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

Alina Kovalenko *

August 20, 2020

Click HERE for the latest version

Abstract

This paper examines the role of local economic conditions in human capital accumulation decisions. I exploit geographic and temporal variation in the recent oil and gas fracking 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 exposure to the fracking boom during high school led to higher absence and grade repetition rates, and lower rates of high school graduation. I link students to their administrative employment records to show that the same individuals are more likely to be employed while in high school and directly after, with effects concentrated in the food and retail sectors. These students experience increases in earnings that persist for at least six years past expected high school graduation. Both schooling and employment effects were concentrated among students in the bottom of the ability distribution, who were likely on the margin of school attendance. My results suggest that natural resource booms may improve individuals' short- and medium-run economic outcomes even when they lead to lower educational investment.

JEL Classification: I20, J24, O13
Keywords: Human capital, schooling, fracking, earnings

---

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

I am grateful to Steve Trejo, Sandy Black, Richard Murphy, Marika Cabral and Tom Vogl for their support and guidance, and to Mike Geruso, John Hatfield, Elizabeth Cascio, Cooper Howes, Nir Eilam, and seminar participants at the University of Texas at Austin for useful discussions and comments. I would also like to thank the Texas Education Research Center and DrillingInfo for generously providing the data. All errors are my own. The conclusions of this research do not necessarily reflect the opinion or official position of the Texas Education Research Center, the Texas Education Agency, the Texas Higher Education Coordinating Board, the Texas Workforce Commission, or the State of Texas.

1 Introduction

Decisions about when and how much education to acquire have important 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 still know relatively little about how these shocks affect human capital investments beyond highest qualification achieved, the mechanisms through which they operate, and most importantly, the short-run and long-run effects of these booms on individual-level economic outcomes. In addition, the lack of panel data covering both educational and labor market outcomes for the same individuals across time has prevented existing work from directly addressing confounding migration effects associated with these booms.

This study fills these gaps by examining schooling and work decisions of young adults in the context of the oil and gas fracking boom. 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). Standard theories of human capital predict that such booms can generate improved employment opportunities that could discourage young individuals from finishing high school or attending college, particularly for those who have low expected marginal returns of education. On the other hand, improved economic conditions may lead to better educational outcomes if they allow students to spend less time working and more time on school, or if they lead to an improvement in school resources. The ex-ante effect of natural resource booms is ambiguous and likely to vary throughout the student ability distribution.

I utilize unique administrative panel data from the state of Texas to study how the fracking oil and gas boom affected academic performance and labor market outcomes of both the average student and of students across the skill distribution. The data are highly detailed and allow me to track individuals from the time they enter kindergarten through middle school, high school, and college. Furthermore, the educational data are merged with earnings records derived from unemployment insurance files, allowing me to track labor market outcomes for the same individuals. These records cover the universe of almost 20 years of high school cohorts and include rich information about student attendance, performance on standardized tests, college enrollment, graduation, employment, and earnings. I combine these data with a detailed oil and gas well-level database maintained by DrillingInfo and information on shale reserves from the Energy Information Administration.

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 fracking boom and estimate difference-in-differences and event study models, which allow me to assess the evolution of relative outcomes while controlling for fixed differences across local labor markets and cohorts of students.

I find that the fracking boom had a large impact on both educational and labor market outcomes for high school students. In the labor market, outcomes were positive: high school students aged 14-18 experienced increases in earnings of 5-17% and increases in employment of 6-20%. The magnitudes of these gains were similar for both men and women, and were concentrated in the retail and food service industries.[1] This improvement in local labor market conditions increased the opportunity cost of attending school, however. These better-paying unskilled service jobs did not affect the educational outcomes of students at the top of the ability distribution but had a large impact on the types of students who were least likely to graduate high school and go on to attend college. I estimate that exposure to the fracking boom led to 0.2

[1] This is in line with results from existing literature which does not directly look at students but 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, Feyrer, Mansur and Sacerdote, 2017).

percentage point (p.p.) higher absence rates, 1 p.p. higher grade repetition rates, and 1.1 p.p. lower high school graduation rates. Across all of these measures, students at the bottom of the ability distribution – who were also the group who saw the largest increases in employment and earnings – drove the deterioration in overall educational outcomes, while students at the top of the distribution were not affected. These results suggest that the students who responded to the fracking boom by substituting work for school were primarily the students closest to the margins of attendance and graduation.

