Natural Resource Booms, Human Capital, and Earnings: Evidence from Linked Education and Employment Records

Alina Kovalenko *

October 19, 2019

Click here for the latest version

Abstract

This project examines the role of the local economic conditions in human capital accumulation decisions. I exploit geographic and temporal variation in the recent fracking oil and gas boom which improved labor market opportunities for young men and women. Using administrative panel data on the universe of students attending public schools in Texas, I find that cohorts exposed to the fracking boom during high school experienced higher absence rates, higher incidence of grade retention, and lower rates of high school graduation. These effects are largest for students in the bottom of the ability distribution, who were likely on the margin of dropping out. By linking students to their administrative employment records, I show that increased work and earnings during high school, concentrated in food and retail sectors, play a large role in explaining negative impacts on human capital. Next, I follow up on these students as they transition into post-secondary education and find lower rates of college enrollment, with effects driven by community colleges. Despite worse academic outcomes, these students experience benefits to employment and earnings that persist up to six years past expected high school graduation. I conclude that improved labor market opportunities are an important determinant of human capital investment.

JEL Classification: I20; J24; O13

Keywords: Human capital, schooling, fracking, earnings

*The University of Texas at Austin, alinakov@utexas.edu.

1 Introduction

Educational investment decisions are among the most important made by an individual. Decisions about when and how much human capital to acquire have long-run implications for the individuals making these choices as well as for society more broadly. A substantial body of research shows that individuals' educational choices are responsive to such aggregate economic shocks as recessions (Clark, 2011), housing booms (Charles, Hurst and Notowidigdo, 2018, Lovenheim, 2011), and trade shocks (Atkin, 2016; Edmonds, Pavcnik and Topalova, 2010). A small literature focusing on natural resource booms in particular (Black, McKinnish and Sanders, 2005, Cascio and Narayan, 2015) has documented a negative response of educational attainment in the short run. However, we know relatively little about how these shocks affect human capital beyond educational attainment, whether these effects vary for groups of different socioeconomic status and ability, and most importantly, what the effects are in the longer time horizon.

Recent technological innovations in extraction technology combined with high oil and gas prices created localized booms across many areas of the United States, causing increased employment and earnings (Feyrer, Mansur and Sacerdote, 2017, Winters et al., 2019). This study considers whether these shocks influence schooling and work decisions of young adults in order to learn about both the determinants of human capital investment and the effects of the fracking boom. Standard theories of human capital predict that by improving employment opportunities and earnings, such booms may discourage young individuals from finishing high school or attending college, particularly for students of lower ability or those on the margin of graduating or enrolling. On the other hand, improved economic conditions may lead to better educational outcomes if they allow students and families to spend less time working and more time on school, or if they lead to an increase in school resources. Since the ex-ante effect of natural resource booms is ambiguous and may also depend on where students fall in the ability distribution, this paper examines it empirically in the context of the fracking technological revolution.

Specifically, I utilize unique administrative data from the state of Texas to study how the fracking oil and gas boom affected human capital and earnings of both the average student and of students in different parts of the skill distribution. The data are highly detailed and allow me to track students from elementary school through high school and into college. Furthermore, they are merged with earnings records derived from unemployment insurance files, allowing me to track employment outcomes. These records cover the universe of almost 20 years of graduating high school cohorts and include rich information about students' attendance, performance on standardized tests, college enrollment, and graduation. I combine these data with a rich oil and gas well-level database maintained by DrillingInfo and information on shale plays and reserves from the Energy Information Administration (EIA).

My empirical approach exploits regional variation in pre-determined geological endowments of unconventional oil and gas deposits contained in shale formations. They lie deep below the ground, and up until the invention of horizontal drilling and hydraulic fracturing techniques in early 2000s, were considered economically and technically infeasible to produce. In other words, these resources went from having essentially no real value to becoming extremely valuable in a very short period of time. I combine this geographic variation with the timing in the onset of the boom and estimate a dynamic difference-in-diference model, which allows me to assess the evolution of relative outcomes while controlling for fixed differences across commuting zones and cohorts of students.

I find that the fracking boom had a significant impact on performance and graduation of high school students. My preferred estimates suggest that the boom in an area with average fracking exposure led to a 0.4 percentage point (pp) increase in absence rates and a 1.87pp increase in grade retention relative to means of 4% and 19%, respectively. I additionally estimate that cohorts exposed to the boom had a significant negative impact on high school completion, with 2.3pp decrease at the mean of 77%. These effects are most pronounced for those in the bottom quartile of the ability distribution: absence rates, grade retention and high school graduation are most responsive for students who score lowest on sixth grade math and reading standardized tests.

I next link each high school student to their administrative employment records and show that improved labor market opportunities play a large role in explaining the negative impacts on human capital. In particular, I find that employment and earnings increased by 8.7% and 14.8% respectively for both young men and women. As a result, some students put less effort into course work while other students chose to drop out altogether. Moreover, heterogeneity analysis by industry suggests that jobs in retail and food services accounted for much of the labor market gains. This is in line with results from existing literature which finds that the biggest employment and earnings benefits associated with the fracking boom accrue to workers employed outside the oil and gas industry (Winters et al., 2019).

Having documented short-term effects, I follow up on the cohorts that were exposed to the boom during high school to examine their later life outcomes as they transition into post-secondary education and the labor market. Using administrative college records, I show that the fracking boom is associated with decreased college enrollment. This decrease is almost entirely driven by enrollment in 2-year community colleges, suggesting that it is affecting students who were on the margin between not going to college and obtaining an associate's degree. In contrast, there is no evidence of a change in public four-year university enrollment. I also consider college graduation and show that there is evidence of small negative impacts on both two- and four-year institutions. Finally, I find that students with the lowest predicted probability of college-going (based on test scores and demographics) experience positive effects on earnings up to six years after expected high school graduation. On the other hand, no statistically significant long-term effect is found for students who were most expected to attend college. This suggests that decisions to invest less in human capital may be partially justified by improved outside options rather than simply myopic behavior.

Why are youth so responsive to the fracking boom? Increased opportunity cost of schooling is the most likely explanation for my findings, as cohorts of students whose educational outcomes were most affected, also experienced the biggest improvement in the labor market. I investigate other potential channels but find little evidence that selective migration and increased school spending can account for my results. I see suggestive evidence of a decrease in teacher quality, consistent with Weber et al., but I show that these decreases would have to be substantially larger to explain my findings.

Broadly the results of this paper contribute to a large literature studying the effects of aggregate economic shocks on human capital in both developed and developing world. These studies include but are not limited to trade shocks in Mexico (Atkin, 2016), infrastructure programs in India (Adukia, Asher and Novosad, 2017), and coal booms in the U.S. (Black, McKinnish and Sanders, 2005). These papers exploit variation in the intensity of localized economic shocks and show that economic booms are generally associated with worse contemporaneous schooling outcomes. My paper is most closely related to a smaller literature looking at the impacts of the fracking boom on educational attainment of young people (Marchand and Weber, 2019; Cascio and Narayan, 2015; Zuo, Schieffer and Buck, 2019). My analysis is consistent with results of these studies and confirms that students respond to improved labor market opportunities by reducing high school graduation and college enrollment in the short run.

I contribute to the literature in three ways. First, to my knowledge this is the first paper to look at long-term, individual-level outcomes of any type, including human capital, in response to fracking exposure. I estimate the effect of exposure to the fracking boom in high school on both contemporaneous and later-life schooling and labor market outcomes. Second, while previous work mainly focused on educational attainment and enrollment at high levels of geographic aggregation available from the Census or ACS, my data allow me to observe more detailed measures of human capital such as standardized test scores, absence rates, grade retention, and track individuals throughout high school, college, and the labor market. These outcomes provide a more complete picture of how economic conditions affect students' paths through the human capital accumulation process. I am also able to directly analyze student labor supply by linking individuals' educational outcomes to their employment and earnings records, which until now was a hypothesized but unmeasured mechanism. Third, having panel data in this context also allows me to distinguish which types of students were affected, both in terms of demographic characteristics and prior ability, and thus is crucial for policymakers seeking to make informed decisions when evaluating the consequences of fracking.

Finally, although existing work documents a sizable migration response into the fracking areas (Wilson, 2016), the majority of work examining educational response to the fracking boom had limited information about students' mobility over time. In this study, I observe every student in public school system of Texas, and thus I can directly separate newly arrived migrants from pre-existing populations. This represents an important improvement on prior work as it allows me to distinguish between changing attitudes towards educational investment of local residents from simply picking up fixed characteristics of incoming workers. Furthermore, given the extent and the length of the fracking boom, identifying its effects on educational investment decisions of individuals is of substantial policy interest in its own right.

The rest of the paper is organized as follows. Section 2 provides background information on fracking boom. In Sections 3 and 4, I describe the data and research design. Section 5 examines the effects of the boom on educational and labor market outcomes of high school students. Section 6 discusses robustness tests and Section 7 presents long-run analysis of college outcomes and earnings. In Section 8, I describe alternative mechanisms, and finally, Section 9 concludes.

2 Background: Fracking Boom

Over the past decade, the interaction of technological change and increased energy prices fueled big shale oil and gas booms in the United States. Shale is a sedimentary rock that sits miles beneath the ground and contains large quantities of oil and natural gas. Unlike conventional deposits which are found in pockets, shale oil and gas are dispersed throughout the formation in thin layers, and drilling it vertically is not efficient. However, the advancements in hydraulic fracturing (known colloquially as "fracking") and directional drilling made it economically and practically feasible to extract resources from previously inaccessible formations. This is done by injecting water, sand and chemicals at high pressure into a directionally drilled well to create small fractures and release trapped oil and gas. These innovations, combined with high prices in mid-2000s, generated localized fracking booms across many areas of the United States. [1]

Texas is a major player in the energy market and sits on top of five major shale formations. The Permian and Eagle Ford are located in the west and south of Texas, while the Barnett, Granite Wash and Haynesville are found in the north and east of the state respectively (Figure 1). Oil and gas deposits contained in these shale formations went from having essentially no real value to becoming extremely valuable in a very short period of time. This resulted in record-high levels of drilling and production.[2] The top left panel of Figure 2 shows the number of new oil and gas wells drilled from 1994 to 2017. The numbers were quite stable until early 2000s, however the introduction of the new technology and soaring prices caused the drilling activities to increase by about 350% over the next decade. This resulted in unprecedented levels of crude oil and natural gas production which more than tripled between 2005 and 2017 (bottom panels of Figure 2).

Oil and gas extraction boom had substantial effects on local labor markets, both directly through employment in the oil and gas industry and indirectly via spillover effects to other industries (Allcott and Keniston (2017); Maniloff and Mastromonaco (2017)). Top right panel of Figure 2 shows that employment in the oil and gas extraction industry in Texas was relatively flat up until mid 2000s, but grew rapidly from 2005 to 2014, consistent with the expansion of drilling. Moreover, Feyrer, Mansur and Sacerdote (2017) find that each million dollars in oil and

[1]Energy Information Administration estimates that crude oil production from hydraulically fractured wells now makes up about one half of total U.S. marketed oil production. This share is even greater for natural gas, where fracking accounts for about two-thirds of current U.S. natural gas production (Today in Energy, EIA: https://www.eia.gov/todayinenergy/detail.php?id=26112)

[2]Texas produces more than 40% of the total U.S. crude oil production, and has more than one-third of U.S. oil reserves. It is also one of the top natural gas producing states holding one-fourth of total gas reserves and producing 30% of total U.S. natural gas production (EIA, 2018).

gas production led to an additional $80,000 in wage income in producing counties with 40% of that income attributable to workers outside the oil and gas industry.

The shale oil and gas boom offers a unique quasi-natural experiment for analyzing how economic conditions affect human capital. Importantly for educational decisions, the boom has been viewed as a long-run shock to local economic activity by industry executives, independent researchers and politicians (EIA, 2015). For my main analysis, I date the start of the boom in Texas to 2005. The figures described earlier in this section support this choice, as it is clear that extraction activity and employment was largely unchanged until mid-2000s. In Section 6, I show that my results are robust to alternative ways of defining timing.

3 Data

3.1 Administrative Education and Earnings Data

The data used in this project come from several sources. The main administrative student-level data come from the Texas Education Agency (TEA) and the Texas Higher Education Coordinating Board (THECB). These records are also linked to the quarterly earnings data from the Texas Workforce Commission (TWC).[3] Importantly for the analysis, these data allow me to follow students from elementary to high school and as they transition into college and ultimately as they enter the labor market, as long as they stay in Texas.

The main sample for the analysis consists of about 4 million individual observations for 18 cohorts of students who started high school between 1996 and 2014. I define cohorts by the academic year in which students first entered grade 9. These records include demographic characteristics such as gender, age, race/ethnicity, indicators for whether a student receives free or reduced price lunch, participates in a gifted program, and receives special education. I also observe students'

[3] Access to these datasets was obtained through a restricted-use agreement with the Texas Education Research Center (ERC), a research center and data clearinghouse of the University of Texas at Austin.

enrollment, attendance, and test scores on standardized exams. To define high school graduation, I link students' 9th grade enrollment records with their respective graduation records up to 5 years later.[4] I associate students with the school district in which they were enrolled in grade 6, and I don't include students who show up in high school enrollment records but were not in the state of Texas in middle school.[5]

The test score data used in this study come from the state standardized exams for mathematics and English. I transform the raw scores on each test into a z-score with zero mean and unit standard deviation by state and cohort.[6] I focus on students' first-time test scores and I exclude scores of students who were recorded as zero due to illness or cheating, or who received a special education waiver or a limited-English proficiency exemption. I use students' 6th grade standardized test scores to examine heterogeneous effects of the boom by academic ability. I create a composite score from student's mathematics and English test scores, and then classify each student into quartiles based on their rank in the cohort-specific test score distribution.

