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

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November 11, 2019

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Abstract

This project examines the role of 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 the 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. Finally, I show that students experience benefits to employment and earnings that persist up to six years past expected high school graduation.

JEL Classification: I20; J24; O13

Keywords: Human capital, schooling, fracking, earnings

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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, educational data 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. These deposits 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 extract. 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 difference-in-diference and event study models, which allow 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 indicate that the boom in an area with average fracking exposure led to a 0.4 percentage point (pp) increase in absence rates and a 1.9pp increase in grade retention relative to means of 4% and 19%, respectively. In addition, I find that cohorts exposed to the boom experienced lower rates of 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 while in high school. 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 contemporaneous effects of fracking on high school outcomes, I follow up on the cohorts of students who 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 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 Marchand and Weber, 2019, 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 the 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 the 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 the fracking boom. Section 3 presents a conceptual framework describing human capital investment decisions in the context of the fracking boom. In Sections 4 and 5, I describe the data and research design. Section 6 examines the effects of the boom on educational and labor market outcomes of high school students. Section 7 presents long-run analysis of college outcomes and earnings. In Sections 8 and 9, I discuss robustness tests and discuss the relative importance of potential mechanisms. Finally, Section 10 concludes.

2 Background: Fracking Boom

Beginning in early 2000s, 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 conventional vertical drilling is not a feasible method of extracting resources from shales. However, 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 oil and gas 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). Due to the introduction of the new extraction technology, the oil and gas deposits contained in 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: the top panel of Figure 2 shows that the number of new unconventional wells drilled in areas lying on top of shale increased by more than 700% by 2014, whereas the number of conventional wells remained stable over the entire period. [2] After the wells are drilled and the shale is fractured, the wells are placed into production. As shown in the bottom left panel of Figure 2, increased drilling resulted in unprecedented levels of crude oil and natural gas production which more than tripled between 2008 and 2017 (bottom panel of Figure 2). [3]

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

[3]Texas produces more than 40% of 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 generating 30% of total U.S. natural gas production (EIA, 2018).

The 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)). For example, Feyrer, Mansur and Sacerdote (2017) find that each million dollars in oil and 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 process of drilling and developing a well is considered the most labor-intensive phase, and once construction ends and production begins, the labor requirements for well maintenance are lower. The bottom right panel of Figure 2 shows that employment in the oil and gas industry in Texas (as a share of total employment) evolved similarly in both shale and non-shale areas until mid 2000s, but grew substantially in areas on top of shale starting from around 2005, consistent with the expansion of drilling.

The shale oil and gas boom offers a unique quasi-natural experiment for analyzing how improved economic conditions affect human capital. Importantly for educational decisions, unlike prior oil booms, the fracking boom has been viewed as a long-run shock to local economic activity by industry executives, independent researchers and politicians (EIA, 2015). Similar to prior work, I date the start of the boom in Texas to 2005 in my main analysis. 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 8, I show that my results are robust to alternative ways of defining the start of the boom.

3 Conceptual Framework

In this section, I use existing theoretical and empirical work to discuss how the local labor market shocks generated by the fracking boom could affect human capital investment. I consider a high school student whose main tradeoff is between the long-run benefits of education and the short-run return to labor. If in any given year he decides to leave high school, he will work in the labor market and earn income that corresponds to his education and experience level. If he remains in school, he forgoes current earnings but will earn higher income in the future as he completes additional years of schooling. According to the human capital theory (Mincer, Becker), an individual makes the decision to stay in school if the present discounted value of the benefits of schooling exceeds the costs. The decision in its simplest form therefore depends on the wage differential between high school graduates and high school dropouts, the opportunity cost of remaining in school, and school and family resources available to students.

By increasing low-skilled jobs and wages, the fracking boom raises the opportunity cost of schooling and motivates students to reduce human capital investment. In addition, if young adults believe that the improvement in labor market opportunities represents a persistent increase in wages of dropouts relative to graduates, it may cause them to reduce investment into schooling as well. An increase in family resources, on the other hand, could generate income or liquidity effects which may offset the negative opportunity cost mechanism. A positive shock to family wealth might lead to increased demand for schooling if schooling is a normal good. If this effect is large, it may offset the negative opportunity cost mechanism. The existing evidence on the importance of liquidity constraints is mixed. Hilger, 2016 and Bulman et al., 2016 find that for most young individuals in the US who wish to attend college liquidity constraints do not represent a significant deterrent. However, Lovenheim, 2011 finds that increased housing wealth leads to higher rates of college enrollment among low-income families.

A change in school resources could be an additional channel affecting students' human capital investment. Since oil and gas extraction generates tax revenue collected by local school districts, it could improve student achievement by, for example, paying teachers higher salaries or investing into new facilities. Given the evidence that higher school spending has either insignificant or positive effects on human capital (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. However, if schools do not increase teachers' salaries by as much as they rise in the private sector due to the boom, school officials may have difficulties retaining existing teachers or having to hire teachers of lower quality. The effect of school resources is therefore ambiguous.

In summary, my empirical analysis will compare the change in educational outcomes for students across different commuting zones, and the estimates therefore reflect the reduced form effect of the fracking boom operating through any channel. Given that the predicted effects of different channels go in the opposite direction, the analysis can shed light on whether the opportunity cost of schooling dominates the increased resources effects. In section 9, I discuss the relative importance of these channels in more detail.

4 Data

4.1 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).[4] 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'

[4] 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.[5] I associate students with the school district in which they were enrolled in grade 6, and I exclude students who show up in high school enrollment records but were not in the state of Texas in middle school.[6]

The test score data used in this study come from 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 cohort.[7] 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

[5]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 the 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 8, I show that affected areas are not associated with increased out-of-state migration.

[6]In Section 8, I show that my results are robust even if I restrict my sample to students who were in Texas in grade 1.

[7]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.

4.2 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. 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.

4.3 Summary statistics

Table 1 reports summary statistics of pre-boom observable characteristics for students in my main sample. The table shows that 77% of students graduate from high school in four years, and 24% and 42% of students enroll into 4-year and 2-year colleges in the next two years after their 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 above and below median reserves (conditional on having non-zero reserves). Students in shale areas with positive oil and gas reserves are similar on average to students in other shale areas with different level of reserves and to students in non-shale areas along most dimensions, including educational and labor market outcomes. However, students in commuting zones without any shale deposits are more likely to be Hispanic and to receive free lunches, as compared to the rest of the sample. It's important to note that hese differences in means between students in 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 students who live in commuting zones with zero reserves from my analysis.

5 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.

6 Main results: high school outcomes

6.1 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.

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 experienced 0.4pp higher absence rates (10% increase evaluated at the mean of 4%).[8] These point

[8]To convert estimates reported in tables into a more interpretable magnitude, I evaluate them at the mean level

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 (0.5pp), the effect is two times larger among the lowest ability students (0.2pp).

6.2 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 1.9pp higher likelihood of grade retention (9.8% increase at the mean of 19%). The event study plot (Figure 6) confirms that the increase in grade retention corresponds to the timing of the start of the boom, and appears to be persistent. Notably, the pre-boom coefficients are close to zero and statistically indistinguishable from the base year. As with attendance, the effects are similar for both males and females. Results by ability suggest that only students in the bottom of the distribution were impacted.

of shale reserves in a community zone with non-zero reserves, i.e. I multiply them by 0.21 millions of MMBTUs. I report these scaled effects in all tables in the "Average effect" row.

6.3 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. 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.

6.4 Labor market outcomes

Nearly 63% of high school students are employed in a job for at least one quarter during their time in high school. Moreover, 30% of students have "meaningful employment", which I define as having administrative quarterly earnings of at least \$900, which corresponds to getting the prevailing state minimum wage of \$5.5 and working 15 hours per week for 12 weeks. According to the Texas Child Labor Law, a child 14 or 15 years of age may not work more than eight hours in one day or more than 48 hours in one week; however, Texas has no restrictions on maximum working hours for minors aged 16 and 17.[9]

Using aggregate data, prior work has found that labor markets with the highest fracking exposure saw increased demand for low-skill workers and also experienced an increase in high school dropout rates (Cascio and Narayan, 2015. However, no direct evidence showing that these two changes come from the same individuals exists so far, perhaps due to data limitations. In this section, I directly link 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 effects of the fracking boom on contemporaneous labor market outcomes in Table 5.