While it is tempting to dismiss the decision to drop out of high school due to improved job opportunities as irrational or myopic, I link students' high school records to administrative college and unemployment insurance records to show that this is not necessarily the case. First, I show that the fracking boom is not associated with any significant change in college enrollment, which suggests that the increased high school dropout rates were driven by students who would not have attended college in the absence of the fracking boom. Because the earnings premium for a terminal high school degree is much smaller than that of a college degree, this means that these students were foregoing far less income by dropping out than a student likely to go on to college. I also show that these earnings gains experienced by high school dropouts persisted through at least age 24-25.[2] This evidence suggests that the decision to invest less in schooling on the part of low-ability students is at least partially justified by these persistent improvements in their outside options.

While the decision to drop out of high school is likely based on a wide variety of factors, I find that the increased opportunity cost of schooling caused by improving labor markets is the most important mechanism through which the fracking boom affected educational outcomes. I investigate several other potential channels but ultimately find that selective migration, changing returns to education, and increased school spending are unable to account for my results.

This paper contributes to a large and growing literature on the role of aggregate economic shocks in human capital decisions in both the developed and developing world. These studies include but are not limited to trade shocks in Mexico (Atkin, 2016), infrastructure programs

[2]The timing of the fracking boom limits the number of affected cohorts for whom I can currently evaluate earnings beyond this age.

in India (Adukia, Asher and Novosad, 2017), oil price shocks in Canada (Emery, Ferrer and Green, 2012, Morissette, Chan and Lu, 2015), oil discovery in Norway (Butikofer, Dalla Zuanna and Salvanes, 2018), housing bubble in the U.S. (Charles, Hurst and Notowidigdo, 2018) and coal boom in Appalachia (Black, McKinnish and Sanders, 2005). It is most closely related to a smaller literature studying the educational response to the fracking boom in the U.S., which includes Cascio and Narayan, 2015, Marchand and Weber, 2020, Weber, 2014, and Zuo, Schieffer and Buck, 2019.[3]

This paper is the first to use linked longitudinal K-12 school-college-employment data to analyze the effects of a natural resource boom on the entire human capital accumulation process for a large number of cohorts. In particular, I extend the existing literature on the contemporaneous effects of fracking on high school students by analyzing post-secondary schooling and longer-term labor market outcomes for the same individuals. 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.

While previous work mainly focused on educational attainment and enrollment at high levels of geographic aggregation (typically available from the Decennial Census or American Community Survey), I observe more detailed measures of human capital such as standardized test scores, absence rates, grade repetition, 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 at different stages of their education. In addition, having panel data allows me to determine which types of students were most affected, both in terms of demographic characteristics and prior academic ability, and thus is crucial for policymakers seeking to make informed decisions when evaluating the consequences of fracking.

The unique nature of my dataset also allows me to address important empirical challenges

[3]The evidence on educational response from these papers is mixed. For example, Weber, 2014 finds that the fracking boom in TX, LA, AR, and OK has increased the share of the adult population with a high school degree. Marchand and Weber, 2020 find that the percentage of high school students passing standardized tests in oil-rich areas of Texas decreased but show no change in completion rates. On the other hand, Cascio and Narayan, 2015 and Zuo, Schieffer and Buck, 2019 show that drilling activities increased high school dropout rates and decreased grade 11 and 12 enrollment respectively.

inherent in analyzing local labor market shocks. 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 student mobility over time. This study overcomes this challenge by studying the universe of students in the public school system of Texas, and thus allows me to distinguish directly between newly arrived migrants and pre-existing student populations. This represents an important improvement on prior work as it allows me to rule out fixed characteristics of incoming migrant workers and their families from explaining my results.

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. Understanding what role labor market opportunities created by the boom play in student decisions will help identify potentially effective policy responses aimed at mitigating any negative consequences.

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. Sections 4 and 5 describe the data and research design. Sections 6 and 7 present main results and robustness checks. Section 8 discusses potential mechanisms, and Section 9 concludes.

2 Background: Fracking Boom

Beginning in early 2000s, the interaction of technological change and increased energy prices fueled massive 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 therefore conventional vertical drilling is typically not considered to be 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 early 2000s, generated localized fracking booms across many areas of the United States.[4]

Texas is a major player in the energy market and sits on top of four major shale formations (Figure A1). 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: panel A of Figure 1 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 (panel B).[5] Typically after the wells are drilled and the shale is fractured, the wells are placed into production. As shown in panel C, increased drilling resulted in unprecedented levels of crude oil and natural gas production which more than tripled between 2008 and 2017.[6]