The THECB records include information on college enrollment and graduation, which I examine separately by the type of institution: 2-year community college and 4-year public university. I also directly look at students' employment and earnings both during high school and up to 6 years after expected high school graduation.

This dataset has several important advantages. First, the ability to link TEA records to data from public institutions of higher education in Texas and quarterly earning allows me to

[4]I prefer this measure of high school graduation to graduation rates reported by the TEA for several reasons. First, graduation and dropout definitions used by TEA changed in mid 2000s and thus reported numbers are not comparable across years and cohorts. Second, although school districts are required to provide leaver records for students who were previously enrolled but don't return to school in the following year, they don't always perfectly know reasons for such changes. My measure of graduation, however, may overestimate high school dropouts if students are differentially more likely to move out of state from booming areas. In Section X, I show that affected areas are not associated with increased out-of-state migration.

[5]In Section X, I show that my results are robust even if I restrict my sample to students who were in Texas in grade 1.

[6]Texas Assessment of Academic Skills (TAAS) exam was administered until 2002, when it was replaced by the Texas Assessment of Knowledge and Skills (TAKS) exam. The new state exam, the State of Texas Assessments of Academic Readiness (STAAR), was implemented in 2012.

analyze the impact of the fracking boom on such previously understudied outcomes as college enrollment and completion, and students' labor market experience. Second, the panel structure and detail of the data allow me to explore heterogeneity in the impact of the boom by demographic characteristics and academic ability. Third, since the records cover every student in the public school system of Texas, they allow me to distinguish between pre-existing population and newly arrived migrants. A main limitation of the data, however, is that I only observe students who remain in Texas throughout my sample period.

3.2 Measuring Exposure to the Boom

To measure the extent of the oil and gas boom, I use shapefiles of shale plays and basins as well as measures of oil and gas reserves from the Energy Information Administration (EIA). To construct predicted shale reserves per capita, I follow Cascio and Narayan, 2015 and Michaels, 2010, and use data on maximum reported reserves separately for oil and gas contained in each shale from the EIA. To assign these reserves to commuting zones, I overlay shale maps with commuting zone boundary shapefiles in GIS, and allocate oil and gas reserves to commuting zones based on the share of each shale that they represent. I then convert these reserves into one common metric defined by millions of British Thermal Units (MMBTUs), which represents energy content, and divide it by 1995 population. Lastly, I supplement these data with information on drilling and production at the county level which comes from DrillingInfo and Texas Railroad Commission.

Figure 3 displays geographic variation in the fracking potential across commuting zones in Texas measured by the shale oil and gas reserves per capita. There is significant variation in predicted reserves per capita across the state with clusters of high-reserve areas in the west and south. To investigate whether shale reserves are correlated with actual drilling, I regress newly drilled wells on interactions between reserves per capita and year indicators, year and commuting zone fixed effects. I plot regression coefficients on interactions in Figure 4, separately for conventional and unconventional wells.[7] As expected, areas with high fracking potential saw significant increases in unconventional oil and gas wells starting from around 2005 and particularly in 2010 and later. However, there is no evidence of an impact of shale reserves on drilling of conventional oil and gas wells.

3.3 Summary statistics

Table 1 reports summary statistics of pre-boom observable characteristics for students and community zones in the sample. 77% of students in the average commuting zone at baseline graduate from high school in four years, and 24% and 42% enroll into 4-year and 2-year colleges in the next two years after expected high school graduation. The average absence rate is 5% and the share of students in the sample who repeat at least one grade during high school is 19%. About 75% of students work during high school at least for one quarter and on average they earn $700 per quarter (calculated including individuals with zero earnings). The full sample contains approximately 3,800,000 students.

Columns 2-4 split the sample into different groups by potential exposure to the boom: commuting zones with zero shale reserves per capita, and those with low and high reserves. Shale areas with positive oil and gas reserves are similar on average to other shale areas with different level of reserves and to non-shale areas along many dimensions, including educational and labor market outcomes. However, commuting zones without any shale deposits have higher shares of Hispanic students and students who receive free lunches, as compared to the rest of the sample. These differences in means between areas with and without reserves do not threaten the internal validity of the main results, as the causal interpretation relies on the parallel trends assumption. Furthermore, in the robustness section, I show that my estimates are similar if I exclude commuting zones with zero reserves from my analysis.

[7]Following prior research, I count horizontal and directional wells as "unconventional" or as drilled on a shale, and vertical wells as "conventional".

4 Research Design

One of the main challenges in estimating the relationship between the fracking boom and educational outcomes is that the decision to extract oil and gas by companies or to permit drilling activities by local communities may be endogenous. Although major policies governing fracking activities are set at the state rather than local level, some wealthy communities may attempt to ban resource extraction due to health concerns. Struggling communities, on the other hand, may be more willing to accept drilling in the hopes of attracting employment or tax revenue. Likewise, drilling companies may choose to operate in areas with more favorable labor market and legal environment. Therefore, using actual drilling or production to measure exposure to the boom might introduce omitted variable bias if the same characteristics that attracted firms also affect individual education decisions.

The empirical approach in this paper is based on the fact that shale oil and gas deposits are unevenly distributed across the state, and the recent invention of fracking technology generated quasi-experimental variation in the fracking potential that is not driven by pre-existing demographic and labor market characteristics which may affect educational decisions. Similar to Cascio and Narayan (2015), I utilize variation in pre-existing geology measured by shale oil and gas reserves per capita to compare commuting zones that were more or less exposed to the treatment as the boom evolved. I date the start of the boom in Texas to 2005.

I estimate the following equation:

$$Y_{izc} = \sum_{k \neq 2001} \beta_k \times \mathbb{1}(k = c) \times Reserves_z + X_{izc}\theta + \gamma_z + \gamma_c + \epsilon_{izc}, \tag{1}$$

where Y_{izc} is an outcome of interest for student i in cohort c and commuting zone z. $Reserves_z$ represents predicted shale reserves per capita, and $\mathbb{1}(k = c)$ is a set of dummy variables equal to one if cohort c was in 9th grade in year k. The vector X_{idt} includes student-level demographic controls such as race/ethnicity, gender, and indicators for special education and free lunch status.

I normalize β_{2001} to zero, so all coefficients can be interpreted as changes relative to the cohort that started high school in 2001, i.e. the last never treated cohort. Cohorts that enrolled in years $k = (2001, 2002, 2003)$ are partially treated since they were already in their sophomore, junior, or senior years of high school when the fracking boom began. Fully treated cohorts (i.e. students who enrolled in 9th grade in the first year of the fracking boom or later) correspond to $k \geq 2005$. Therefore, each estimate of β_k provides the change in outcomes in more affected relative to less affected commuting zones for cohorts that start 9th grade in year k, as compared to the last fully untreated cohort.

The variables γ_c and γ_z are cohort and commuting zone fixed effects, respectively, and are included to control for observed and unobserved factors that are common to a given cohort across all commuting zones and to account for observed and unobserved differences of a given commuting zone that are constant over time. The standard errors are clustered at commuting zone level.

I also consider a modified version of a difference-in-differences model in Eq. (1) above, but which replaces year dummies with two indicators for being fully and partially treated. This strategy summarizes the impact of the boom more concisely and increases the power of the estimates. The exact specification is:

$$Y_{izc} = \beta_1(Reserves_z \times Partial_c) + \beta_2(Reserves_z \times Full_c) + X_{izc}\theta + \gamma_z + \gamma_c + \epsilon_{izc}, \tag{2}$$

where $Partial_c$ equals to one if a student was in 9th grade between 2002 and 2004, and $Full_c$ equals to one if a student was in 9th grade in 2005 or later. All other variables remain the same.

The key identifying assumption is that the trends in educational outcomes in commuting zones with different levels of fracking potential would continue to move in parallel in the absence of the boom. While fundamentally untestable, event study specification in Eq. 1 can help assess its validity by looking at estimates of β_k in the pre-boom period. If the parallel trends assumption holds, we would expect that β_k would be indistinguishable from zero for $k < 2001$. I will show that this is the case in the next section.

5 Main results: high school outcomes

5.1 School attendance

I first examine whether oil and gas shale boom differentially affected school attendance in areas with high reserves. I calculate absence rate for each student as the number of days absent divided by the total number of days taught. I primarily focus on absences in 9th grade of high school to capture students' behavior before some of them decide to drop out.[8]

Figure 5 shows year-specific coefficients β_k from Equation 1, along with 95% confidence intervals. All estimates are calculated relative to the base group, k=2001, which is the last fully untreated cohort. Partially treated students (i.e. those who were in their sophomore, junior, or senior year of high school when the boom started) are represented in the region k $\in$ [-2002,2004] between the dashed lines. Year 2005 represents the first fully treated cohort, and region k $\geq$ 2005 includes cohorts who are fully treated. If absence rates for areas with different levels of fracking potential were trending similarly prior to the boom, the estimated coefficients associated with event times k $\leq$ 2001 would be small and not statistically significant. As expected, the estimates in pre-treatment region do not show a differential pre-existing trend in absence rates. This helps confirm the validity of the identifying assumption of the model. The rest of the estimates display a strong positive trend, consistent with the gradual expansion of the boom.

Table 2 presents results from the corresponding difference-in-differences approach described by Equation 2. Each column in this table reports estimates from running a separate regression. Columns 1 and 2 suggest that cohorts in commuting zones with average fracking potential ex-

[8] In Table X, I present results using absence rates for other grades - need to add.

perienced 0.4pp higher absence rates (10% increase evaluated at the mean of 4%).[9] These point estimates imply that students missed an additional half a day of school during their 9th grade, contingent on a standard 180-day school year. Columns 3 and 4 show that this effect is similar for both males and females.

I next consider whether students respond differentially to the boom based on where they fall in the skill distribution. I approximate students' ability by calculating their composite score on math and English standardized tests in 6th grade. In columns 5-8, I estimate the effects for students of different ability quartiles. While I do find a small positive effect on absence for fully treated students in the top quartile (0.16pp), the effect is three times larger among the lowest ability students (0.48pp).

5.2 Grade retention

I next examine whether the boom resulted in higher incidence of grade retention, which I define as a student's enrollment in the same grade for two consecutive years at any time during high school. The difference-in-difference results from the preferred specification shown in column 2 of Table 3 indicate that students in a commuting zone with average level of shale reserves per capita experienced 1.87pp higher likelihood of grade retention (9.8% increase at the mean of 19%). These estimates are precisely estimated and statistically significant at the 5% level. The event study plot (Figure 6) indicates that the effect happened soon after the boom and increased gradually over the years. Notably, the pre-boom coefficients are close to zero and statistically indistinguishable from the base year. As with attendance, the effects are present for both males and females. Results by ability suggest that only students in the bottom of the distribution were impacted.

[9] To convert estimates reported in tables into a more interpretable magnitude, I evaluate them at the mean level of shale reserves in a community zone with non-zero reserves, i.e. I multiply them by 0.21 millions of MMBTUs.

5.3 High school graduation

Having shown that absences and grade retention increase as a result of the boom, I now consider whether these changes resulted in lower rates of high school completion. As shown in Figure 7, the relative difference in high school graduation between different areas is close to zero in the pre-period. However, shortly after the beginning of the boom, I find a significant decrease in the probability of graduation for each treated cohort, as compared to the last untreated cohort. As before, the treatment effects appear to grow over time, with the boom having a larger effect on cohorts that begin high school 5-7 years after the introduction of fracking.

Table 4 presents results from a difference-in-differences model outlined in Eq. 2. The estimates from the main specification in column 2 indicate that students in an area with average fracking potential experience a 2.3 pp decrease in the probability of on-time high school graduation.[10] Evaluated at the mean graduation rate of 77%, this represents a 2.9% decline. Men experience a slightly higher 1.2% decrease in the probability of graduation as compared to 0.8% for women. In the remaining columns 5-8, I examine whether the effects are heterogeneous by prior ability. While the point estimates are marginally significant for all quartiles except the top, they are particularly large and precise for the lowest ability students. This is what one would expect if these students were on the margin of dropping out of high school anyway.

Taken together, the results suggest that there are trend breaks in educational outcomes shortly after the beginning of the boom, and that the pre-boom estimates are indistinguishable from zero. The heterogeneous results by ability accord with where we would expect the fracking boom to have the biggest effect on attendance, retention and graduation - students already on the margin of dropping out or putting little effort in school. I next show that this underinvestment in human capital can be explained by increased participation in the labor market.

[10] In Table X, I show similar estimates for five- and six-year high school graduation - add later.