The point estimate in column 2 of Table 5 implies a 7.7% increase in earnings associated with the boom when evaluated at the average level of treatment exposure. 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. This estimate corresponds to a 14.8% increase in earnings when evaluated at the pre-boom mean of \$697. Thus, these results imply that there are sizable responses on both extensive and intensive margins of labor supply.[10] In columns 3-6, I look at the probability of being employed overall and split by

[9] Individuals between 14 and 17 cannot work in jobs that have been explicitly deemed to be too hazardous (e.g. jobs involving exposure to radioactive substances, roofing operations, coal mining, etc.). For more details see: https://twc.texas.gov/jobseekers/texas-child-labor-law

[10] The results are similar if I include employment with below minimum wage earnings.

industry. The estimates show that the boom increased total employment of young individuals in areas with average exposure by 16.7% (evaluated at the mean of 31%). The employment response was particularly substantial in the food and retail sector (an increase of 18.7% and 31.4% respectively), which historically tends to employ large shares of young individuals and which indirectly benefited from the fracking boom. I also find a positive effect on employment in oil and gas sector but it is less precisely estimated, partly due to a very small number of high school students working in this sector. [11]

I supplement these results with an event study analysis in Figure 8 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 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.

7 Long-term results

7.1 College Enrollment and Graduation

The choices that students make during high school may have an impact on their college plans and career trajectories later in life. 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 6.[12] Panel A shows that the fracking boom

[11] The results are very similar if I exclude quarters that include summer months, and therefore the estimates are not driven by increased summer employment of high school students.

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

is associated with a 1.9 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 9, and are consistent with the estimates above.

Table 7 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 community college graduation. I supplement these results with an event study analysis in the right panel of Figure 9. There is also evidence of a slight decrease is the probability of public university graduation. I view these estimates as suggestive, however, since I am not able to observe six-year graduation records for many of my post-boom cohorts yet.

7.2 Adult Earnings

I now follow up on the students I observed during high school and college and look at their earnings six years past expected high school graduation.[13] Column 1 of Table 8 shows that students in commuting zones with average reserves experiences a $307 increase in earnings, a 9% increase at the pre-boom mean of $3,504).

The earnings estimates above, however, don't control for the level of educational attainment. To avoid conditioning on this likely endogenous variable, I instead predict the propensity of stu-

[13] I would ideally prefer to look at earnings at a later point in students' life but not enough time has passed since the beginning of the boom to be able to observe earnings for treated cohorts at an older age.

dents' 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 students with different propensity of college-going are reported in columns 4-7 of Table 8. The estimates in columns 4 and 5 suggest that cohorts in treated commuting zones who were less likely to attend college experience positive earnings effects six years after expected high school graduation, as compared to similar cohorts in terms of predicted college-going but who are from areas not exposed to the boom. Specifically, students who were exposed to the boom during high school have 9-13% higher earnings at age 24-25. In contrast, there is only a small positive impact on earnings for the group with the highest predicted probability of going to college. This is not surprising since the fracking boom differentially affected low-skilled jobs, and my prior analysis by ability distribution confirms that the educational response is concentrated among these people.

While these effects for lower quartiles are likely driven by improved labor market opportunities associated with the boom, they may be partially explained by increased share of people who stay out of college and gain work experience (In section 7.1, I estimated a 1pp decrease in college enrollment). A back of the envelope calculation suggests that the estimated change in college-going could explain at most 16% of the earnings effects. This is calculated under the assumption that individuals in early-mid twenties earn zero while in college and $4,800 per quarter, which is the BLS estimate for the average wage for students of this age, if they did not go to college.[14] In summary, the fact that marginal students benefit from higher earnings and employment that last for many years suggests that decisions to invest less in human capital may be partially justified

[14]The exact calculation is the following: $(0.01 \times 4{,}800)/300$

by improved outside options rather than simply myopic behavior.

8 Robustness

8.1 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 9 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 10, 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 13-17 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 11, 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.

8.2 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 10 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 11, 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.

9 Discussion

My main results showed that the fracking boom in Texas caused a decrease in human capital investment among high school and college students. While I argued in the previous section that the increased opportunity cost of education due to improved labor markets was a key driver, these reduced-form estimates could in principle also be affected by other changes caused by the boom. In this section I consider two additional channels that could plausibly be affected by the fracking boom and which past literature has found to be relevant for educational outcomes: 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 12, 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. While this does not necessarily mean that improvements in school resources had no effect on the margin, it does suggest that any potential benefits to educational outcomes were offset by changes coming through other channels.

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 12 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 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.[15] Overall, while a decrease in teacher experience likely had a

[15]For example, Staiger and Rockoff (2010) find that students assigned to teachers with low experience score 0.1

negative impact on educational outcomes, existing research suggests that these effects are likely to be quantitatively small.

10 Conclusion

The theoretical predictions for the effects of rapid economic development on educational outcomes are ambiguous. On one hand, increased school resources have been shown in work such as Hyman (2017) and Hægeland, Raaum and Salvanes (2012) to lead to higher exam scores and higher rates of college enrollment. On the other hand, Black, McKinnish and Sanders (2005), Atkin (2016) and others demonstrated that improvements in local labor markets can increase the opportunity cost of education and lead students to drop out of high school. Determining which of these effects dominates is ultimately an empirical question and has important implications for policymakers seeking to understand the full range of costs and benefits that result from these booms.

In this paper, I investigate this issue directly by leveraging the fracking boom as a natural experiment. Over the past decade, the shale revolution - a result of technological breakthroughs in horizontal drilling and hydraulic fracturing that turned previously unusable resource deposits into valuable commodities over a very short period of time - has dramatically changed the energy industry and resulted in significant employment and earnings gains across many areas of the United States. I use administrative individual-level data for the universe of students in Texas, a state which benefited substantially from the fracking boom, that allow me to follow all students through high school, college, and the labor market. A difference-in-difference specification exploits geographic variation in the distribution of these previously inaccessible resources to determine how areas with different levels of fracking potential experienced different education and labor market outcomes.

standard deviations lower on standardized exams. Given a 2pp increase in the share of teachers with less than 5 years of experience estimated in Table 12, a back of the envelope calculation suggests it would translate into only a 0.002 standard deviation decrease in student achievement.

I find that the boom had significant effects on absence rates (0.4pp increase) and grade retention (1.9pp increase) for high school students in areas with high fracking potential. I also show that students experienced lower rates of high school completion, with 2.3pp decrease at the mean of 77%. While the dropout effects are broadly similar to those estimated in existing literature (such as Cascio and Narayan, 2015 and Zuo, Schieffer and Buck, 2019), this paper is the first to analyze individual-level measures of academic performance such as attendance and grade retention in this context. When I break these findings down by ability, I find that they are driven by students in the bottom of the ability distribution, i.e. those who were likely on the margin of school attendance.

I next show that improved labor market opportunities for young people play a large role in explaining the negative impacts on human capital. In particular, I link each high school student to their administrative employment records and show that employment and earnings while in high school 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, a finding consistent with prior work on labor market effects of the fracking boom.

These findings can help policymakers to better understand the consequences of resource booms. My results suggest that the effects of resource booms are relatively muted for high-ability students; instead, effects on overall educational outcomes operate largely through students the bottom of the ability distribution, a large number of whom would be unlikely to ultimately attend college regardless of the boom. Past work in the education literature such as Lochner and Monge-Naranjo (2012) and Cameron and Heckman (2001) has found that the marginal value of additional education for these types of students is often low. To the extent that policymakers want to improve outcomes for these types of students- a majority of which are economically disadvantaged minorities - my results suggest that improved labor market opportunities can be an important channel even when they lead to lower educational attainment.