The oil and gas extraction booms that followed these technological developments 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 such as transportation, construction, trade and hospitality (Allcott and Keniston, 2017, Maniloff and Mastromonaco, 2017, Cai, Maguire and Winters, 2019). For example, Feyrer, Mansur and Sacerdote, 2017 estimate that 40% of wage income generated by the fracking boom is attributable to workers outside the oil and gas industry. Panel D of Figure 1 shows that the share of workers employed in the oil and gas industry evolved similarly in both shale and non-shale areas of Texas until around mid 2000s, but grew substan-

[4] 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)

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

[6] 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).

tially in areas that sit on top of shale starting from around 2005, consistent with the expansion of drilling. Similar patterns are observed in panels E and F which display employment share in transportation and warehousing and wholesale trade industries. Prior work has also documented that labor demand shocks were particularly large for workers with low levels of education. For example, Modestino, Shoag and Ballance, 2016 show that employers cut skill and experience requirements in response to tightening labor markets due to fracking.

Because shale resources were inaccessible until very recently, they were unlikely to influence economic development prior to the early 2000s and can plausibly be thought of as being exogenous with respect to local economic conditions up until that point.[7] Furthermore, Texas is a very large state with substantial shale deposits, and the boom's effect on labor markets was sufficiently large and far-reaching to be visible even for the range of jobs available to high school students. The Texas Education Research Center also maintains rich data covering the universe of students in the public school system in Texas that allows me to track students from elementary school through college and into the labor market. Together, these factors make this an ideal setting to analyze the effects of shocks to local economic conditions on human capital and earnings.

3 Conceptual Framework

In this section, I use existing theoretical and empirical work to help explain how local labor market shocks generated by the fracking boom could affect schooling decisions of young adults. In a simple conceptual framework, an individual faces a trade-off between the long-run benefits of schooling and the short-run return to labor. If in any given year she decides to leave school, she will work in the labor market and earn income that corresponds to her education and experience level. If she remains in school, she forgoes current earnings but will earn higher income in the future as she completes additional years of schooling. According to the standard human capital theory (Mincer, 1958, Becker, 1964), an individual makes the decision to stay in school if the present discounted value of the benefits of schooling exceeds the costs.

[7] In section 5, I provide more formal evidence for this assumption.

A local fracking boom affects the trade-off between staying in school to obtain additional education and leaving early to participate in the labor market. By increasing low-skilled employment and wages, the boom raises the opportunity cost of schooling and induces students to reduce human capital investment. Improved labor market opportunities could also decrease returns to education if there is a persistent increase in low-skill relative to high-skill wages. In this case, we may expect to see a decrease in human capital investment as well.

In addition, improved labor markets could affect schooling decisions though increased family income or school resources. The boom may increase household earnings for parents or other members of the household, which could plausibly lead to increased demand for schooling if it is a normal good. The existing evidence on the importance and magnitude of family income and liquidity constraints is mixed, ranging from a zero to a sizable positive effect on schooling. [8] School resources available to students may also be affected by fracking. Since oil and gas extraction generates tax revenue collected by local school districts, it could have a positive effect on student achievement through investment in new learning materials, increased teacher salaries, or other improved educational resources. These effects, however, could be offset by decreased property values near fracking sites or lower quality of teachers if improved labor markets induce them to quit or seek employment elsewhere.

Thus, an individual's the decision in its simplest form ultimately depends on the opportunity cost of remaining in school, the wage differential between low- and high-skill jobs, and family and/or school resources available to students. I expect the opportunity cost and returns to education effects to reduce schooling, the family income effect to have zero or positive impact on schooling, and school resources to have an ambiguous effect. The net effect is therefore unclear ex-ante and depends on the relative sizes of the competing forces described above. [9]

The net effects of these channels are also likely to differ throughout the student ability dis-

[8] For example, Hilger, 2016 and Bulman et al., 2016 find that for most young individuals in the United States 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.

[9] The fracking boom could also affect schooling decisions through other channels, such as marriage markets (Kearney and Wilson, 2018, crime (James and Smith, 2017, Bartik et al., 2019), and pollution (Hill, 2018), but I focus on impacts through labor market opportunities.

tribution. If the fracking boom leads to more and better-paying jobs that can be done without a high school diploma, students at the bottom of the distribution – more of whom are on the margin of high school graduation and unlikely to attend college – may find dropping out and entering the labor force more appealing. High-ability students, on the other hand, are less likely to find these jobs to be attractive alternatives to college, but improved family and household resources caused by the boom may allow them to afford it when they would not otherwise be able to. The question of who responds to local labor market shocks has not been studied in the existing literature, yet it is crucial for understanding the determinants of human capital decisions and the impact of potential policies promoting education through economic channels.