5.4 Labor market outcomes

To identify the impact of the oil and gas boom on contemporaneous labor market outcomes, I link all students in each cohort of my main sample with their employment and earnings records when they are 15-18 years old. I then apply the same empirical strategy as before and report the resulting estimates in Table 5 and plot dynamic coefficients in Figure 8.

Column 2 of Table 5 reports a 7.7% increase earnings associated with the boom when evaluated at the average level of treatment. Column 1 of Table 5 reports the effect on average earnings which also includes those with zero earnings, and shows that cohorts in areas with average exposure to the boom earn about $103 more per quarter, which corresponds to a 14.8% increase when evaluated at the pre-boom mean of $697. These results imply that there are sizable responses on both extensive and intensive margins of labor supply.

In columns 3-6, I look at the probability of being employed overall and split by industry. I also consider "meaningful employment" defined as having administrative earnings of at least the prevailing state minimum wage of $5.5 over the sample period times 15 hours per week times 12 weeks per quarter. Thus, meaningful employment is coded as one if a student had earnings above $900 for at least one quarter during the time they were expected to be in high school.[11] The estimates show that the boom increased total employment of young individuals in areas with average exposure by 8.7% (evaluated at the mean of 73%). This employment response was particularly substantial in the food and retail sector, which historically tends to employ large shares of young individuals and which indirectly benefited from the fracking boom. I also can't rule out sizable effects on employment in oil and gas sector but these are not precisely estimated.

I supplement these results with an event study analysis in Figure 6 for each of the outcomes discussed above. There are three main takeaways: first, there is no evidence of pre-treatment trends in earnings and employment; second, there are significant increases in reported labor

[11] To be added soon.

market outcomes after the expansion of the boom; third, the effects are driven by the retail and food services industries, which indirectly benefitted from the oil and gas boom.

6 Robustness

6.1 Alternative specifications

In this section, I provide additional analysis intended to test the sensitivity of my main findings to a variety of alternative specifications. Table 6 considers different assumptions about the timing of the boom. Instead of using 2005 as the first year of the boom for all areas, I follow Bartik et al. (2019) who identify the first date that the fracking potential of each shale became public knowledge. This introduces additional temporal variation in when the fracking potential measured by shale reserves should have an effect. This exercise produces a very similar pattern of results.

In Table 7, I show estimates from Equation 2 focusing only on areas with non-zero shale reserves per capita. The estimates are similar in magnitude compared to the estimates from the baseline sample. Next, I replace my continuous measure of reserves with a set of dummy variables representing different quartiles of reserves per capita. I present the estimates in Figures 14-18 of the Appendix. The results are similar to the main continuous specification, and the magnitudes grow as one moves from the bottom to the top quartile of reserves per capita, as expected. Lastly, I show that my main results are not sensitive to the use of a linear probability model. In Table 8, I estimate the main specification as a probit and logit model. These estimates are very similar in both magnitude and precision to the main results.

6.2 Selective migration

The estimated effects on educational outcomes may be influenced by changing migration patterns. First, systematic migration into booming areas as a result of improved labor market opportunities has the potential to change the composition of individuals and lead to biased results. For example, if individuals who are more likely to invest less into schooling relocate to booming areas for work, then these areas may be disproportionately experiencing higher rates of high school dropouts, absences and grade retention. However, in my data I observe every student in the public school system of Texas, and thus I am able to directly identify pre-existing local population from newly arrived students. In particular, in my baseline sample I only focus on students who were already in the area in 6th grade, so I exclude students who appear later in the records from my analysis. In order to explore this issue even further, in Figure 9 I present event study plots estimated on a subsample of students who were present in the data as early as in first grade. These estimates are very similar to the ones using the baseline sample in both the magnitude and statistical significance.

Second, I explore whether there is evidence of increased out-of-state migration from booming areas in Texas as compared to areas that were not affected by the boom. Since I cannot track people who leave Texas, I may potentially be overestimating the number of dropouts if they finish high school elsewhere. To explore whether this is a concern, I use county migration data from the Internal Revenue Service which is based on year-to-year address changes reported on individual income tax returns. I calculate the rate of out-migration as the number of out-of-state migrants divided by the population in 1995, and regress it on my reserve measure interacted with year dummies. The estimates are plotted in Figure 10, and show no evidence of changing pattern of out-of-state migration, alleviating the concern that high school graduation results are driven my differential out-migration.[12]

[12] Do back-of-the-envelope calculation to determine how high out-migration would have to be in order to explain my results

7 Long-term results

7.1 College Enrollment and Graduation

The results so far indicate that students who experience increased labor market opportunities during high school invest less into their human capital. In this section, I consider whether students in areas affected by the oil and gas boom changed their enrollment and graduation from post-secondary institutions. I look at community colleges separately from public four-year institutions. The results for college enrollment within the next two years after expected high school graduation are reported in Table 9.[13] Panel A shows that the fracking boom is associated with a 1.86 p.p. decrease in community college enrollment in areas with one SD higher exposure to the boom, which is a 4.5 % decrease over the pre-boom sample average. In contrast, there is no evidence of change in public four-year university enrollment (Panel B). In columns 5-8, I present estimates for college enrollment split by ability. Interestingly, the largest response is reported at both the bottom and the top of the ability distribution. Some of this pattern is likely driven by the decrease in high school graduation, although the effect on community college enrollment is still higher than the decrease in high school graduation. The decreased likelihood of community college enrollment at the top quartile of the distribution may suggest that these students enroll into four-year universities instead. The corresponding estimates from the event study model are presented in Figure 7.

Table 10 explores the effect of the boom on probability of graduation from community college in four years and graduation from a public university in six years. I find evidence of a negative impact for both of these outcomes. I supplement these results with an event study analysis in Figure 8. I view these estimates as suggestive, however, since I am not able to observe six-year graduation records for some of my post-boom cohorts yet.[14]

[13] Looking at immediate college enrollment does not qualitatively change the results.

[14] Need to look at transfers from community college to 4-year university.

7.2 Adult Earnings

I now turn to the impact of the oil and gas boom on later life earnings. I do so by predicting the propensity of students' college-going by their demographic characteristics and test scores. In particular, I estimate a logit model by regressing an indicator for enrolling in any college on student demographics, 6th grade test scores, their interactions, and cohort and commuting zone fixed effects. I only include pre-boom cohorts in this estimation and use the estimates produced from this model to calibrate my prediction to include all cohorts. I then split the predicted probability of college-going into quartiles and look at adult earnings separately by each group.

The results for earnings measured 6 years after expected high school graduation are displayed in Figure 12. They suggest that cohorts in treated commuting zones who experienced negative impacts on human capital during high school and were less expected to attend college experience positive earnings effects six years after expected high school graduation, as compared to cohorts in areas not exposed to the boom. In contrast, there is no significant impact on earnings for the group with the highest predicted probability of going to college. While examining earnings of individuals with college education in their mid-20s is not ideal since prior work documents that college graduates exhibit steeper earnings trajectories (Canon, Gascon et al., 2012), there is little reason to expect that earnings of these students would be differentially affected had I examined them at a later point in time. This is because none of the outcomes of high ability students were affected in my analysis.

In summary, the fact that marginal students benefit from both short-term and later-life earnings and employment suggests that decisions to invest less in human capital may be partially justified by improved outside options rather than simply myopic behavior.[15]

[15] I'm still working on analysis of later-life earnings. I plan to add a back-of-the-envelope calculation evaluating how much increased earnings for bottom quartiles are explained by reduced college-going, expecting it to explain some but not all of the increase. I am also working on incorporating information on age earnings profiles to show that measuring earnings of groups with low education level at age 25-26 (which is what I am currently limited to) is representative of their later earnings. I also consider constructing earnings profiles from the ERC earnings data using earlier cohorts from control areas since I can observe them for a longer period of time.

8 Alternative Channels

I have shown that the recent fracking boom in Texas caused a decrease in human capital investment among high school and college students. I also presented evidence that these effects are driven by improved employment opportunities for young individuals and argued that the opportunity cost of schooling is the main mechanism. In this section, I discuss other possible explanations for my results. In particular, I explore two alternative hypotheses: school resources and teacher quality.

1) **School resources**. In Texas, oil and gas wells are taxed as real property at the local level once the wells start producing. Since local property taxes provide more than a half of total revenue for schools, expansion of the tax base may lead to higher school spending. In Figure 13, I show that the oil and gas tax base in treated areas experienced a large increase after the beginning of the boom. This was also reflected in school spending per student, which went up by more than $2,000 in exposed regions as compared to non-treated areas. Given the evidence that higher school spending has either insignificant or positive effects on human capital formation (Hyman (2017), Jackson, Johnson and Persico (2015)), the extent to which the fracking boom is associated with higher spending, this would lead to better educational outcomes in areas with greater intensity of extraction activities. But this is the opposite to what I find, and thus, it is unlikely that my findings reflect changes in school resources. [16]

2) **Teacher quality**. Improved employment and earnings in the booming and indirectly affected sectors may not only raise the opportunity cost of time for students, but also for teachers. As a result, teachers may leave the classroom causing negative effect on student outcomes. I use individual-level data on teacher characteristics which include experience, degree level, and earnings to explore this possibility. Table 11 shows that there was not a significant change in the number of teachers with advanced degrees and no change in teacher pay. There is a small but

[16] Need to add regression estimates for these outcomes to the table

significant positive effect on the share of teachers with low level of experience, suggesting that it may be contributing to the overall negative impacts on student outcomes, but it is too small to explain all of the main findings. [17] Overall, these results provide limited evidence that other factors play a substantial role in driving the negative effects of the fracking boom on students' educational outcomes.

9 Conclusion

Over the past decade, the shale revolution - a result of technological breakthroughs in horizontal drilling and hydraulic fracturing - has dramatically changed the energy industry and resulted in significant employment and earnings gains across many areas of the United States. I use it as an opportunity to investigate whether improved labor market opportunities affects students' human capital investment and earnings. The results of this analysis suggest that localized fracking booms led to higher incidence of grade retention, higher absence rates, lower probability of high school graduation and college enrollment. The findings also highlight that the effects are driven by the students in the bottom of the ability distribution. Despite worse academic outcomes, these students experience benefits to employment and earnings that persist up to six years past expected high school graduation.[18]

These estimates have implications for how the government might best respond to future booms. The responsiveness of educational investment decisions to aggregate economic shocks is an important factor in the design of optimal education financing policies. For example, if educational attainment decreases in times of major booms, then perhaps subsidies and additional financial aid for college could be increased to help offset this change. The results of this study have broader implications as well, since by changing schooling choices, fracking booms may affect aggregate human capital, potentially altering both labor productivity and employment probabilities of the

[17]Add student-teacher ratio and discuss the size of the effect on teacher experience more

[18]Need to discuss how my results compare to previous work

entire labor force for years to come. Future research examining the impacts of the current fracking boom in the longer run is warranted. [19]

[19] Need to think more about policy implications

References

Adukia, Anjali, Sam Asher, and Paul Novosad. 2017. "Educational investment responses to economic opportunity: evidence from Indian road construction." *Becker Friedman Institute for Research in Economics Working Paper*, , (2017-08).

Allcott, Hunt, and Daniel Keniston. 2017. "Dutch disease or agglomeration? The local economic effects of natural resource booms in modern America." *The Review of Economic Studies*, 85(2): 695–731.

Atkin, David. 2016. "Endogenous skill acquisition and export manufacturing in Mexico." *American Economic Review*, 106(8): 2046–85.

Bartik, Alexander W, Janet Currie, Michael Greenstone, and Christopher R Knittel. 2019. "The local economic and welfare consequences of hydraulic fracturing." *American Economic Journal: Applied Economics*, 11(4): 105–55.

Black, Dan A, Terra G McKinnish, and Seth G Sanders. 2005. "Tight labor markets and the demand for education: Evidence from the coal boom and bust." *ILR Review*, 59(1): 3–16.

Canon, Maria E, Charles S Gascon, et al. 2012. "College Degrees: Why Aren?t More People Making the Investment?" *The Regional Economist*, , (Apr).

Cascio, Elizabeth U, and Ayushi Narayan. 2015. "Who needs a fracking education? the educational response to low-skill biased technological change." National Bureau of Economic Research.

Charles, Kerwin Kofi, Erik Hurst, and Matthew J Notowidigdo. 2018. "Housing Booms and Busts, Labor Market Opportunities, and College Attendance." *American Economic Review*, 108(10): 2947–94.

Clark, Damon. 2011. "Do recessions keep students in school? The impact of youth unemployment on enrolment in post-compulsory education in England." *Economica*, 78(311): 523–545.

Edmonds, Eric V, Nina Pavcnik, and Petia Topalova. 2010. "Trade adjustment and human capital investments: Evidence from Indian tariff reform." *American Economic Journal: Applied Economics*, 2(4): 42–75.

Feyrer, James, Erin T Mansur, and Bruce Sacerdote. 2017. "Geographic dispersion of economic shocks: Evidence from the fracking revolution." *American Economic Review*, 107(4): 1313–34.

Hyman, Joshua. 2017. "Does money matter in the long run? Effects of school spending on educational attainment." *American Economic Journal: Economic Policy*, 9(4): 256–80.

Jackson, C Kirabo, Rucker C Johnson, and Claudia Persico. 2015. "The effects of school spending on educational and economic outcomes: Evidence from school finance reforms." *The Quarterly Journal of Economics*, 131(1): 157–218.