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Figures

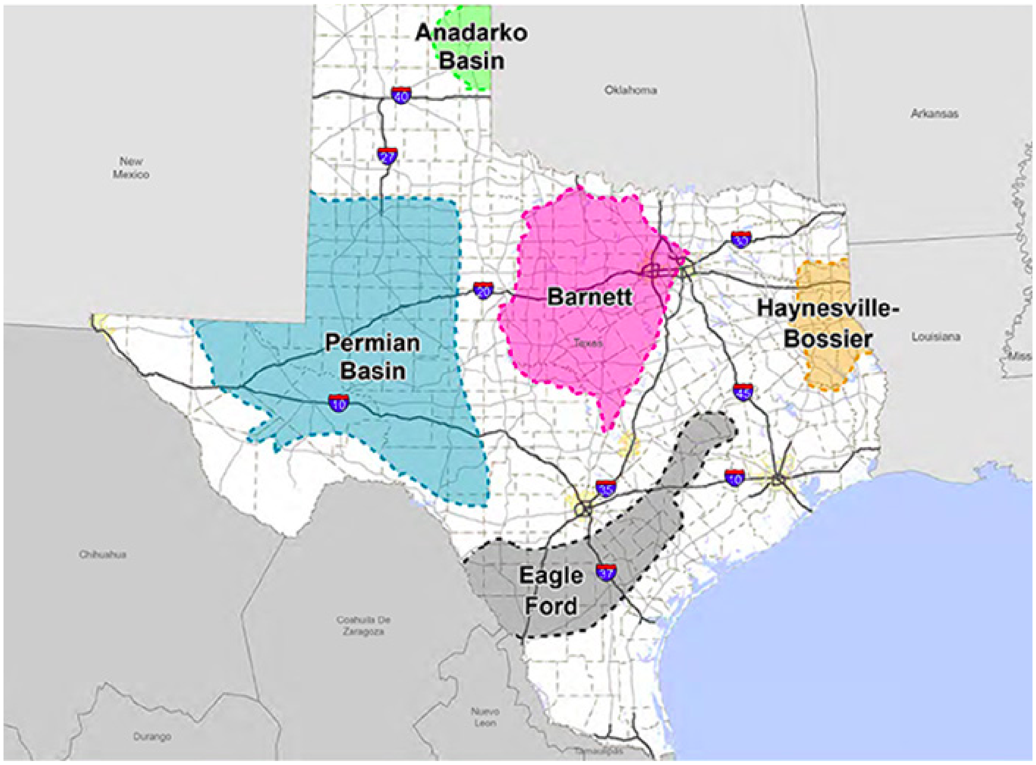

Figure 1: Shale formations in Texas

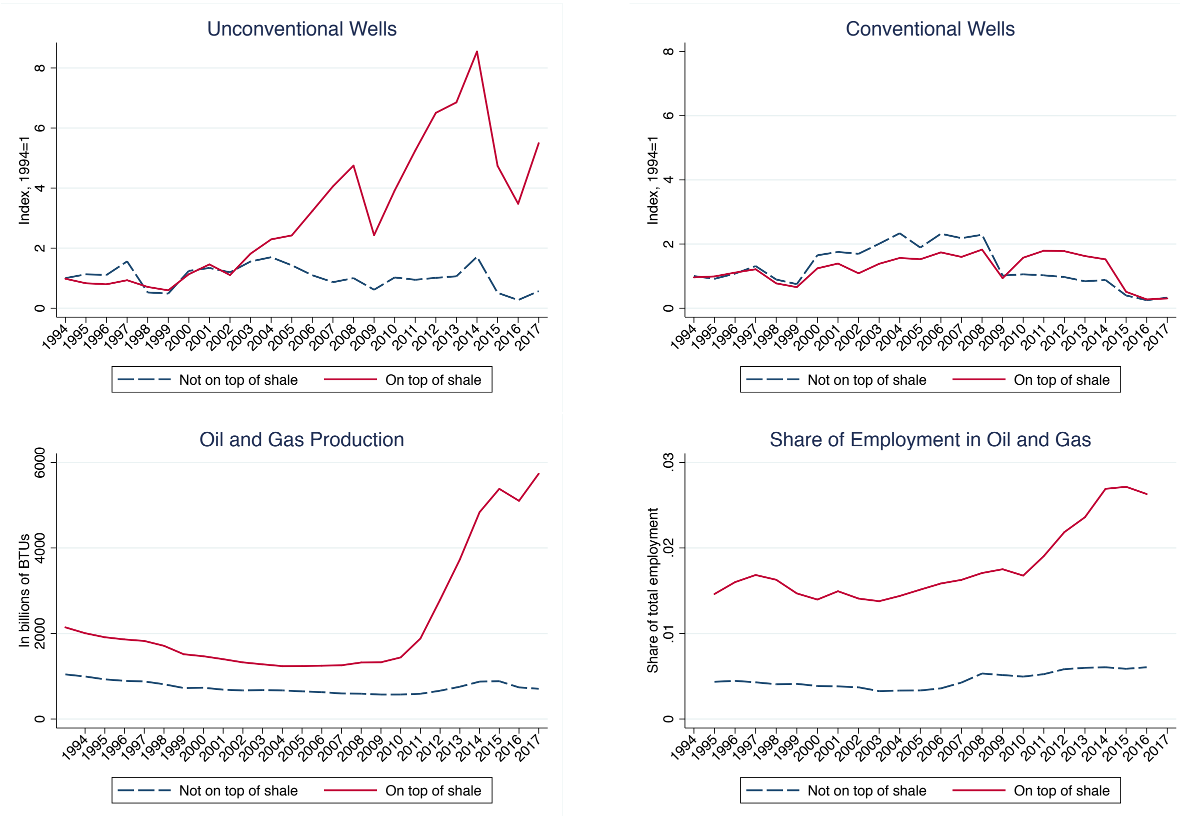

Figure 2: Oil and gas new wells drilled, production and employment

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

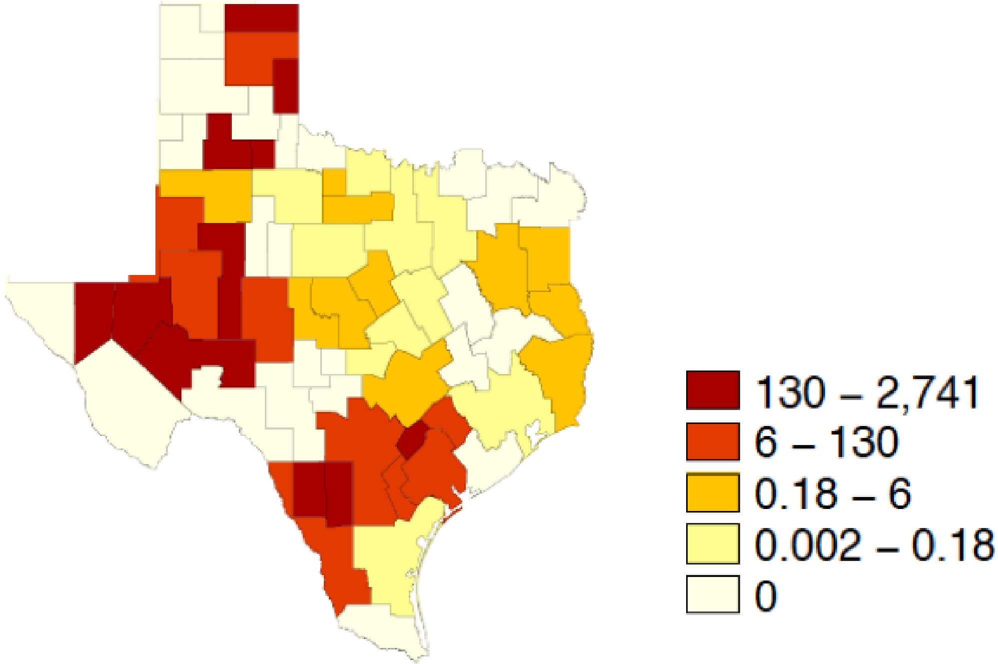

Figure 3: Predicted oil and gas reserves per capita in millions of MMBTUs

Source: Author's calculations from the Energy Information Administration

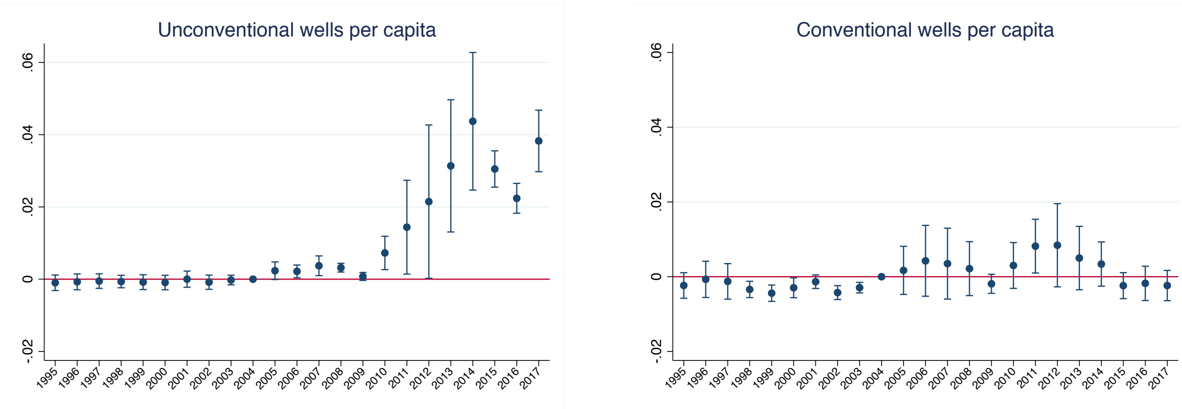