In summary, my empirical analysis will compare the change in educational outcomes for cohorts of 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 empirical analysis will shed light on which one dominates. In Section 8, I discuss the relative importance of these channels in more detail.

4 Data

The data used in this project come from several administrative registries maintained by the Texas Education Research Center (ERC).[10] My main sample consists of about 4.7 million individual observations across 19 cohorts of students who attended middle school in Texas and enrolled in high school in the state between 1996 and 2014. I define cohorts by the academic year in which students first entered grade 9, and I associate students with the school district in which they were enrolled in grade 6.[11] These records come from the Texas Education Agency (TEA) and include data on student enrollment, attendance, test scores on standardized exams, high school graduation, and demographic information such as gender, age, race, free lunch and special education status. I link these students to administrative college enrollment and graduation records,

[10] Access to these data was obtained through a restricted-use agreement with the Texas ERC, a research center and data clearinghouse of the University of Texas at Austin.

[11] In Section 8, I show that my results are robust if I restrict my sample to students who lived in Texas at least from elementary school.

maintained by the Texas Higher Education Coordinating Board (THECB). Finally, these data are also matched to quarterly earnings records from the Texas Workforce Commission (TWC) which cover all employees in Texas subject to the state unemployment insurance system.[12]

I consider several academic outcomes. First, I look at high school students' absences, grade repetition and graduation. I calculate absence rates as the ratio of the number of days a student is absent to the total number of days taught. I define a student as a grade repeater if they are enrolled in the same grade for two consecutive years during high school. To measure high school graduation, for each student I link their enrollment records in 9th grade with their respective graduation records up to 5 years later. Second, I use 6th grade test scores as proxy for student academic ability in order to examine heterogeneous effects of the boom at different parts of the skill distribution. The test score data come from state standardized exams for mathematics and English.[13] I transform raw scores on each test into z-scores with zero mean and unit standard deviation by cohort.[14] I create a composite score from a 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. Lastly, the ability to link TEA records to post-secondary educational outcomes allows me to analyze the impact of the fracking boom on such previously understudied outcomes as college enrollment and completion. I examine these outcomes separately for community colleges and public four-year universities.

I also consider several labor market outcomes. First, I create a measure of quarterly earnings for each high school student in my main sample, at ages 14 to 18. I average and take the natural log of non-missing quarterly earnings for each student over four years of high school, and deflate them by the consumer price index (CPI).[15] I also consider a measure of quarterly earnings which assigns zeros to quarters in which no earnings are observed. Second, I create indicators for being

[12]Unemployment insurance records cover employers who pay $1500 or more in total gross wages in a calendar quarter or have at least one employee during 20 different weeks in a calendar year regardless of the wages.

[13]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.

[14]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.

[15]All earnings are in 2013 dollars.

employed overall and split by industry. Finally, I examine earnings 6-7 years after expected high school graduation, at ages roughly 24 to 25, which are the most recent records currently available for all cohorts in my sample.

I supplement education and earnings records with information on oil and gas drilling and production from DrillingInfo, a private company that provides data and analysis to the energy sector.[16] I aggregate well-level records for the daily number of new wells drilled and monthly production to county-year level. These data can be split by well type (horizontal, directional, vertical, and unknown), and as in prior work, I categorize production and drilling from horizontal and directional wells as unconventional or produced by fracking (Feyrer, Mansur and Sacerdote, 2017). I use shapefiles of shale plays and estimates of shale oil and gas reserves from the Energy Information Administration (EIA).

Column 1 of Table 1 reports summary statistics of baseline observable characteristics for students in my main sample. The average absence rate is 6% and the share of students in the sample who repeat at least one grade during high school is 23%. About 73% of students work during high school for at least one quarter and on average they earn $1506 per quarter. 71% of students graduated from high school in four years, and 20% and 37% of students enroll into 4-year and 2-year colleges in the next two years after their expected high school graduation.

5 Research Design

5.1 Measuring Exposure to the Boom

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. For example, struggling communities may be more willing to accept fracking in order to boost 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

[16] I obtained access to the data through a special agreement with DrillingInfo.

introduce omitted variable bias if the same characteristics that ultimately led to extraction of oil and gas reserves also affect individual education decisions.