Lovenheim, Michael F. 2011. "The effect of liquid housing wealth on college enrollment." *Journal of Labor Economics*, 29(4): 741–771.

Maniloff, Peter, and Ralph Mastromonaco. 2017. "The local employment impacts of fracking: A national study." *Resource and Energy Economics*, 49: 62–85.

Marchand, Joseph, and Jeremy Weber. 2019. "How Local Economic Conditions Affect School Finances, Teacher Quality, and Student Achievement: Evidence from the Texas Shale Boom."

Michaels, Guy. 2010. "The long term consequences of resource-based specialisation." *The Economic Journal*, 121(551): 31–57.

Wilson, Riley. 2016. "Moving to economic opportunity: the migration response to the fracking boom." *Available at SSRN 2814147.*

Winters, John V, Zhengyu Cai, Karen Maguire, and Shruti Sengupta. 2019. "Do Workers Benefit from Resource Booms in Their Home State? Evidence from the Fracking Era."

Zuo, Na, Jack Schieffer, and Steven Buck. 2019. "The effect of the oil and gas boom on schooling decisions in the US." *Resource and Energy Economics*, 55: 1–23.

Figures

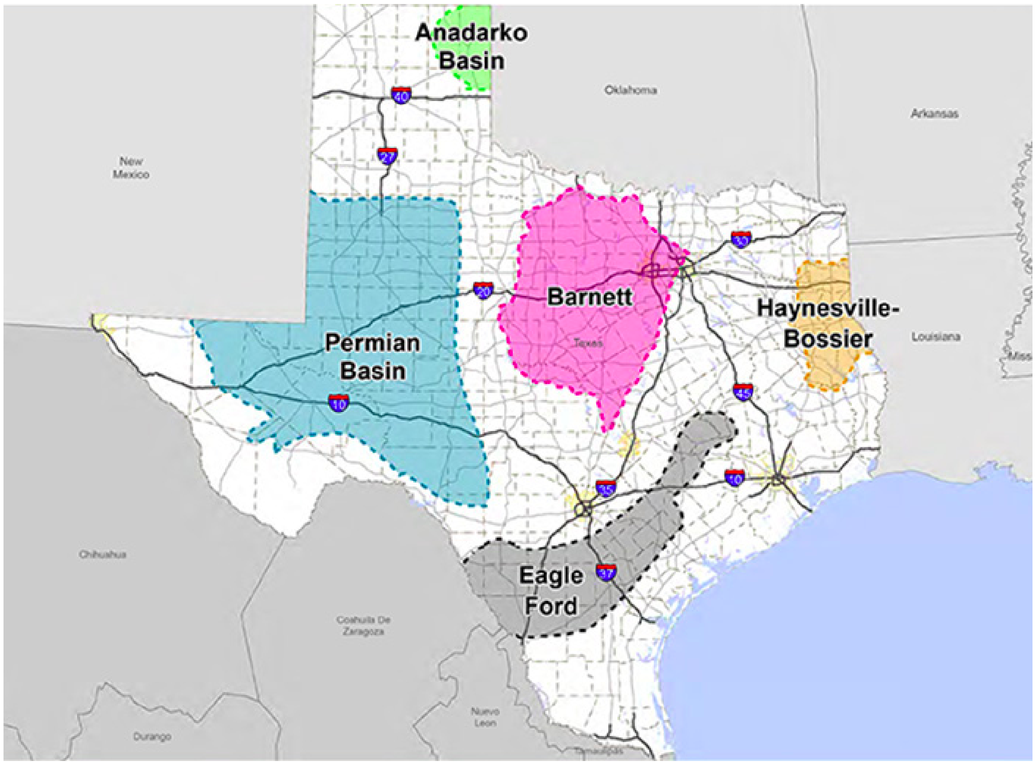


Figure 1: Shale formations in Texas

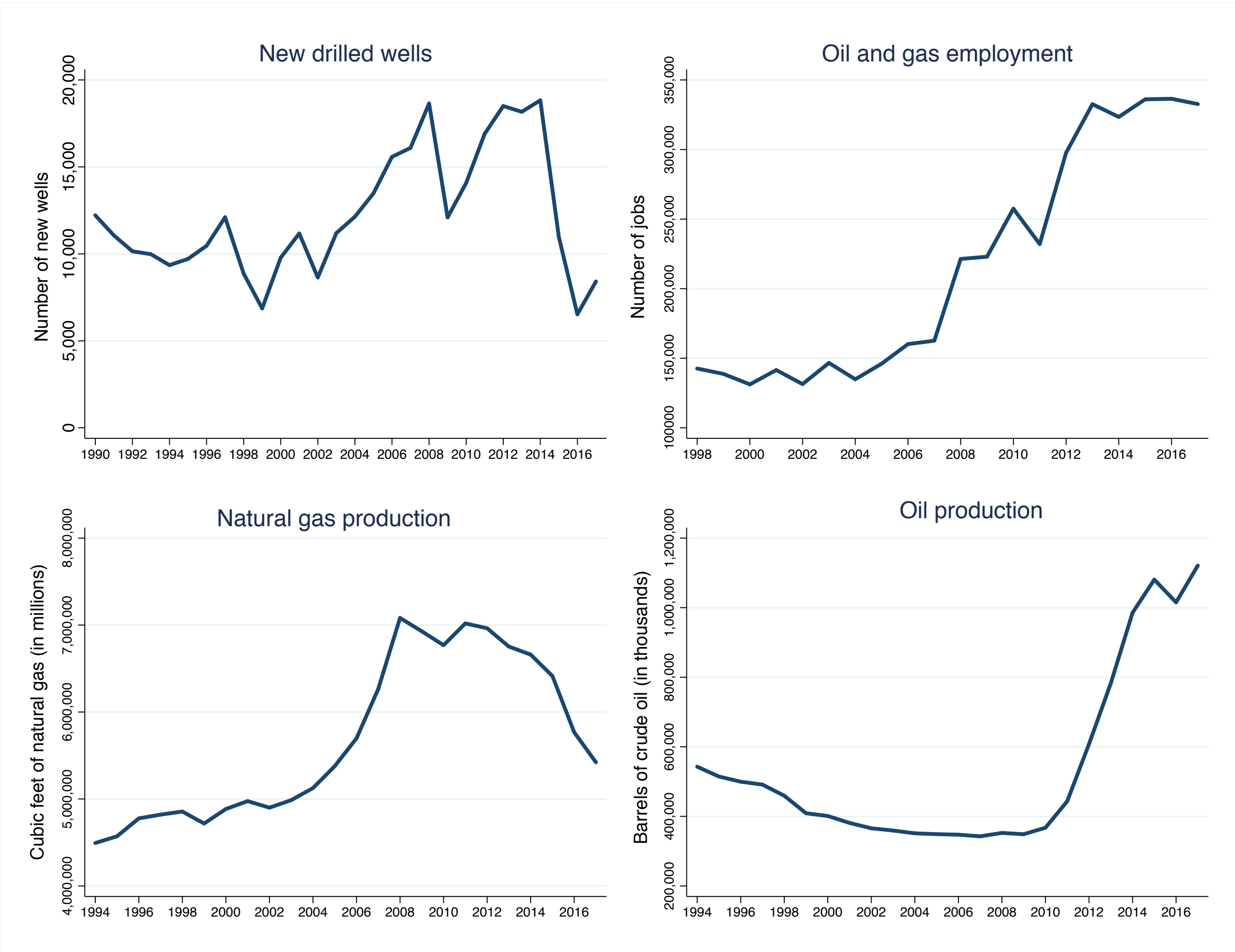


Figure 2: Oil and gas new wells drilled, production and employment

Source: Author's calculations from DrillingInfo, Texas Railroad Commission, and Bureau of Labor Statistics

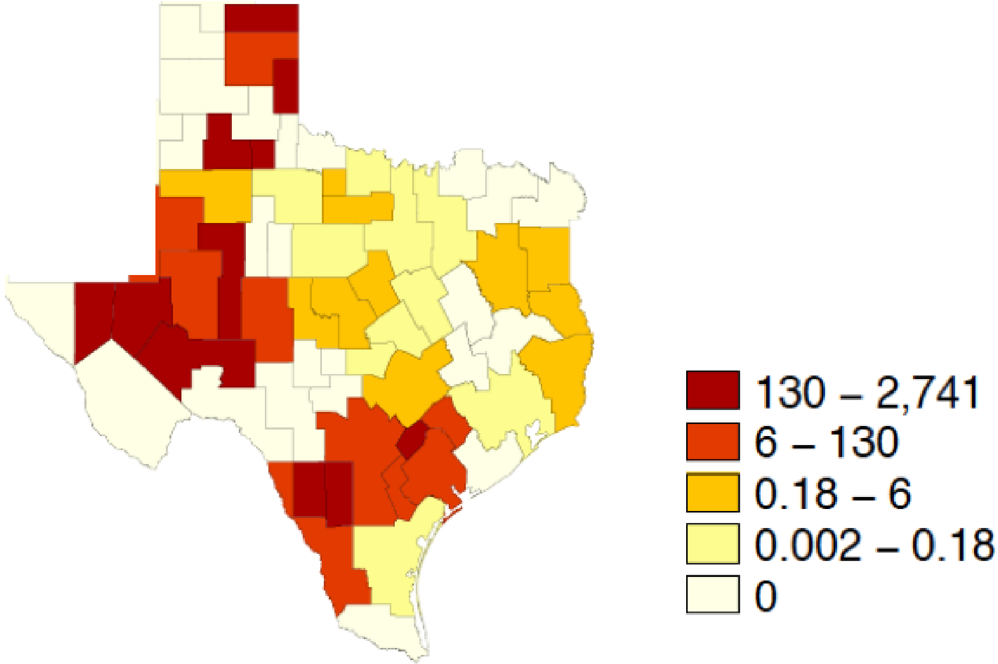
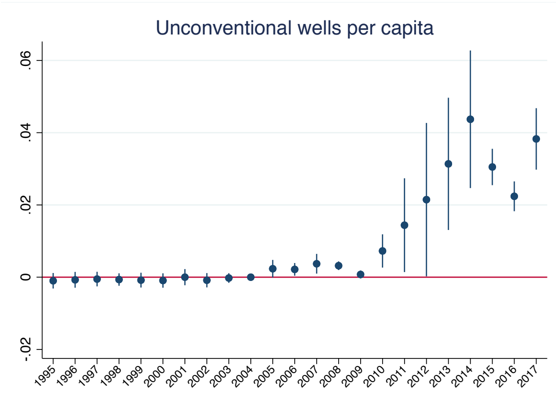