Figure 4: The effect of the fracking boom on oil and gas drilling, by well type

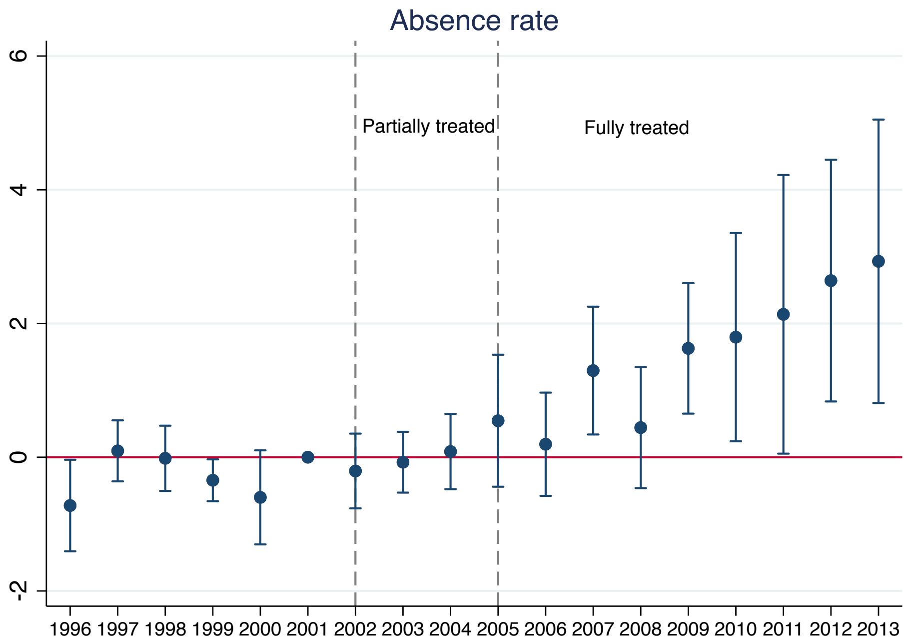

Figure 5: The effect of the fracking boom on absence rate in 9th grade

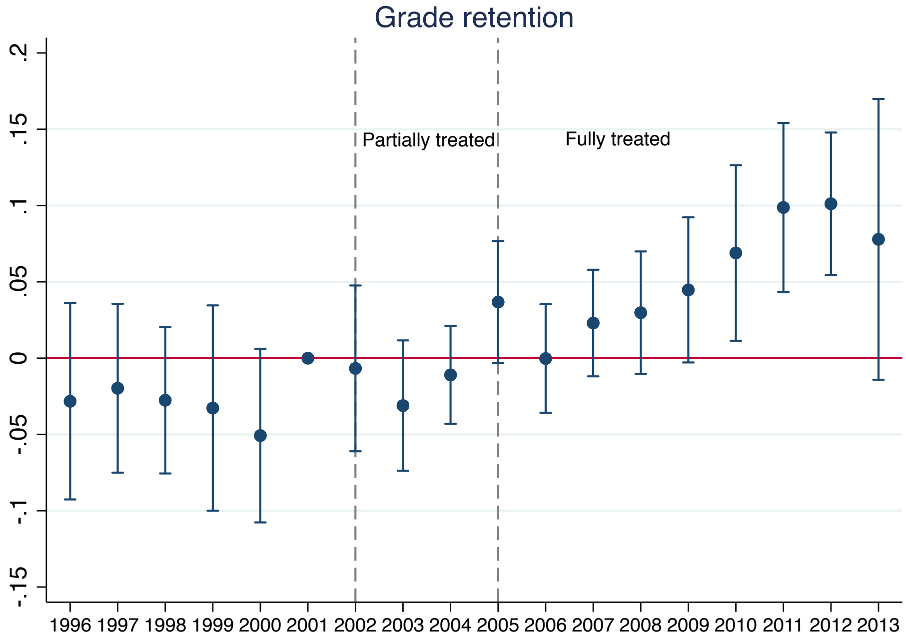

Figure 6: The effect of the fracking boom on grade retention in grades 9-12

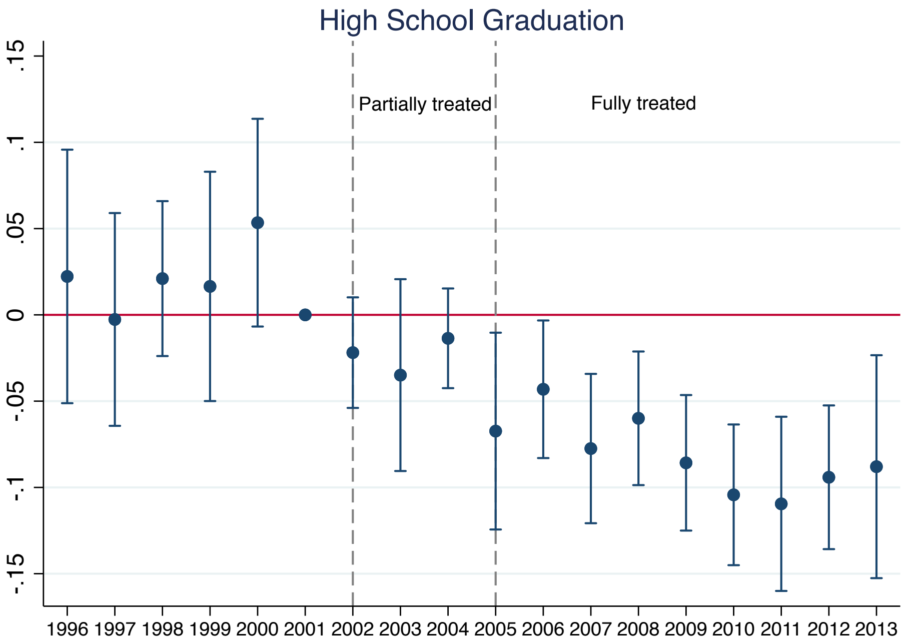

Figure 7: The effect of the fracking boom on four-year high school graduation

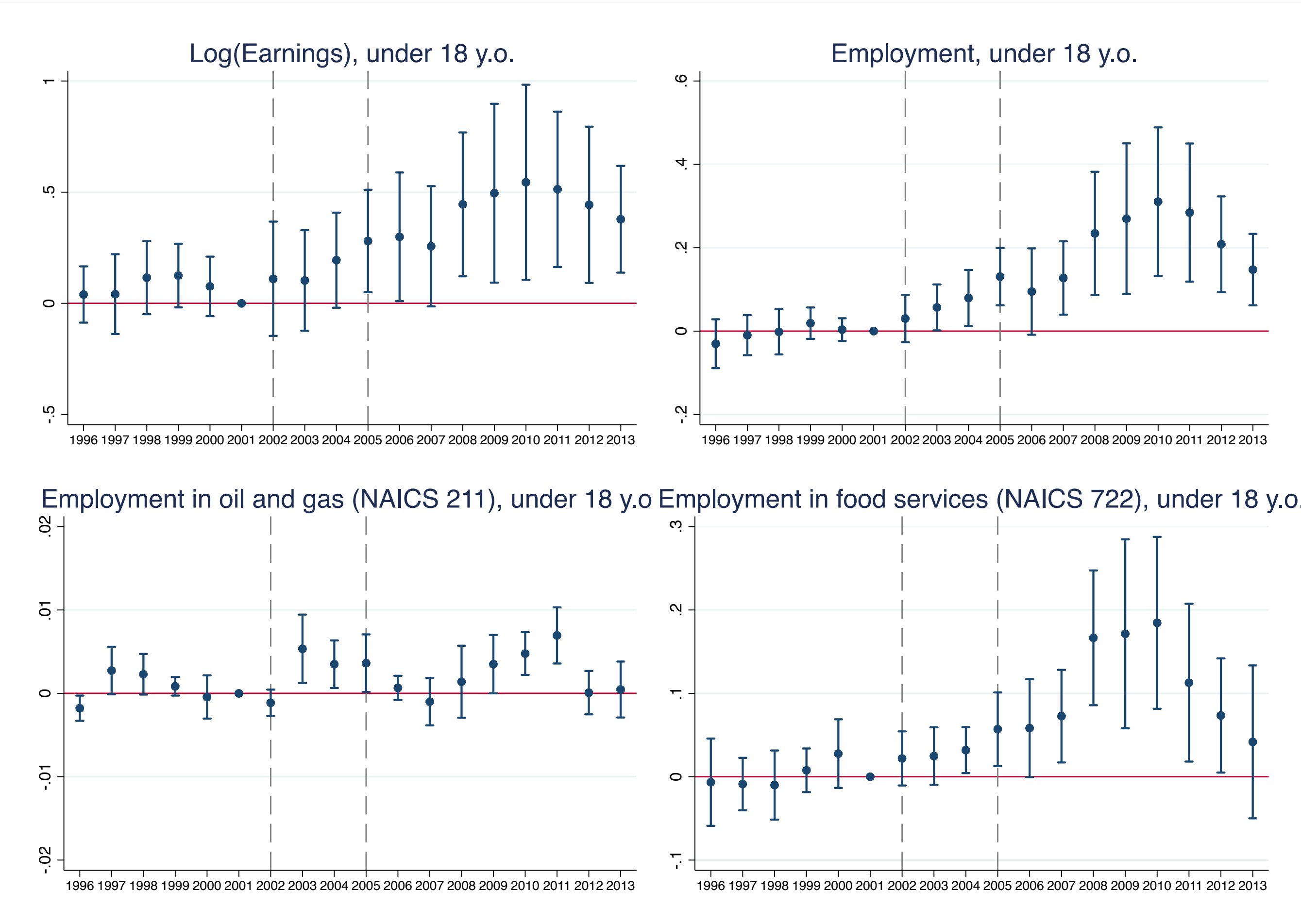

Figure 8: The effect of the fracking boom on labor market outcomes of 15-18 year old students