I instead use shale oil and gas reserves per capita as a measure of a fracking potential of an area, following the approach of Cascio and Narayan, 2015 and Michaels, 2010. I define a local area for my analysis as a commuting zone, guided by the fact that fracking has been shown to generate shocks to local labor markets that extended beyond county and school district boundaries (Feyrer, Mansur and Sacerdote, 2017).[17] To construct my reserves measure, I 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, and allocate oil and gas reserves to commuting zones based on the share of each shale that they represent. I then convert these predicted reserves into one common metric defined by millions of British Thermal Units (MMBTUs), which represents energy content, and divide it by baseline population in 1995.

Figure 2 displays geographic variation in the fracking potential across commuting zones in Texas as measured by the shale oil and gas reserves per capita. There is significant variation in predicted reserves across the state with clusters of high-reserve areas found in the west and south. My research design relies on the assumption that reserves are a good proxy for drilling activity and, ultimately, the extent of the local labor market boom that results. To show that this assumption is valid, I regress new drilled wells on interactions between reserves per capita and year indicators as well as year and commuting zone fixed effects. I plot regression coefficients in Figure 3. Areas with high fracking potential saw significant increases in oil and gas wells, suggesting that underlying reserves are a good proxy for subsequent drilling. The number of wells starts to increase around 2005 and reaches a peak in the early 2010s; in contrast, prior to the start of the boom, the coefficients are precisely estimated zeros.

[17]Commuting zones are geographic units intended to approximate local labor markets and are constructed based on where people live and work (Tolbert and Sizer, 1996). Another advantage of using commuting zones is that, unlike metropolitan statistical areas, they also include rural areas, which is important in my setting because these areas often lie on top of shales.

5.2 Empirical Framework

My main specification is a difference-in-differences model, where I compare changes in educational and labor market outcomes across cohorts of high school students with high exposure to the fracking boom to changes in outcomes across cohorts with lower exposure. Similar to existing literature, I date the start of the boom in Texas to 2005.[18] I estimate the following equation:

$$y_{icj} = \sum_{k \neq 2001} \beta_k \times \mathbb{1}(k = c) \times Reserves_j + X_{icj}\theta + \gamma_j + \delta_c + \lambda_j \times Z_j^{pre95} + \epsilon_{icj}, \qquad (1)$$

where y_{icj} is an outcome of interest for student i in cohort c living in commuting zone j. I normalize predicted shale reserves per capita, $Reserves_j$, by the average non-zero reserves in my sample for ease of interpretation.[19] The term $\mathbb{1}(k = c)$ represents a set of dummy variables which are equal to one if cohort c was in 9th grade in year k. 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 of students who enrolled in 9th grade in years 2002-2004 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 difference in outcome for cohorts that start 9th grade in year k between the average reserve and zero-reserve areas, as compared to the last fully untreated cohort.

I include commuting zone fixed effects, γ_j, to control for time-invariant differences between commuting zones, such as land area or preferences for education, and cohort fixed effects, δ_c, to capture area-invariant differences between cohorts of high school students, such as state-wide employment shocks. I also control for individual-level covariates X_{icj} which include race/ethnicity, gender, and indicators for special education, English proficiency and free lunch status. The standard errors are clustered at commuting zone level.

[18] 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 7, I show that my results are robust to alternative assumptions about the timing of the boom.

[19] This transformation implies that a one unit change in reserves per capita corresponds to going from a commuting zone with no shale reserves to a commuting zone with average reserves.

I also consider a modified version of a difference-in-differences model above which replaces year dummies with two indicators for being fully and partially treated. This approach summarizes the impact of the boom more concisely and provides more power to detect average treatment effects. The exact specification is:

$$y_{icj} = \beta_1(Reserves_j \times Partial_c) + \beta_2(Reserves_j \times Full_c) + X_{icj}\theta + \gamma_j + \delta_c + \lambda_j \times Z_j^{pre95} + \epsilon_{icj}, \quad (2)$$

where $Partial_c$ equals one if a student was in 9th grade between 2002 and 2004, and $Full_c$ equals 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 student outcomes in commuting zones with different levels of fracking potential would continue to move in parallel in the absence of the boom, conditional on controls and fixed effects. The event study specification in equation (1) helps formally assess pre-trends by looking at estimates of β_k in the pre-fracking period. In the next section, I show that these estimates are indistinguishable from zero, confirming that there was no underlying trends in outcomes that differed across commuting zones with different levels of treatment.