Figure 3: Predicted oil and gas reserves per capita in millions of MMBTUs

Source: Author's calculations from the Energy Information Administration



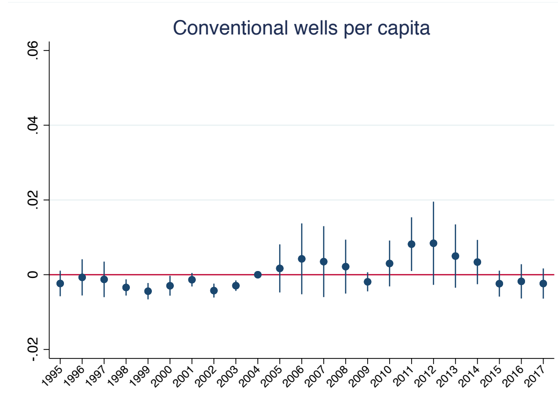


Figure 4: The effect of the fracking boom on oil and gas drilling, by well type

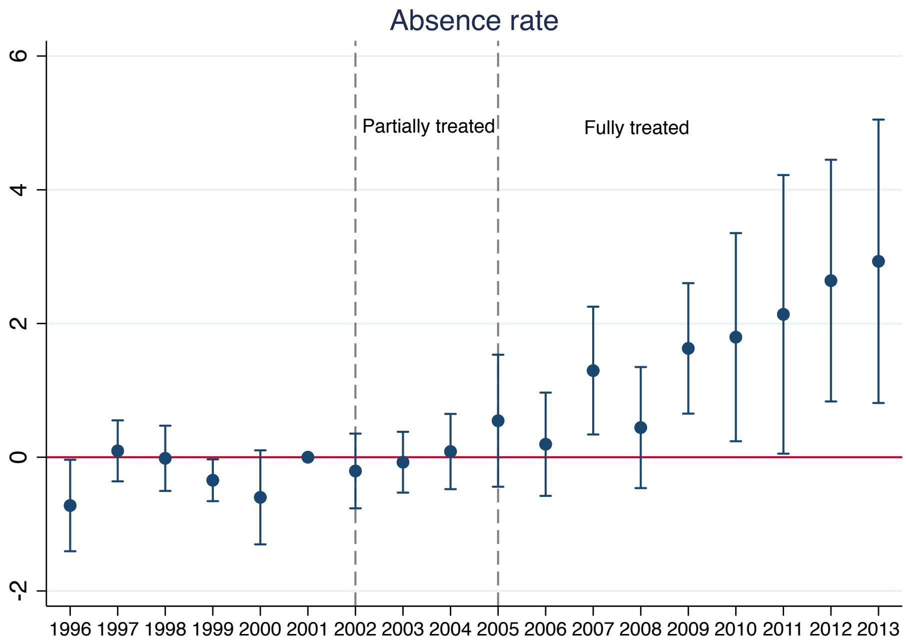


Figure 5: The effect of the fracking boom on absence rate in 9th grade

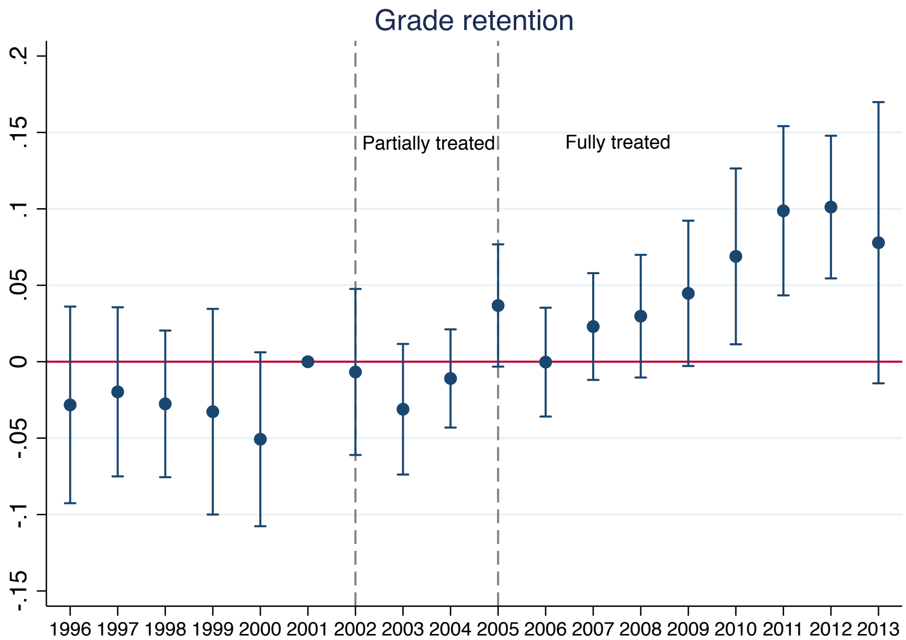


Figure 6: The effect of the fracking boom on grade retention in grades 9-12

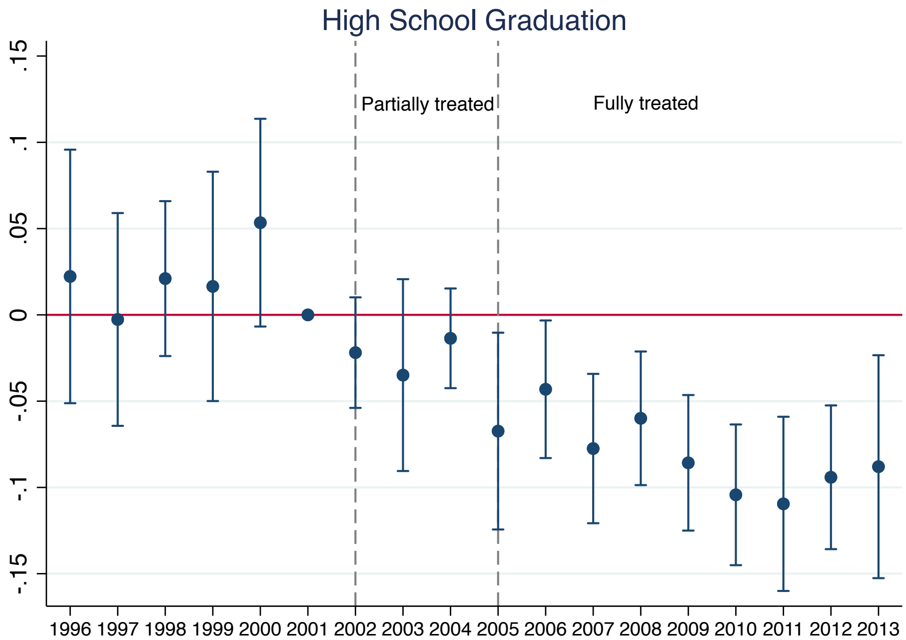


Figure 7: The effect of the fracking boom on four-year high school graduation

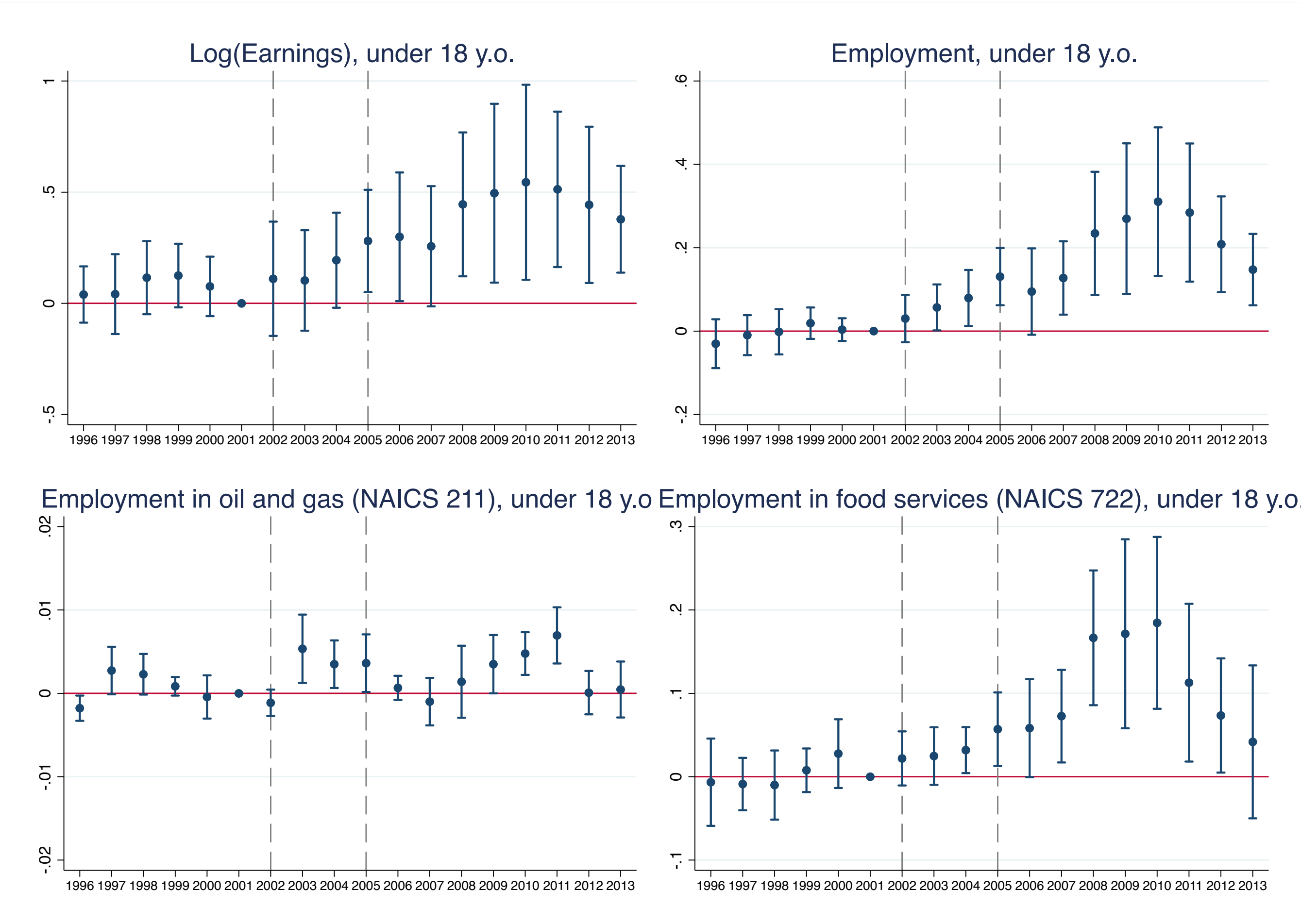


Figure 8: The effect of the fracking boom on labor market outcomes of 15-18 year old students

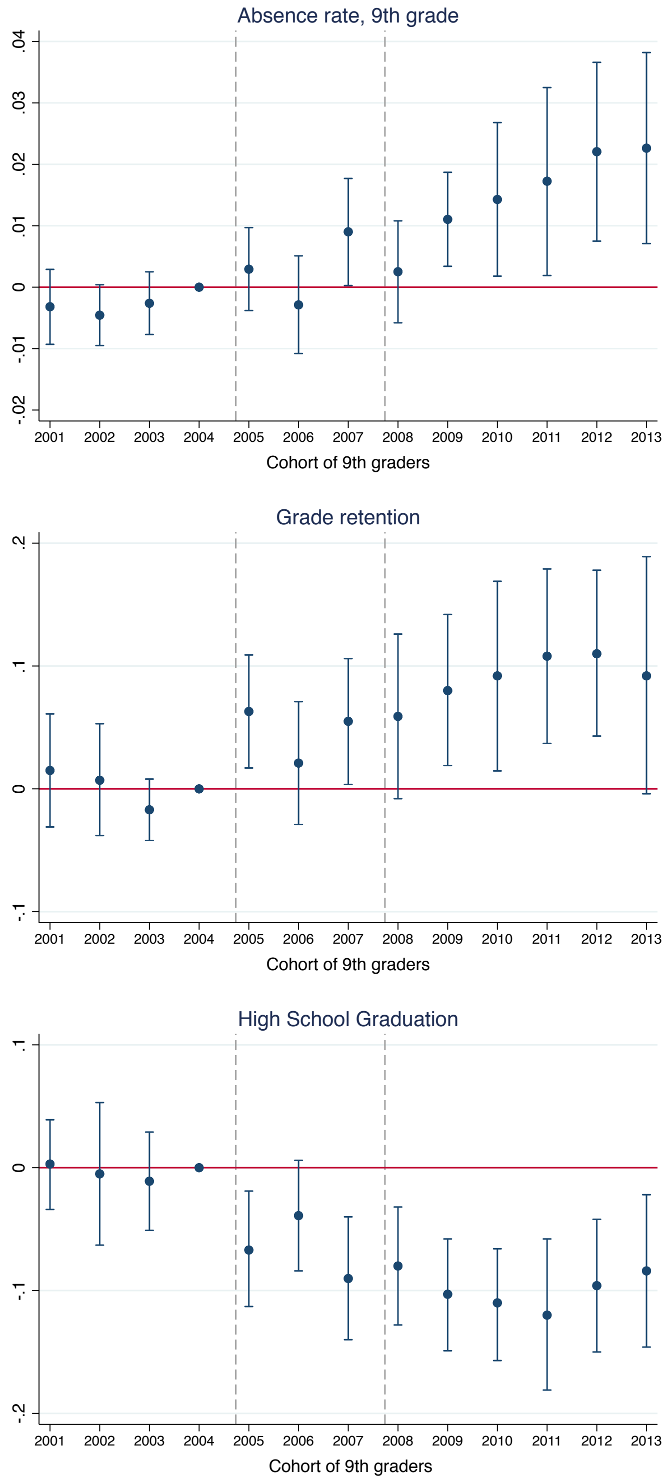


Figure 9: The effect of the fracking boom on absence rates, grade retention and four-year high school graduation, conditional on students being in TX from grade 1