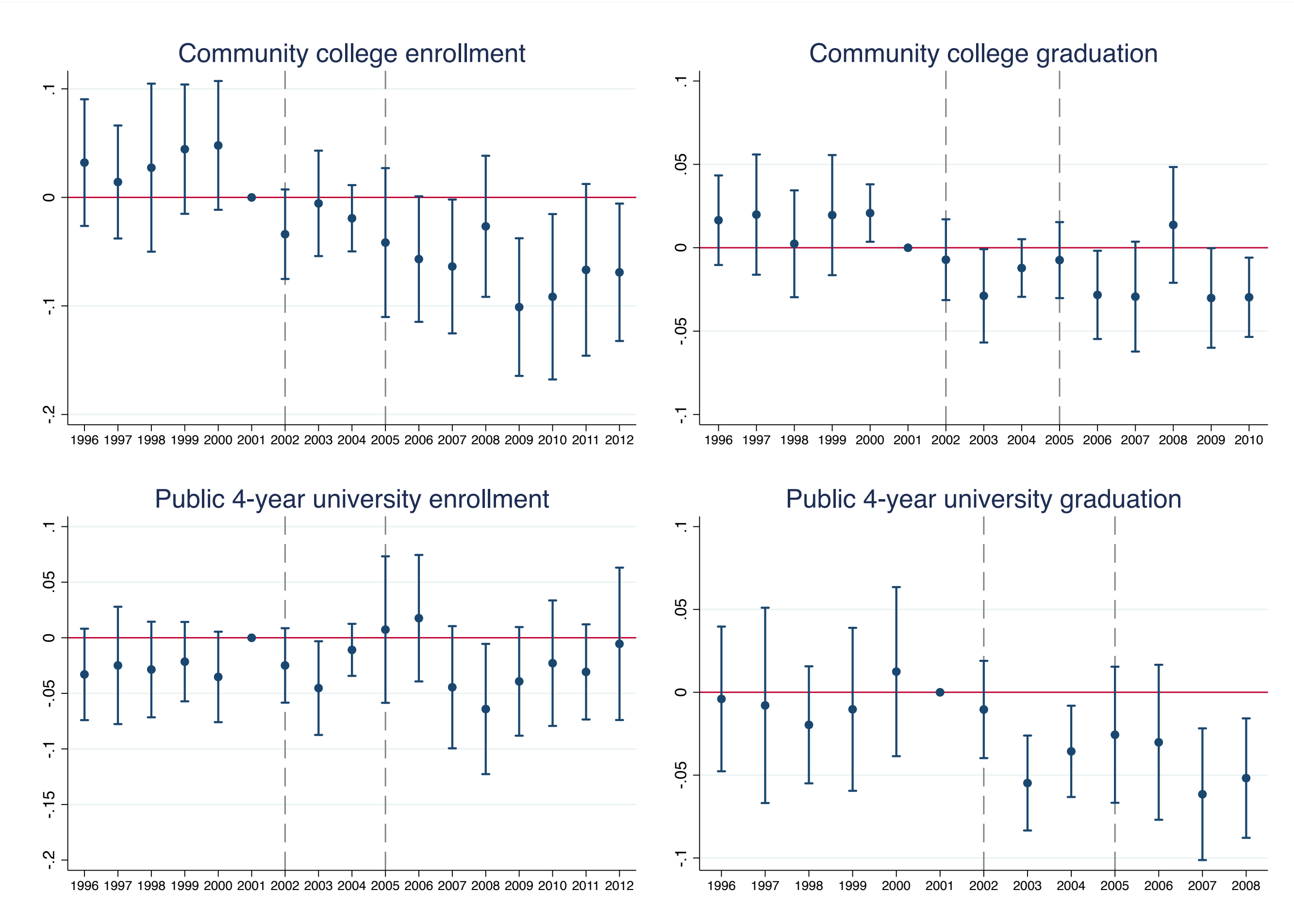

Figure 9: The effect of the fracking boom on college enrollment and graduation, by college type

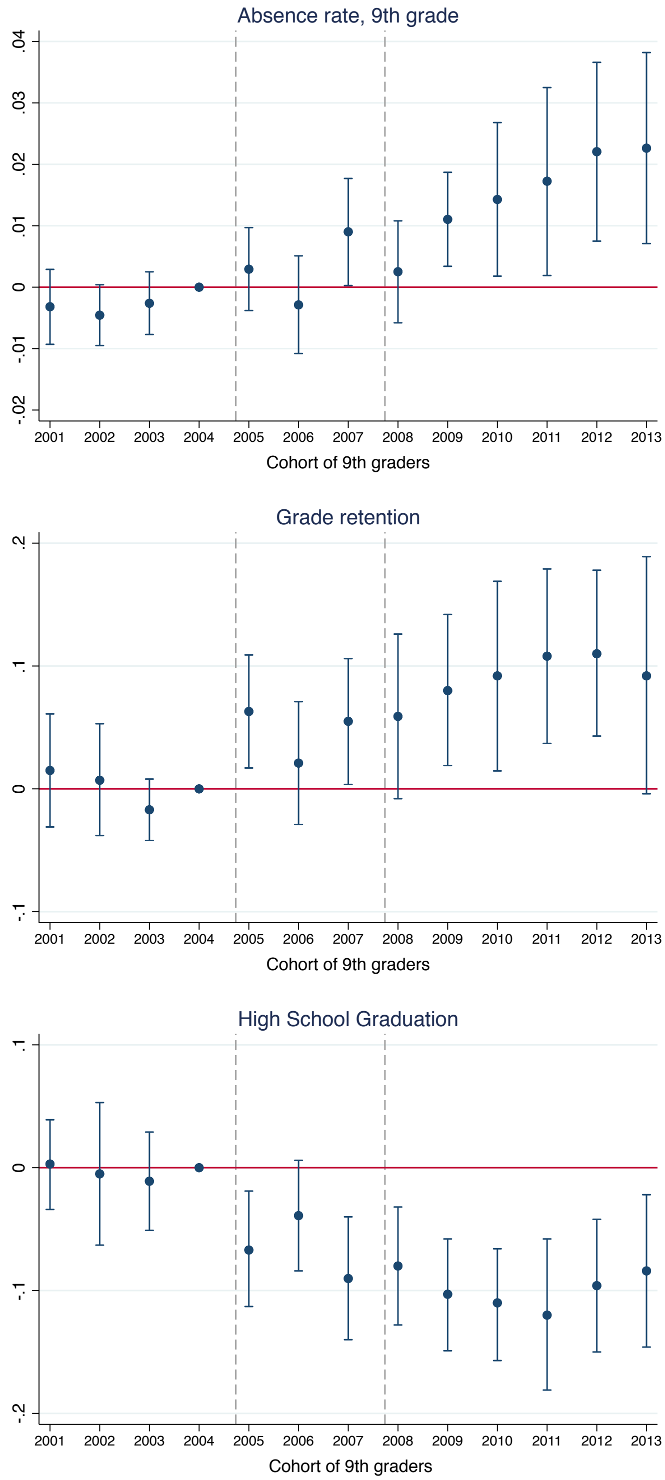

Figure 10: The effect of the fracking boom on absence rates, grade retention and four-year high school graduation, conditional on students being in TX from grade 1