The identifying assumption would also be violated if there are time-varying shocks specific to areas with high or low fracking exposure and which are correlated with student outcomes. Columns 2 and 3 of Table 1 show that counties with higher shale reserves are less populous and have slightly lower median household income. These differences in levels are captured by commuting zone fixed effects. However, in order to control for possible differences in trends across areas that may be spuriously correlated with the fracking boom, I flexibly control for commuting zone baseline characteristics, Z_j^{pre95}, by interacting them with cohort fixed effects, δ_c in all models. I am not aware of any other policies or shocks that coincided with the timing and geographic variation as the fracking boom; in Section 7, I show that there was no evidence of demographic shifts in student cohort composition associated with the boom. Taken together, these exercises provide support for my assumption that the scale of each area's fracking boom was driven largely by factors exogenous to local economic conditions and student educational outcomes.

6 Main Results

6.1 Labor Market Outcomes

I begin by documenting that the fracking boom led to increased employment and earnings for high school students. Past work has shown that fracking exposure led to aggregate increases in job opportunities for low-skilled workers, but without student-level data these studies have been unable to directly observe how these changes affect students. This data problem is not unique to my particular research question; more broadly, evidence on the determinants of employment while in school is remarkably scarce. Thus by directly linking student and employment outcomes, my work not only improves on the existing literature by precisely identifying the link between fracking-driven improvements in labor markets and educational attainment decisions, but also sheds light on the factors that cause students to seek employment more generally.

Employment is quite common for high school students in Texas.[20] As shown in Table 1 , nearly 73% of youth aged 14-18 are employed for at least one quarter during high school. Moreover, 30% of students are reported to have "meaningful employment", which I define as having quarterly earnings equal to working at the prevailing 2005 minimum wage of $5.15 for at least ten hours per week (roughly $600 per quarter). The majority of employed students work in the food service, retail, or entertainment sectors.

Figure 4 presents event study estimates from equation (1) for the effect of the fracking boom on employment and earnings of adolescents ages 14 to 18. All estimates are calculated relative to the last untreated cohort of students who started 9th grade in 2001. 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 between the dashed lines. Cohorts who started high school in 2005 or later are considered fully treated. If labor market outcomes in areas with different

[20]This is due in part to the state's flexible child labor laws. Minors aged 14-15 are restricted to working a maximum of 48 hours per week (with no more than 8 hours in one day) and the state imposes no minor-specific restrictions starting at age 16. In addition, 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 on child labor laws in Texas see: https://twc.texas.gov/jobseekers/texas-child-labor-law

levels of fracking potential were trending similarly prior to the boom, the estimated coefficients for cohorts prior to 2001 would be small and not statistically significant. The estimates in the pre-boom period do not show differential pre-existing trends for any of the outcomes I consider, which provides support for the validity of my identifying assumptions.

The post-boom estimates for quarterly earnings and probability of being employed in panels A and B display a strong positive trend with the effects becoming particularly large and significant in late 2000s, consistent with the gradual expansion of the boom.[21] Since the reserves variable is normalized to the average reserve volume across all regions with positive reserves, students in commuting zones with average reserves would be estimated to experience a 5% increase in quarterly earnings and a 4 percentage point increase in the probability of employment (6% increase when evaluated at the pre-boom mean) in 2010 relative to a commuting zone with no reserves. These effects are much larger for labor markets at the right end of the reserve distribution: for example, the effects reach 17% and 20% increases in earnings and employment in commuting zones with reserves at the 90th percentile. In panels C and D of Figure 4 (and in Figure A2), I show that the employment response was particularly large in the food services and retail trade sectors. This is not surprising since these industries historically tend to employ large shares of adolescents. As discussed earlier, these are also the industries that indirectly benefited from the fracking boom. The employment effect in oil and gas sector presented in panel E is positive but it is much smaller and noisier, partly due to a very small number of high school students working in this sector. In summary, these results suggest that the fracking boom led to substantial increases in employment and earnings of high school students, and that these increases were concentrated in service industries typically associated with youth employment.

The results from a more restrictive difference-in-difference specification, described by equation (2), appear in column (1) of Table 2, and are consistent with the findings from event study models above. The magnitudes of the effects are similar to other studies examining the labor market effects of the fracking boom in the U.S. overall and in Texas in particular (Bartik et al., 2019, Krupnick and Echarte, 2017, Cai, Maguire and Winters, 2019, Lee, 2015). In panel B, I report

[21] 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.

the effect on average quarterly earnings which also includes quarters with zero earnings. It shows that cohorts in areas with average exposure to the boom earn about 5% more per quarter when evaluated at the pre-boom mean of $464. The similarity of the effect to the log earnings measure implies that the impact is not driven by a changing probability of having non-zero earnings.