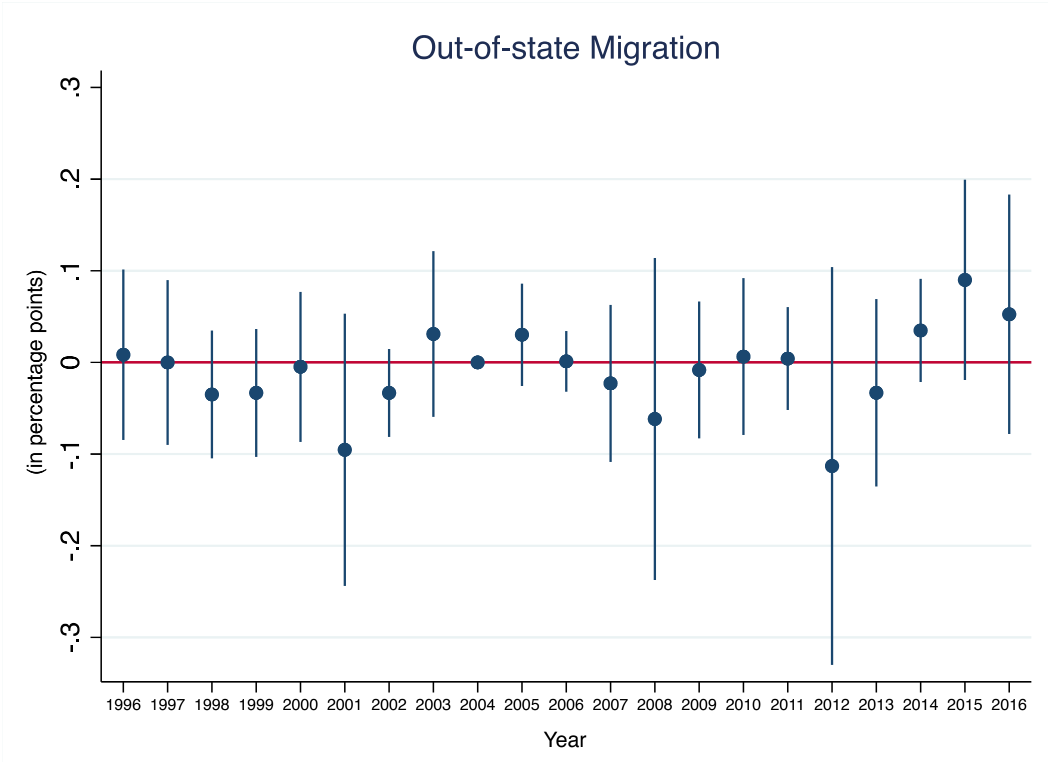


Figure 10: The effect of the fracking boom on out-of-state migration rate in TX

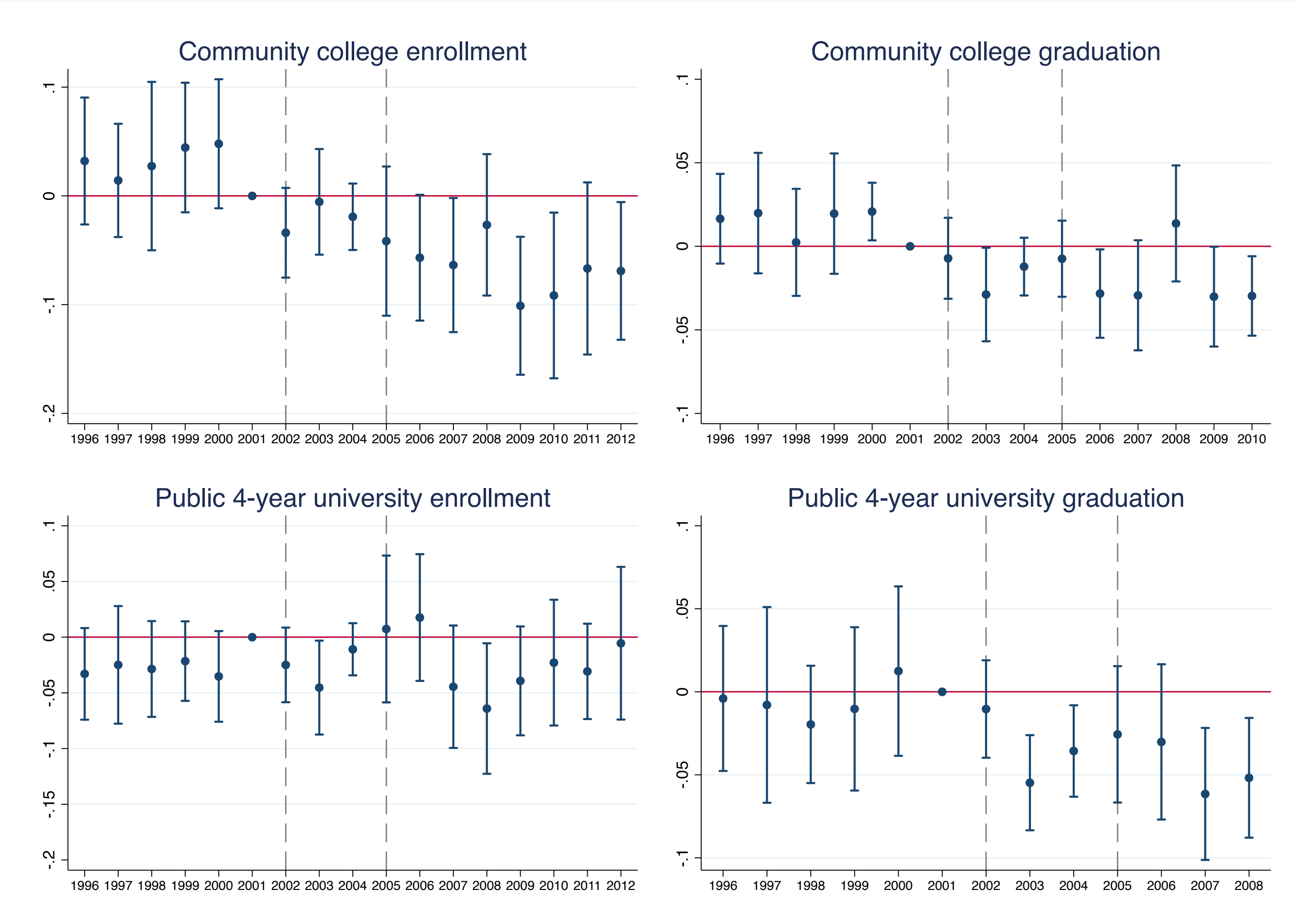


Figure 11: The effect of the fracking boom on college enrollment and graduation, by college type

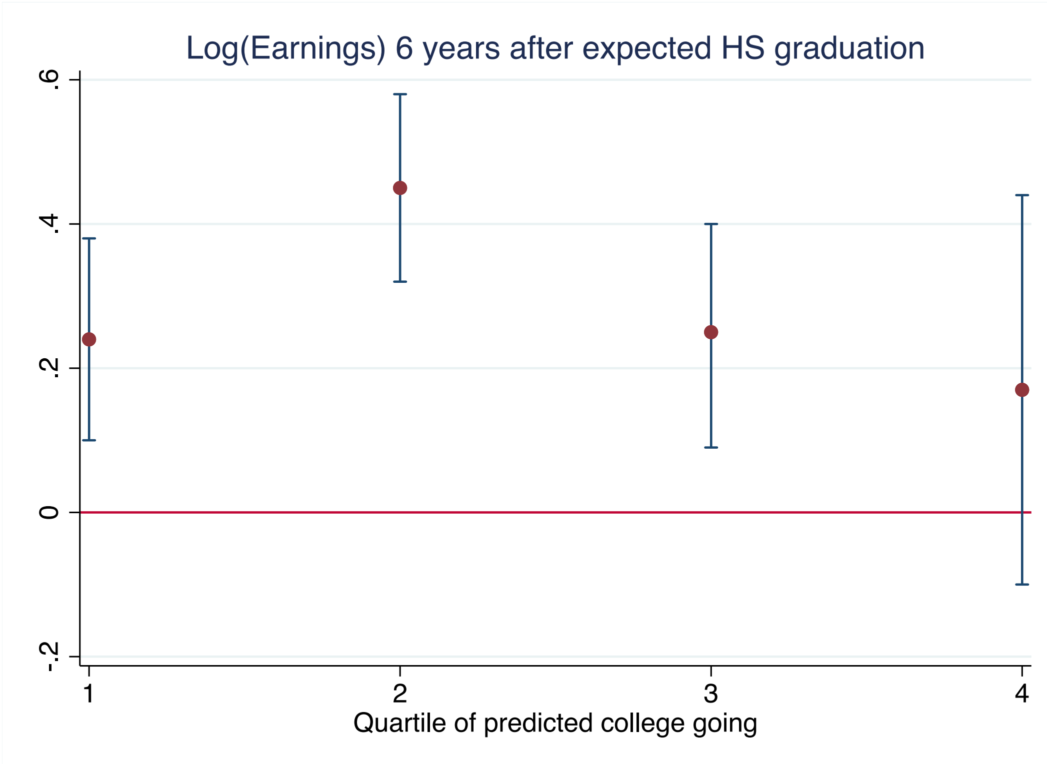


Figure 12: The effect of the fracking boom on earnings 6 years after expected high school graduation, by quartile of predicted probability of college-going

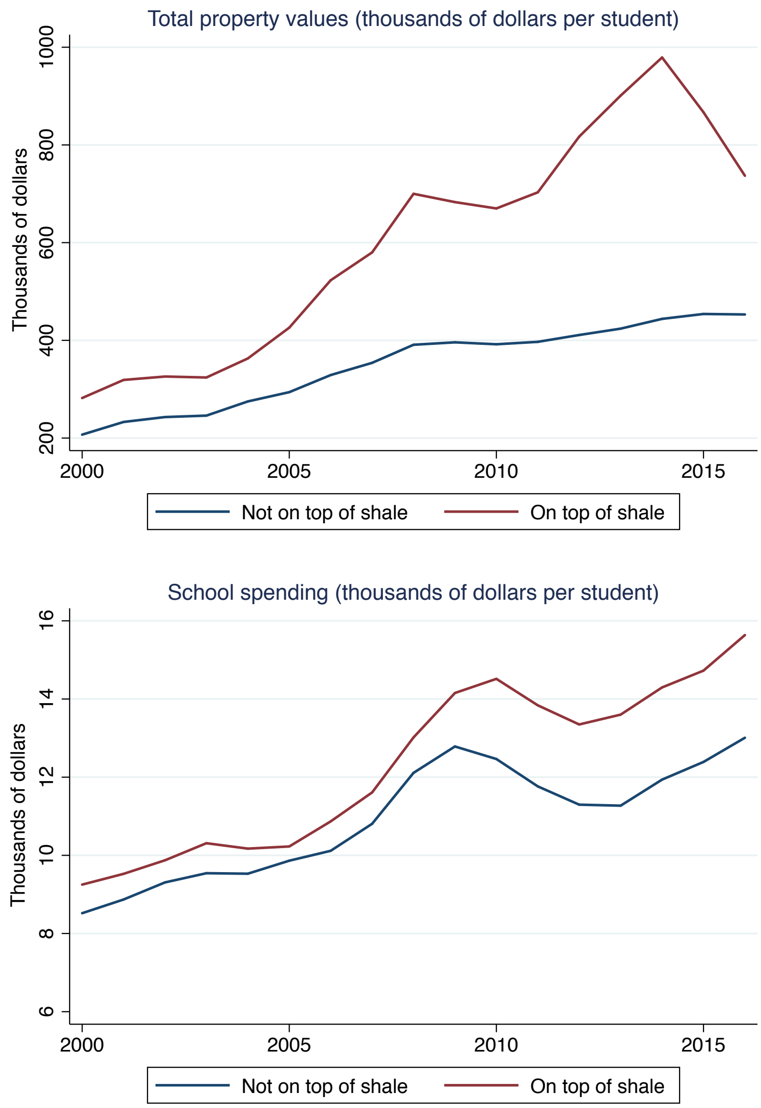


Figure 13: Total property values and school spending, in thousands of dollars per student

Tables

Table 1: Summary Statistics

	Reserves per capita			
Variable	All	Zero	Low (Q1-Q2)	High (Q3-Q4)
HS graduation rate	0.77	0.76	0.77	0.78
	(0.42)	(0.43)	(0.42)	(0.42)
Absence rate in grade 9	0.04	0.04	0.04	0.04
	(0.06)	(0.06)	(0.06)	(0.05)
Grade retention rate	0.19	0.20	0.19	0.16
	(0.39)	(0.40)	(0.39)	(0.36)
Enrollment in 4-year college	0.24	0.23	0.24	0.21
	(0.43)	(0.42)	(0.43)	(0.41)
Enrollment in community college	0.43	0.43	0.44	0.41
	(0.50)	(0.49)	(0.50)	(0.49)
Graduation from 4-year college	0.16	0.15	0.17	0.15
	(0.37)	(0.35)	(0.38)	(0.36)
Graduation from community college	0.05	0.07	0.05	0.07
	(0.23)	(0.25)	(0.22)	(0.26)
Male	0.49	0.49	0.49	0.49
	(0.50)	(0.50)	(0.50)	(0.50)
White	0.51	0.38	0.53	0.57
	(0.50)	(0.48)	(0.50)	(0.50)
Black	0.13	0.07	0.15	0.10
	(0.33)	(0.25)	(0.36)	(0.30)
Hispanic	0.34	0.55	0.28	0.32
	(0.47)	(0.50)	(0.45)	(0.47)
Asian	0.03	0.01	0.03	0.01
	(0.16)	(0.08)	(0.18)	(0.06)
Gifted	0.13	0.13	0.14	0.13
	(0.34)	(0.34)	(0.34)	(0.33)
Special education	0.04	0.04	0.04	0.04
	(0.20)	(0.18)	(0.20)	(0.19)
Economically disadvantaged	0.36	0.53	0.31	0.39
	(0.48)	(0.50)	(0.46)	(0.49)
Shale reserves per capita	0.13	0.00	0.004	0.70
	(0.38)	(0.00)	(0.003)	(0.79)
Total employment, under 18 y.o.	0.71	0.64	0.73	0.72
	(0.45)	(0.48)	(0.45)	(0.45)
"Meaningful" employment, under 18 y.o.	0.30	0.27	0.31	0.31
	(0.46)	(0.44)	(0.46)	(0.46)
Average earnings, under 18 y.o.	678.32	602.29	697.27	684.31
	(1044.24)	(951.91)	(1056.83)	(1142.39)
Average earnings conditional on	1551.75	1551.84	1550.69	1563.81
"meaningful" empl., under 18 y.o.	(1510.08)	(1376.92)	(1518.97)	(1717.68)
Number of students	1,717,586	327,239	1,277,704	112,643
Number of commuting zones	67	25	21	21

Standard deviations are in parentheses.