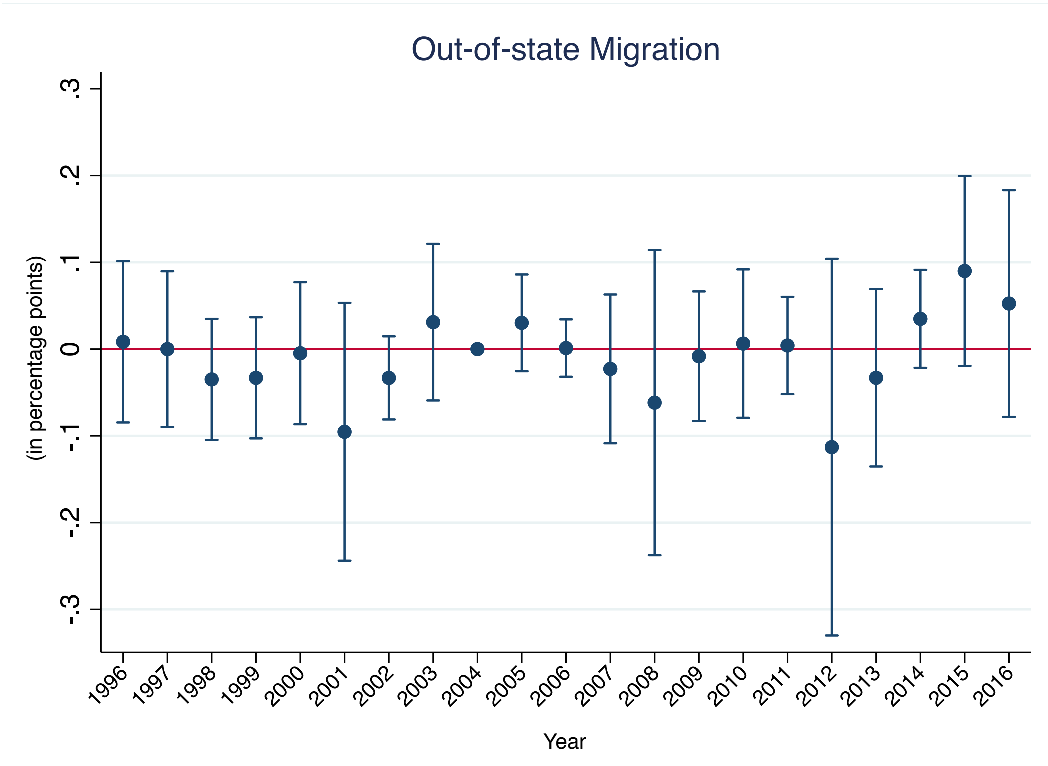

Figure 11: The effect of the fracking boom on out-of-state migration rate in TX

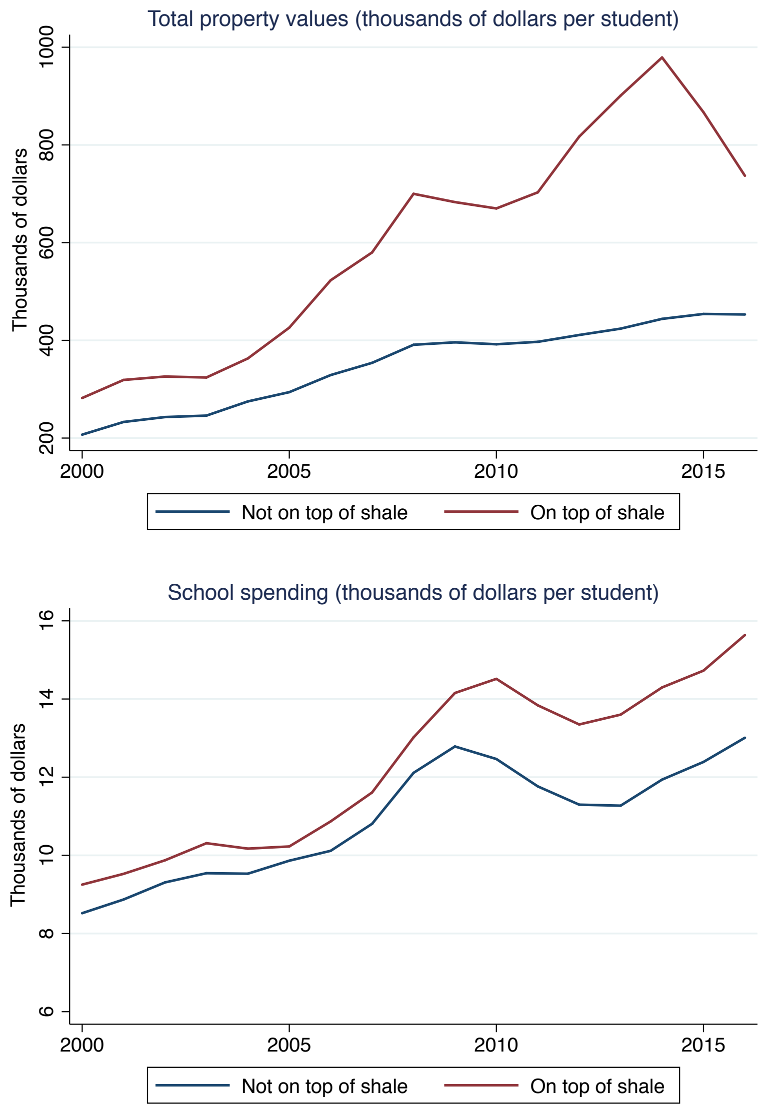

Figure 12: Total property values and school spending, in thousands of dollars per student

Tables

Table 1: Summary Statistics

	Reserves per capita			
Variable	All	Zero	Below median	Above median
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)
Number of students	1,717,586	327,239	1,277,704	112,643

The table reports means and standard deviations (in parentheses) for observable characteristics of students in the main sample in the pre-boom period (1996-2004).

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)
Average effect for fully treated	0.003**	0.004***	0.004***	0.004**	0.005***	0.003**	0.002*	0.002*
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

Commuting zone fixed effects and year fixed effects are included in all specifications. Standard errors, shown in parentheses, are clustered at commuting zone level. In the "Average effect for fully treated" row, I evaluate the estimates at the mean level of shale reserves in a community zone with non-zero reserves (0.21 millions of MMBTUs0).
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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)
Average effect for fully treated	0.013**	0.019**	0.022**	0.016**	0.020**	0.012	0.009	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

Commuting zone fixed effects and year fixed effects are included in all specifications. Standard errors, shown in parentheses, are clustered at commuting zone level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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)
Average effect for fully treated	-0.016**	-0.023***	-0.027***	-0.018**	-0.024***	-0.013*	-0.10*	-0.009
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

Commuting zone fixed effects and year fixed effects are included in all specifications. Standard errors, shown in parentheses, are clustered at commuting zone level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5: The effect of the fracking boom on earnings and employment at ages 15-18

	Average earnings	Log(earnings)	Employment			
			Total	Oil and gas	Food services	Retail
	(1)	(2)	(3)	(4)	(5)	(6)
Fully treated	488.75***	0.365***	0.247***	0.002*	0.097***	0.210***
	(139.33)	(0.135)	(0.072)	(0.001)	(0.031)	(0.063)
Partially treated	191.51**	0.086	0.083**	0.002*	0.028	0.091**
	(78.27)	(0.081)	(0.041)	(0.001)	(0.017)	(0.34)
Average effect for fully treated	102.64***	0.077***	0.052***	0.0004*	0.020***	0.044***
Baseline mean	*696.59*	*6.58*	*0.31*	*0.001*	*0.15*	*0.14*
Observations	3,835,757	2,409,805	3,835,757	3,835,757	3,835,757	3,835,757

Commuting zone fixed effects and year fixed effects are included in all specifications. Standard errors, shown in parentheses, are clustered at commuting zone level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6: 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***	-0.116**	-0.073**	-0.070**	-0.105***
	(0.022)	(0.029)	(0.035)	(0.030)	(0.043)	(0.036)	(0.033)	(0.030)
Partially treated	-0.044**	-0.047**	-0.058**	-0.035*	-0.054*	-0.079***	-0.011	-0.029
	(0.017)	(0.018)	(0.023)	(0.020)	(0.030)	(0.020)	(0.024)	(0.032)
Average effect for fully treated	-0.013**	-0.019***	-0.020***	-0.017***	-0.024**	-0.015**	-0.015**	-0.022***
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	0.001	0.008	-0.008	0.012	0.052*	0.025	0.082**
	(0.030)	(0.028)	(0.026)	(0.031)	(0.024)	(0.030)	(0.033)	(0.034)
Partially treated	-0.003	-0.001	-0.012	0.011	0.015	0.019	-0.014	0.029
	(0.015)	(0.016)	(0.014)	(0.023)	(0.012)	(0.019)	(0.024)	(0.020)
Average effect for fully treated	0.004	0.000	0.002	-0.002	0.003	0.011*	0.005	0.017**
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	906,362	906,370	925,367	906,376

Commuting zone fixed effects and year fixed effects are included in all specifications. Standard errors, shown in parentheses, are clustered at commuting zone level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: 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***	-0.019**	-0.024**	-0.058**	-0.047***
	(0.011)	(0.011)	(0.011)	(0.014)	(0.008)	(0.011)	(0.023)	(0.018)
Partially treated	-0.028**	-0.029**	-0.023*	-0.035***	-0.009	-0.043***	-0.021*	-0.037*
	(0.011)	(0.011)	(0.012)	(0.012)	(0.010)	(0.012)	(0.012)	(0.019)
Average effect for fully treated	-0.007**	-0.008**	-0.007**	-0.008***	-0.004**	-0.005**	-0.012**	-0.010***
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	779,197	779,204	779,201	779,209
Panel B. Effect on 4-year public college graduation								
Fully treated	-0.028	-0.051**	-0.032**	-0.068**	-0.013**	-0.013	-0.047	-0.021
	(0.020)	(0.020)	(0.015)	(0.028)	(0.006)	(0.016)	(0.032)	(0.037)
Partially treated	-0.030**	-0.030**	-0.022**	-0.036*	-0.013**	-0.004	-0.028	-0.029
	(0.012)	(0.013)	(0.010)	(0.021)	(0.005)	(0.011)	(0.022)	(0.021)
Average effect for fully treated	-0.006	-0.011**	-0.007**	-0.014**	-0.003**	-0.003	-0.010	-0.004
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	653,342	653,341	653,342	653,346
Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Commuting zone fixed effects and year fixed effects are included in all specifications. Standard errors, shown in parentheses, are clustered at commuting zone level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: The effect of the fracking boom on earnings 6 years after expected high school graduation