The labor market response may vary based on students' individual characteristics. In particular, I examine whether the fracking boom had heterogeneous effects based on student gender and proxy for prior academic ability. The estimates reported in columns (2)-(3) are generally similar across gender, with the exception of oil and gas industry where an increase in employment was concentrated predominantly among males. Students at the bottom of the class distribution, who are likely to be on the margin of school attendance, may be more attracted by improved job opportunities than their high-performing peers. To test this hypothesis, I approximate student academic ability by calculating their composite score on math and English standardized tests in 6th grade, and divide this measure into quartiles. The results from separately estimating equation (2) for each group of students are presented in columns (4)-(7) of Table 2. There are some stark differences by student ability; both employment and earnings increased considerably for students at the bottom of the skill distribution, while neither outcome changed for students in the top quartile. The next section builds on this observation by further exploring the link between student ability and educational outcomes.

6.2 High School Performance and Completion

In this section, I directly link students with their academic outcomes to examine whether the increase in students' employment following the fracking boom affected their schooling performance. Although some prior work has documented that there is a decrease in educational attainment in the labor markets affected by fracking, data limitations have prevented these papers from analyzing the relationship between educational and labor market outcomes. Directly establishing this link allows me to determine which types of students respond to local labor market shocks, which is crucial for economists and policymakers seeking to understand how the benefits of local economic booms are distributed. In the following paragraphs, I examine whether shale oil and gas boom differentially affected high school absence rates, grade repetition and graduation in areas with high reserves.

Absence rates. First, I examine the effect of the fracking boom on high school students' absence rates. I calculate absence rates for each student by taking the ratio of days absent to total number of days taught in each year and then take the average across grades 9 through 12. [22] Panel A of Figure 5 reports year-specific coefficients, β_k, from equation (1), along with 95% confidence intervals. There was not a preexisting trend between areas with different fracking potential prior to the boom. After the beginning of the boom, students in commuting zones with high fracking potential experienced a gradual persistent increase in absence rates.

Corresponding estimates from the more concise model in equation (2) are shown in Table 3 and confirm the results of the event study model. Each column in this table reports estimates from running a separate regression. Students in labor markets with average reserves experienced a 0.2 p.p. increase in absence rate. These point estimates imply that students missed an additional half a day of school, contingent on a standard 180-day school year. While the effects were similar for both males and females, the average effects mask substantial heterogeneity across students of different ability. The effect is largest for students at the bottom of the skill distribution (0.3 p.p.) and is not statistically different from zero for the top quartile. This heterogeneity accords with the employment and earnings estimates in the previous section which were strongest for the same group of students.

Grade repetition. I next examine whether exposure to the fracking boom resulted in higher incidence of grade repetition, 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-differences results shown in panel B of Table 3 indicate that students in a commuting zone with average level of shale reserves per capita experienced 1 p.p. higher likelihood of grade repetition (4.8% increase when evaluated at the mean of 21%). The event study plot in panel B of Figure 5 confirms that the increase in grade repetition 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

[22] In Appendix A, I show absence rate results by grade. The results are similar but higher for 9th grade since it captures students' behavior before some of them decide to drop out.

base year. As with absence rates, the effects on grade repetition are similar across males and females but are concentrated at the bottom of the ability distribution.

High school graduation. Having shown that absences and grade retention increase as a result of the boom, I now consider whether it may have also affected high school completion. The event study plot in Figure 5 shows no discernible pre-trend in high school graduation. However, shortly after the beginning of the boom, we see a significant decrease in the probability of graduation. As before, the treatment effects appear to grow over time, with the boom having a larger effect on fully treated cohorts that begin high school after 2009, when the fracking boom is in its more intense phase.

Panel C in Table 3 presents results from a difference-in-differences model outlined in equation (2). The estimates in column 1 indicate that students in an area with average fracking potential experience a 1.1 p.p. decrease in the probability of high school graduation.[23] Evaluated at the mean graduation rate of 75%, this represents a 1.5% decline. Men experience a slightly higher decrease in the probability of graduation (1.9%) than women (1.0%) . In the remaining columns, I examine whether the effects differ by students' prior ability. While I do find a small negative effect for students in the top quartile (0.4 p.p.), the effect is almost five times larger among the lowest ability students (1.9 p.p.). This is what one would expect if these students were on the margin of dropping out of high school.

Taken together, these results suggest that the pre-boom estimates are indistinguishable from zero and that there are trend breaks in educational outcomes shortly after the beginning of the boom. The heterogeneous results by proxy for ability align with the predictions for which types of students we would expect to respond most: students already on the margin of school attendance or dropping out. Moreover, it is clear that students who decreased their educational investment are exactly the ones who experienced increased earnings and participation in the labor market.