Table 2: The effect of the fracking boom on absence rate in 9th grade

	Full sample		Men	Women	Quartile of grade 6 test score distribution			
					Q1 (Bottom)	Q2	Q3	Q4 (Top)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fully treated	0.015**	0.019***	0.020***	0.018**	0.023***	0.014**	0.009*	0.008*
	(0.006)	(0.007)	(0.007)	(0.007)	(0.008)	(0.06)	(0.005)	(0.004)
Partially treated	0.005	0.005	0.006*	0.004	0.007	0.005	0.001	0.003
	(0.004)	(0.004)	(0.003)	(0.005)	(0.006)	(0.004)	(0.005)	(0.003)
Baseline mean	*0.04*	*0.04*	*0.04*	*0.04*	*0.06*	*0.05*	*0.04*	*0.03*
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,834,313	3,834,313	1,890,308	1,944,005	958,481	958,544	958,570	958,718

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

Table 3: The effect of the fracking boom on high school grade retention

	Full sample		Men	Women	Quartile of grade 6 test score distribution			
					Q1 (Bottom)	Q2	Q3	Q4 (Top)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fully treated	0.063**	0.089**	0.103**	0.075**	0.094**	0.056	0.042	0.039
	(0.030)	(0.035)	(0.041)	(0.030)	(0.036)	(0.038)	(0.025)	(0.021)
Partially treated	0.007	0.009	0.006	0.011	0.006	0.021	-0.012	-0.012
	(0.016)	(0.016)	(0.020)	(0.016)	(0.031)	(0.021)	(0.013)	(0.008)
Baseline mean	*0.18*	*0.18*	*0.20*	*0.17*	*0.32*	*0.18*	*0.11*	*0.07*
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,835,757	3,835,757	1,891,039	1,944,718	958,932	958,932	958,943	958,943

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

Table 4: The effect of the fracking boom on high school graduation

	Full sample		Men	Women	Quartile of grade 6 test score distribution			
					Q1 (Bottom)	Q2	Q3	Q4 (Top)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Effect on four-year graduation								
Fully treated	-0.075**	-0.108***	-0.128***	-0.088**	-0.113***	-0.064*	-0.047*	-0.043
	(0.030)	(0.036)	(0.042)	(0.031)	(0.037)	(0.035)	(0.025)	(0.022)
Partially treated	-0.027	-0.028	-0.039	-0.018	-0.053	-0.004	0.019	0.005
	(0.026)	(0.029)	(0.031)	(0.030)	(0.037)	(0.021)	(0.030)	(0.013)
Baseline mean	*0.77*	*0.77*	*0.75*	*0.79*	*0.58*	*0.77*	*0.86*	*0.91*
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,835,757	3,835,757	1,891,039	1,944,718	958,932	958,932	958,943	958,943

Table 5: The effect of the fracking boom on earnings and employment under 18 years old

	Average earnings	Log(earnings)	Employment			
			Total	Oil and gas	Food services	Amusement parks
	(1)	(2)	(3)	(4)	(5)	(6)
Fully treated	488.75***	0.365***	0.301***	0.001	0.156***	0.037**
	(139.33)	(0.135)	(0.077)	(0.001)	(0.044)	(0.018)
Partially treated	191.51**	-0.086	0.172***	0.002*	0.079**	0.013*
	(78.27)	(0.081)	(0.054)	(0.001)	(0.039)	(0.007)
Baseline mean	*696.59*	*6.58*	*0.73*	*0.001*	*0.38*	*0.05*
Observations	3,835,757	2,409,805	3,835,757	3,835,757	3,835,757	3,835,757

Table 6: Sensitivity of the Main Results to Assumptions about the Timing of the Boom

					Community college		Public university	
	Absence	Retention	HS grad.	Employed	Enrollment	Graduation	Enrollment	Graduation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Fully treated	0.019***	0.087**	-0.095***	0.241***	-0.086***	-0.033***	-0.015	-0.046**
	(0.007)	(0.035)	(0.031)	(0.070)	(0.028)	(0.010)	(0.026)	(0.020)
Partially treated	0.005	0.029*	-0.034	0.133**	-0.059***	-0.012	-0.012	-0.033*
	(0.004)	(0.016)	(0.023)	(0.056)	(0.018)	(0.010)	(0.020)	(0.015)
Baseline mean	*0.04*	*0.19*	*0.77*	*0.75*	*0.42*	*0.05*	*0.24*	*0.16*
Observations	3,835,757	3,835,757	3,835,757	3,835,757	3,625,475	3,625,475	2,613,371	2,613,371

Table 7: Sensitivity of the Main Results to Alternative Specifications

					Community college		Public university	
	Absence	Retention	HS grad.	Employed	Enrollment	Graduation	Enrollment	Graduation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Areas with non-zero reserves per capita								
Fully treated	0.019***	0.089**	-0.108***	0.301***	-0.089***	-0.037***	-0.014	-0.051**
	(0.007)	(0.035)	(0.036)	(0.077)	(0.029)	(0.011)	(0.027)	(0.020)
Partially treated	0.005	0.009	-0.028	0.172***	-0.047**	-0.029**	-0.000	-0.030**
	(0.004)	(0.016)	(0.029)	(0.054)	(0.018)	(0.011)	(0.016)	(0.012)
Panel B. Bins of quartiles of reserves per capita								
Quartile 1	-0.001	0.008	-0.010	0.008	0.004	-0.004	-0.013	0.001
	(0.001)	(0.007)	(0.008)	(0.014)	(0.009)	(0.007)	(0.008)	(0.004)
Quartile 2	0.003*	0.020***	-0.024***	0.027	-0.008	-0.007	-0.013**	-0.004
	(0.02)	(0.007)	(0.008)	(0.026)	(0.014)	(0.008)	(0.007)	(0.004)
Quartile 3	0.003	0.033**	-0.029*	0.068***	-0.012	-0.008	-0.022***	-0.015***
	(0.002)	(0.017)	(0.015)	(0.023)	(0.012)	(0.007)	(0.005)	(0.005)
Quartile 4	0.008***	0.044***	-0.060***	0.131***	-0.028**	-0.020**	-0.017**	-0.016***
	(0.002)	(0.009)	(0.011)	(0.015)	(0.012)	(0.008)	(0.007)	(0.004)
Observations	3,835,757	3,835,757	3,835,757	3,835,757	3,625,475	3,625,475	2,613,371	2,613,371

Table 8: Sensitivity of the Main Results to Logit and Probit Specifications

					Community college		Public university	
	Absence (1)	Retention (2)	HS grad. (3)	Employed (4)	Enrollment (5)	Graduation (6)	Enrollment (7)	Graduation (8)
Panel A. Logit Model								
Fully treated	0.029	0.092**	-1.116***	0.299***	-0.094**	-0.050***	-0.005	-0.046*
	(0.020)	(0.041)	(0.042)	(0.077)	(0.031)	(0.015)	(0.027)	(0.024)
Partially treated	0.001	0.008	-0.036	0.181***	-0.047**	-0.035***	0.005	-0.028*
	(0.013)	(0.019)	(0.030)	(0.057)	(0.019)	(0.013)	(0.017)	(0.015)
Panel B. Probit Model								
Fully treated	0.030	0.089**	-0.111***	0.300***	-0.092***	-0.047***	-0.006	-0.045**
	(0.021)	(0.038)	(0.039)	(0.076)	(0.030)	(0.013)	(0.027)	(0.023)
Partially treated	0.001	0.007	-0.031	0.183***	-0.047**	-0.034***	0.006	-0.027*
	(0.013)	(0.018)	(0.028)	(0.058)	(0.019)	(0.012)	(0.017)	(0.014)
Baseline mean	*0.04*	*0.19*	*0.77*	*0.75*	*0.42*	*0.05*	*0.24*	*0.16*
Observations	3,835,757	3,835,757	3,835,757	3,835,757	3,625,475	3,625,475	2,613,371	2,613,371

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

Table 9: The effect of the fracking boom on college enrollment

	Full sample		Men	Women	Quartile of grade 6 test score distribution			
					Q1 (Bottom)	Q2	Q3	Q4 (Top)
Panel A. Effect on enrollment in community college								
Fully treated	-0.062**	-0.089***	-0.097***	-0.080***	-0.081**	-0.039	-0.063**	-0.108***
	(0.022)	(0.029)	(0.035)	(0.030)	(0.035)	(0.030)	(0.032)	(0.028)
Partially treated	-0.044**	-0.047**	-0.058**	-0.035*	-0.044	0.065***	-0.022	-0.025
	(0.017)	(0.018)	(0.023)	(0.020)	(0.028)	(0.020)	(0.024)	(0.031)
Baseline mean	*0.42*	*0.42*	*0.39*	*0.45*	*0.30*	*0.43*	*0.49*	*0.48*
Panel B. Effect on enrollment in 4-year public college								
Fully treated	0.017	-0.014	-0.006	-0.022	0.017	0.062*	0.030	0.081*
	(0.030)	(0.027)	(0.025)	(0.030)	(0.025)	(0.031)	(0.034)	(0.032)
Partially treated	-0.003	-0.000	-0.012	0.012	0.017	0.034*	-0.031	0.024
	(0.015)	(0.016)	(0.013)	(0.024)	(0.012)	(0.019)	(0.022)	(0.024)
Baseline mean	*0.24*	*0.24*	*0.22*	*0.26*	*0.07*	*0.16*	*0.29*	*0.46*
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,625,475	3,625,475	1,782,967	1,842,508	937,802	932,698	925,329	829,646

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

Table 10: The effect of the fracking boom on college graduation

	Full sample		Men	Women	Quartile of grade 6 test score distribution			
					Q1 (Bottom)	Q2	Q3	Q4 (Top)
Panel A. Effect on community college graduation								
Fully treated	-0.033***	-0.037***	-0.035***	-0.039***	-0.017**	-0.018	-0.051**	-0.055***
	(0.011)	(0.011)	(0.011)	(0.014)	(0.008)	(0.012)	(0.022)	(0.015)
Partially treated	-0.028**	-0.029**	-0.023*	-0.035***	-0.010	-0.042***	-0.019	-0.035*
	(0.011)	(0.011)	(0.012)	(0.012)	(0.008)	(0.012)	(0.013)	(0.020)
Baseline mean	*0.05*	*0.05*	*0.04*	*0.06*	*0.03*	*0.05*	*0.06*	*0.06*
Observations	3,116,811	3,116,811	1,523,732	1,593,079	805,286	799,098	795,874	716,553
Panel B. Effect on 4-year public college graduation								
Fully treated	-0.028	-0.051**	-0.032**	-0.068**	-0.005	0.004	-0.033	-0.025
	(0.020)	(0.020)	(0.015)	(0.028)	(0.007)	(0.017)	(0.038)	(0.033)
Partially treated	-0.030**	-0.030**	-0.022**	-0.036*	-0.012**	0.012	-0.042*	-0.048**
	(0.012)	(0.013)	(0.010)	(0.021)	(0.005)	(0.012)	(0.022)	(0.022)
Baseline mean	*0.16*	*0.16*	*0.13*	*0.18*	*0.03*	*0.09*	*0.20*	*0.34*
Observations	2,613,371	2,613,371	1,523,732	1,593,079	671,873	676,436	666,452	598,610
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

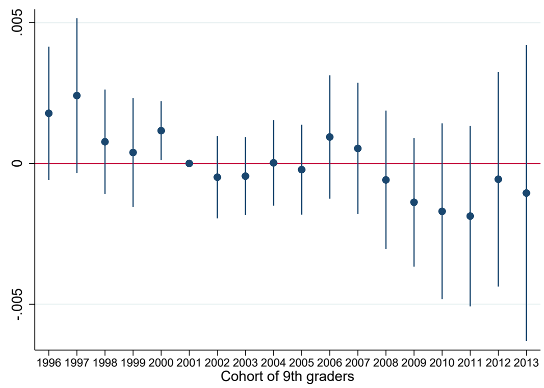
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Exploring alternative mechanisms

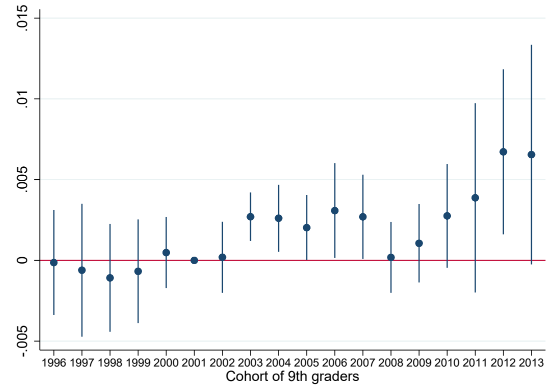
	% Advanced degrees	% Less 5 years of exp.	Log(earnings)
	(1)	(2)	(3)
Reserves*Post	-0.014	0.118**	0.058
	(0.022)	(0.053)	(0.062)
Observations	12,166,340	12,166,340	12,166,340