	Earnings			Earnings by quartile of predicted college-going			
	All	Men	Women	Q1 (Bottom)	Q2	Q3	Q4 (Top)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Reserves×Post	1,462.88***	2,116.14***	808.01***	1,432.38***	2,104.09***	1266.61***	957.39*
	(257.54)	(388.06)	(194.70)	(388.06)	(336.98)	(323.06)	(450.39)
Average effect	307.20***	444.39***	169.68***	300.80***	441.86***	265.99***	201.05*
Baseline mean	*3,504.87*	*3,845.52*	*3,182.96*	*3,126.08*	*3,350.80*	*3,555.33*	*3821.76*
Observations	2,613,371	1,271,619	1,341,752	653,343	653,342	653,342	653,344

Commuting zone fixed effects and year fixed effects are included in all specifications. Standard errors, shown in parentheses, are clustered at commuting zone level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: 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 10: 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 11: 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 12: 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)
Average effect	-0.003	0.024**	0.012
Observations	12,166,340	12,166,340	12,166,340

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

A Appendix

Figures

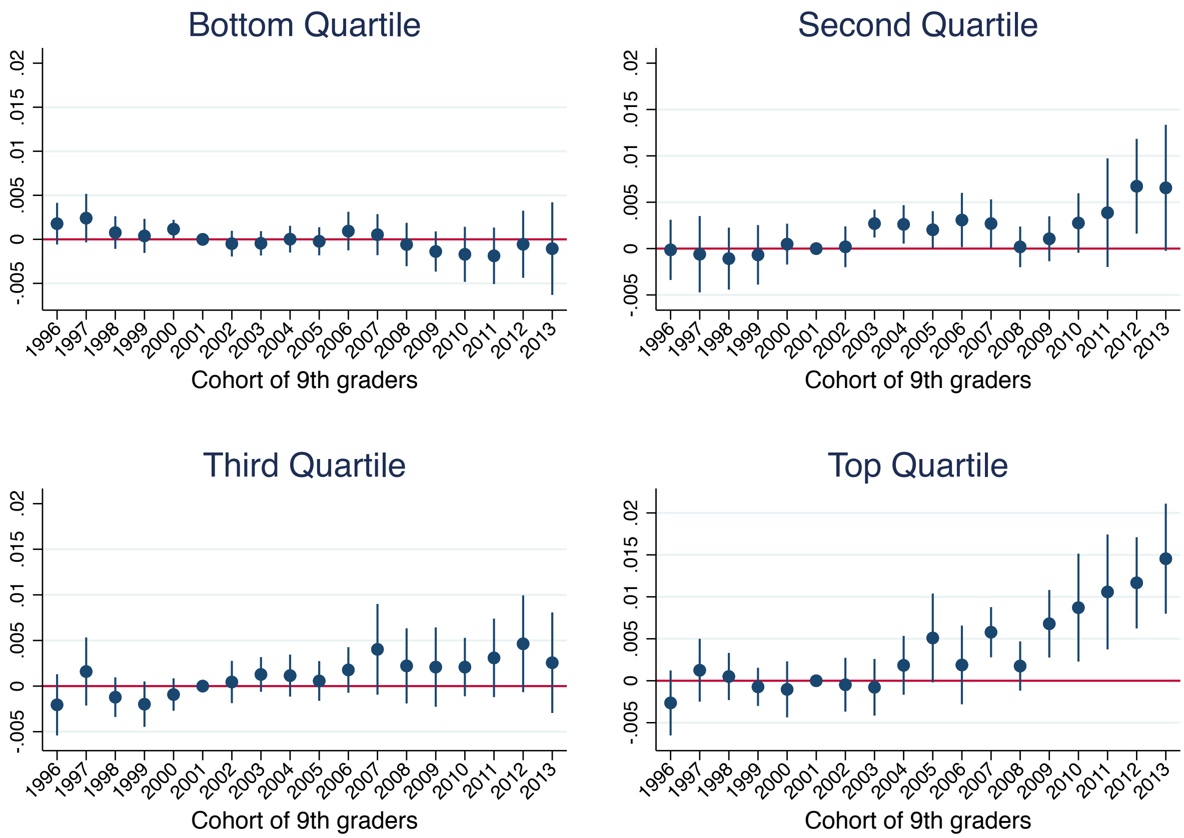

Figure 13: The effect of the fracking boom on absence rate in 9th grade, by quartile of predicted shale reserves per capita

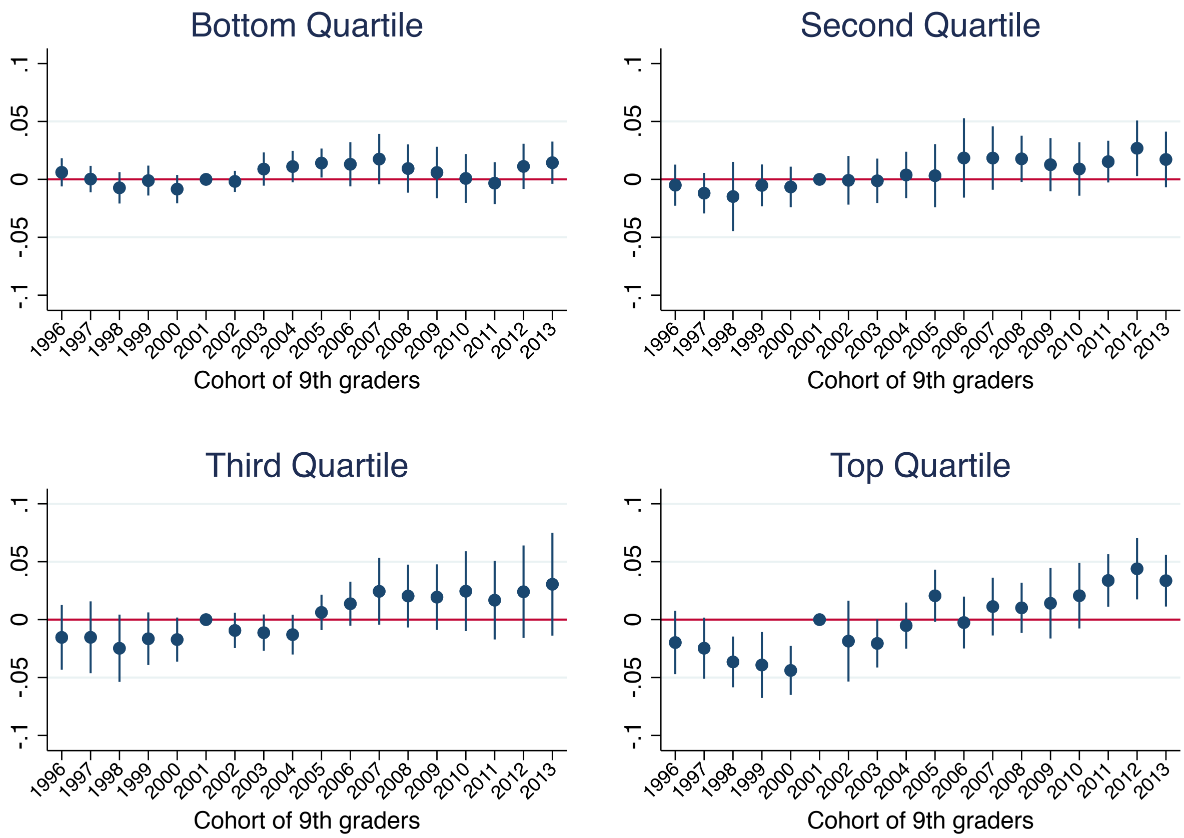

Figure 14: The effect of the fracking boom on grade retention, by quartile of predicted shale reserves per capita

