upstream polluter can be sued by a downstream property owner for the monetary damages, because harming someone's property by polluting is no more acceptable than vandalizing it – and this would result in a better responsibility and incentive for landowners to reduce the pollution. In that case, the government can still collect tax revenue from the oil industry to ensure public goods provision and simultaneously achieve better goals for environmental control.