A Appendix

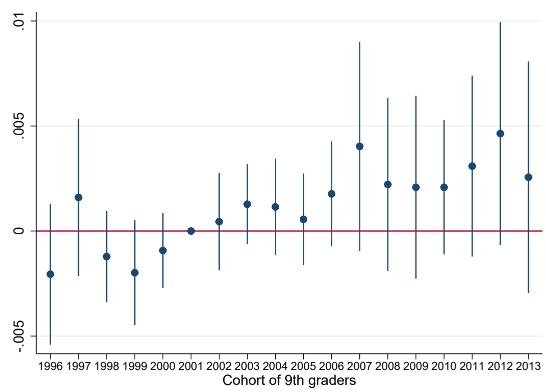
Figures



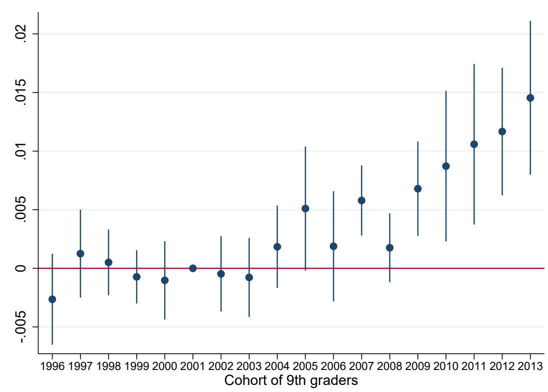
(a) Quartile 1



(b) Quartile 2

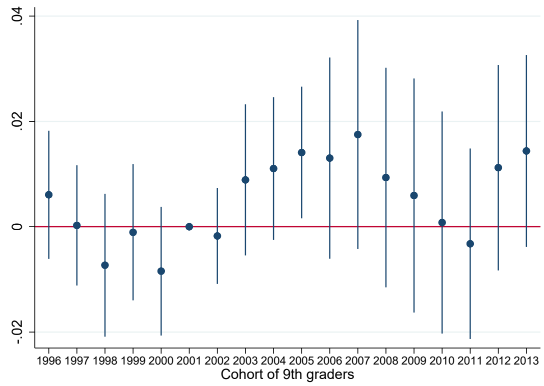


(c) Quartile 3

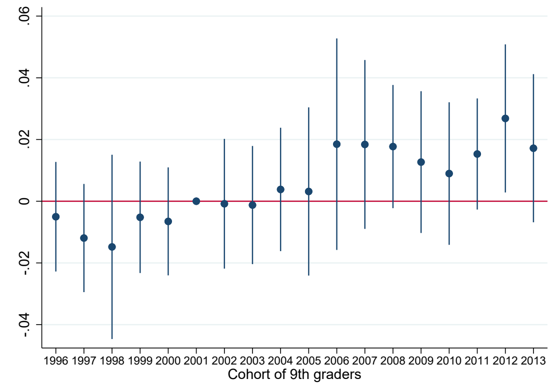


(d) Quartile 4

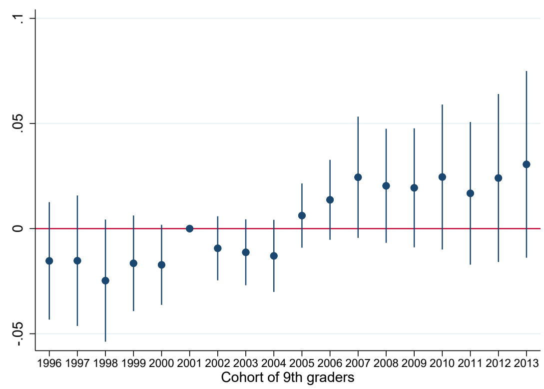
Figure 14: The effect of the fracking boom on absence rate in 9th grade, by quartile of predicted shale reserves per capita



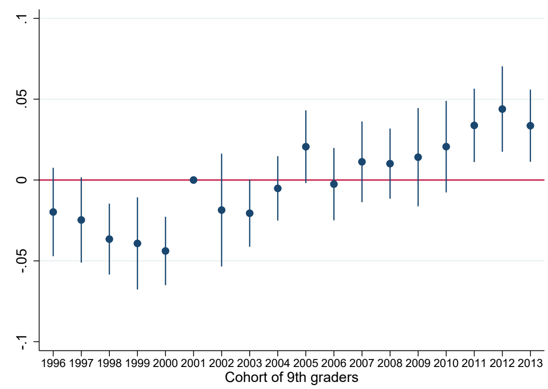
(a) Quartile 1



(b) Quartile 2

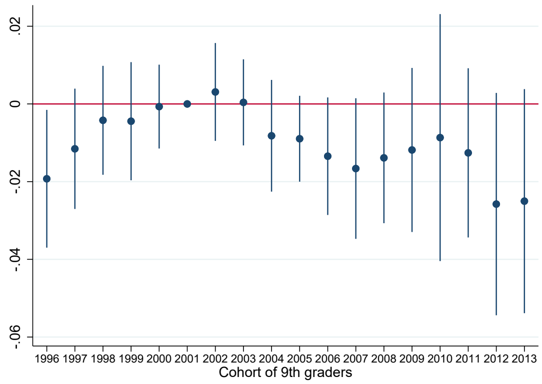


(c) Quartile 3

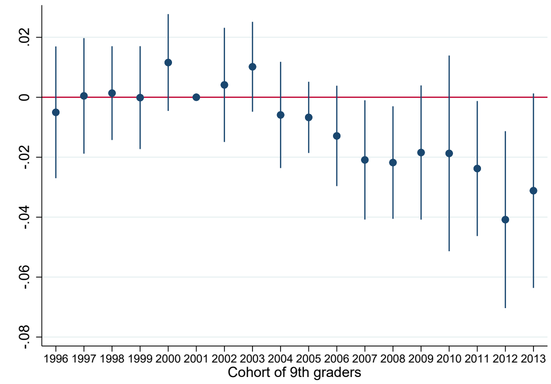


(d) Quartile 4

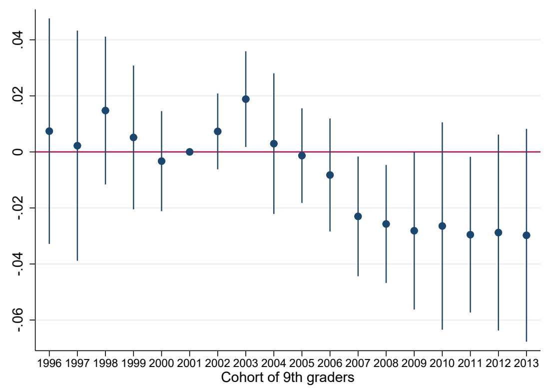
Figure 15: The effect of the fracking boom on grade retention, by quartile of predicted shale reserves per capita



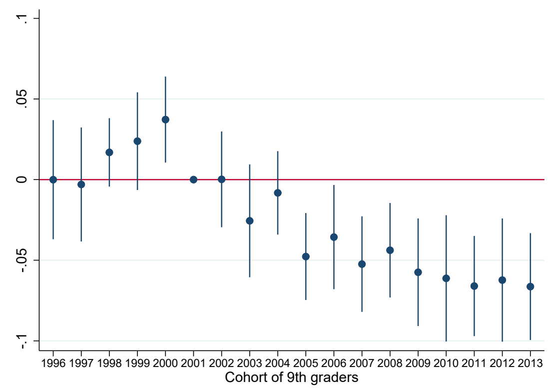
(a) Quartile 1



(b) Quartile 2

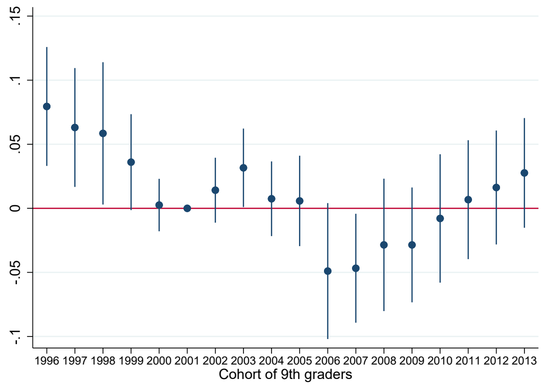


(c) Quartile 3

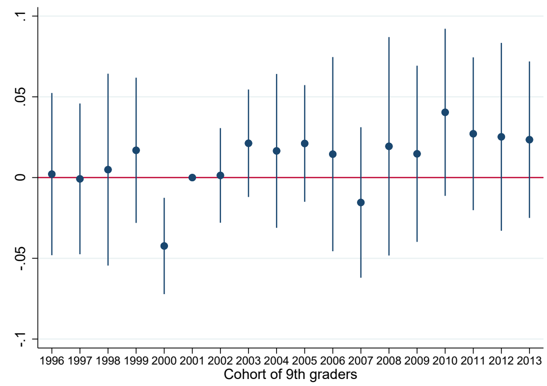


(d) Quartile 4

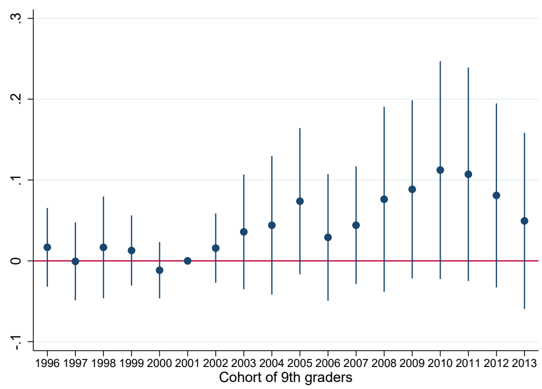
Figure 16: The effect of the fracking boom on high school graduation, by quartile of predicted shale reserves per capita



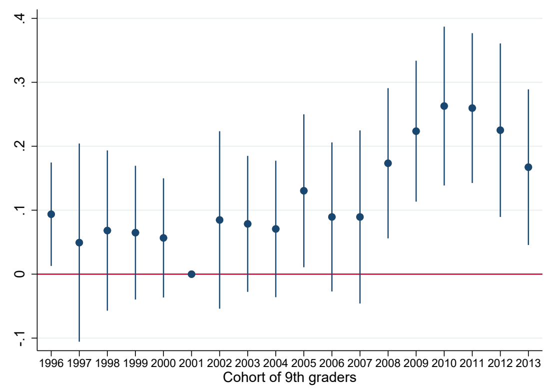
(a) Quartile 1



(b) Quartile 2

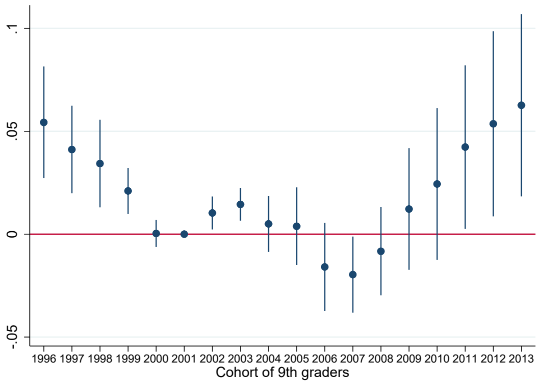


(c) Quartile 3

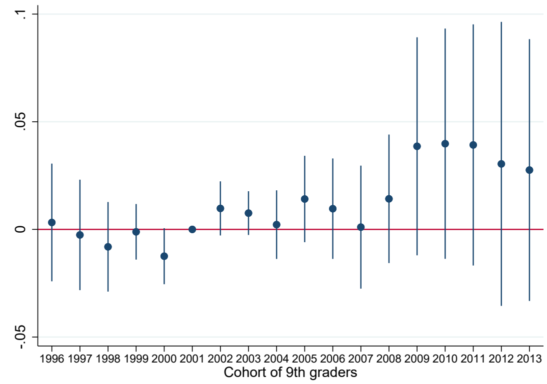


(d) Quartile 4

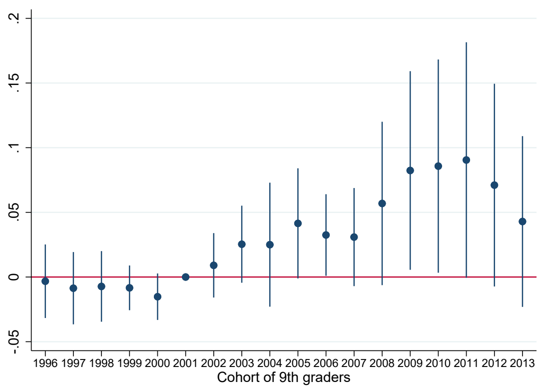
Figure 17: The effect of the fracking boom on log(earnings) during high school, by quartile of predicted shale reserves per capita



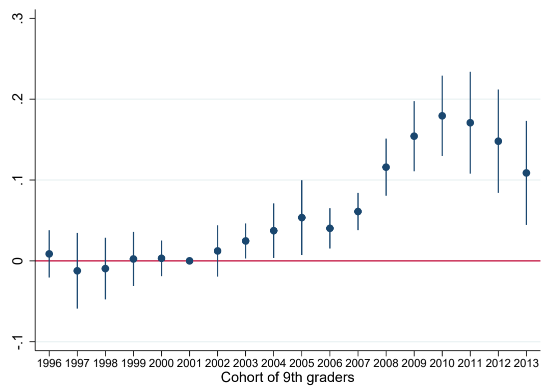
(a) Quartile 1



(b) Quartile 2



(c) Quartile 3



(d) Quartile 4

Figure 18: The effect of the fracking boom on probability of being employed during high school, by quartile of predicted shale reserves per capita