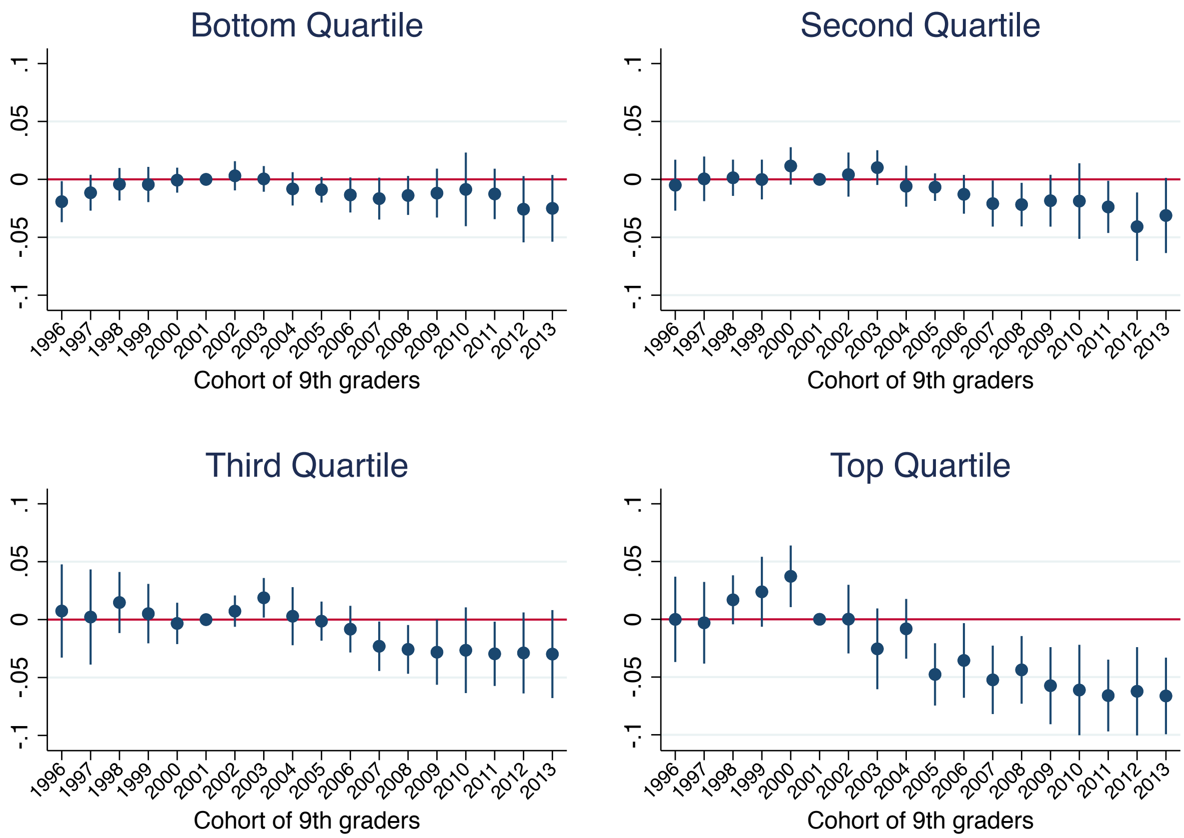

Figure 15: The effect of the fracking boom on high school graduation, by quartile of predicted shale reserves per capita

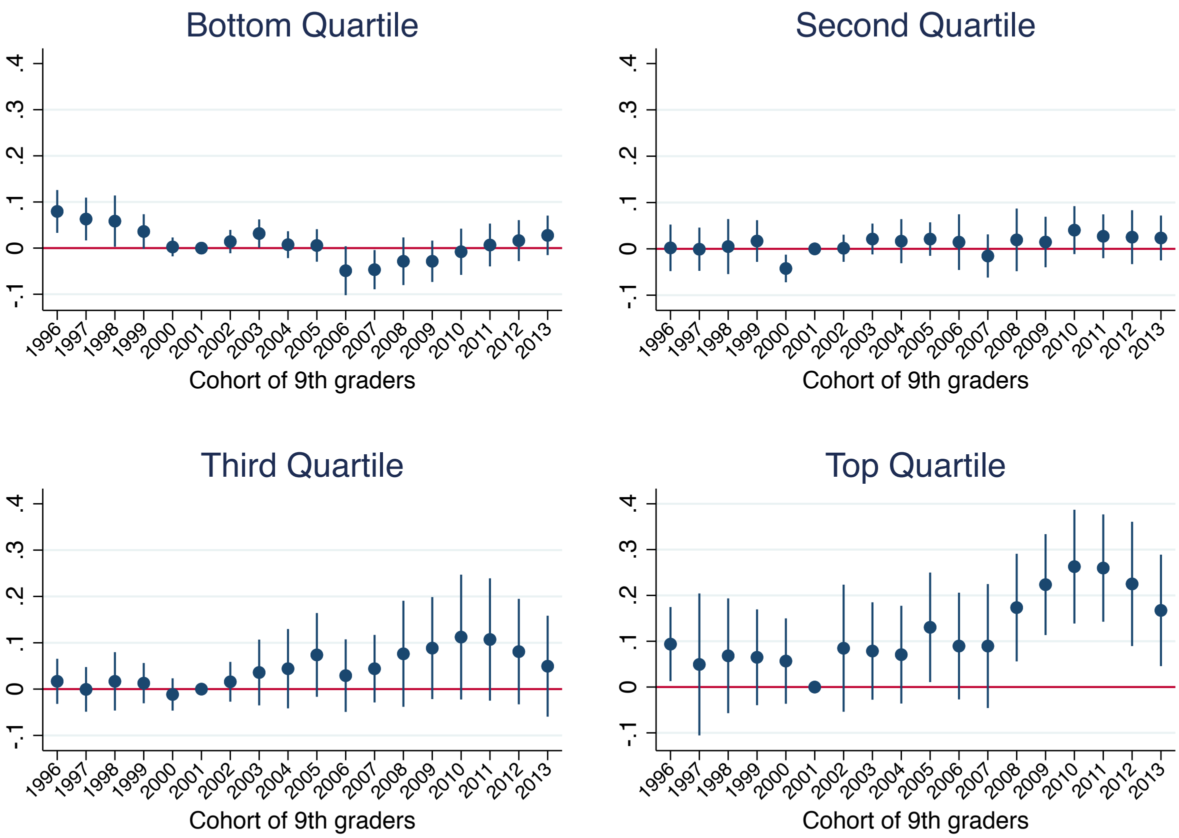

Figure 16: The effect of the fracking boom on log(earnings) during high school, by quartile of predicted shale reserves per capita

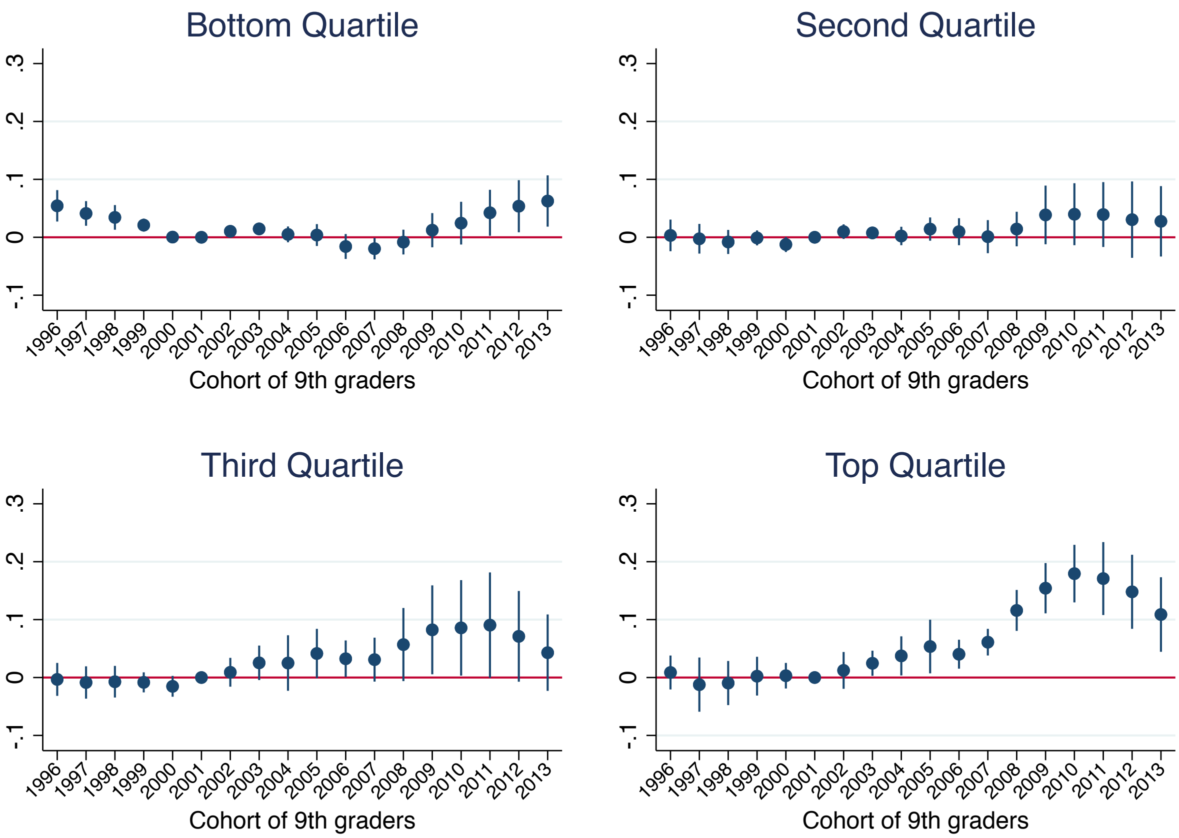

Figure 17: The effect of the fracking boom on probability of being employed during high school, by quartile of predicted shale reserves per capita