[23] These estimates reflect on-time high school graduation, i.e. in the next four years after enrollment. The estimates are similar if I consider five- and six-year high school graduation instead.

6.3 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 the short-term. In this section, I consider whether students in areas affected by the shale boom during high school changed their enrollment and graduation from post-secondary institutions.

The results for college enrollment in the next two years after expected high school graduation are reported in panels A and B of Table 4.[24] There is little effect of exposure to the boom on students' likelihood of attending either a community college or a four-year public institution in Texas. The corresponding estimates from the event study model are presented in Figure 6, and are consistent with the results described above. In columns (4)-(7), I present estimates for college enrollment split by proxy for ability. The estimates are not statistically different from zero except for students in the top quartile of the skill distribution, who increase their college enrollment rate by 1.1 p.p. One possible reason for why high-ability students would be more likely to go to college in response to the fracking boom would be if it increased family financial resources. This could give talented but financially constrained students opportunities to attend college that they would not otherwise have.[25] In contrast, students of lower ability who were unlikely to attend college regardless of local labor market conditions would not be expected to benefit from this effect; this is consistent with the fact that college enrollment rates were largely unchanged despite a significant increase in dropout rates.

Panels C and D of Table 4 explores the effect of the fracking boom on the probability of college graduation. Panel A reports results for graduation from community college in two years, and panel B shows estimates for graduation from a public university in six years after expected high school graduation. There does not appear to be a significant change in the probability of community college graduation. On the other hand, there is evidence of a small decrease in the probability of public university graduation. The estimate in column (1) implies that students who

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

[25]Unfortunately, this cannot be tested directly in my data due to the lack of detail about family income.

were exposed to the boom during high school are 0.4 p.p. less likely to graduate from a public four-year university. While these results could reflect similar underlying mechanisms to what I observe for high school students, they should be interpreted as suggestive due to the fact I am not able to observe six-year graduation rates for five of the fully treated cohorts in my data. The corresponding event study estimates are reported in Figure 6.

6.4 Adult Earnings

While exposure to the fracking boom may improve immediate student employment and earnings, it is not clear how long these positive effects should be expected to persist. In this section, I examine whether this by following up on the same students six years past their expected high school graduation.[26]

Table 5 presents results from estimating equation (2) for cohorts that were fully treated during high school where the outcome variables are earnings at age 24-25. Before I examine earnings, I show that there is no evidence of selection into having observed earnings in my dataset. Since I only observe records for students who stay in Texas, it is important to make sure that the fracking boom did not change the probability that a student remains in the state. In column 1, I use probability of being employed as my outcome and show that it does not change in response to the fracking boom. In column 2, I focus on quarterly earnings which include years with zeros, and in columns 3-7 I use log earnings. The estimate in column 3 implies that students who were in commuting zones with average reserves during high school experience a 1.5% increase in quarterly earnings at age 24-25, as compared to students who were not exposed to the fracking boom.

To understand how the effect of the boom varies by the level of educational attainment, I predict 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

[26] 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.

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 estimates in columns (6)-(8) reveal 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 with similar levels of predicted college-going who were not exposed to the boom. I find that students who were exposed to the boom during high school have 1.6-2.7% higher earnings at age 24-25. In contrast, there is no impact on earnings later in life 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 as well.[27] 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 by improved outside options rather than simply myopic behavior.

7 Robustness Checks

7.1 Alternative Specifications

The estimated impacts of the fracking boom on students' academic and labor market outcomes are robust to a variety of alternative specifications. In panel A of Table 6, I report results from the baseline specification for reference. In panel B, I re-estimate the main results without student-level controls and commuting zone baseline characteristics interacted with cohort effects. Removing controls from the main specification has little effect on the coefficient estimates. Panel C restricts the sample to a set of commuting zones which have non-zero reserves per capita, thus limiting the

[27] While the effects for lower quartiles are likely driven by improved labor market opportunities associated with the boom, they may be partially explained by an increased share of people who don't graduate from high school and gain additional work experience. A back of the envelope calculation suggests that the estimated change in graduation could explain at most 36% of the earnings effects. This is calculated under the conservative assumption that individuals in their early twenties earn zero while in high school and $3,200 per quarter if they do not have a high school degree. The exact calculation is the following: (0.011×3,200)/97, where 97 is an estimated increase in quarterly earnings.

variation in my analysis to areas that had the potential to benefit directly from extraction. The magnitude of these estimates is sometimes attenuated, but the precision and pattern of effects are very similar to the baseline sample. In panel D, I consider different assumptions about the timing of the fracking boom. Instead of using 2005 as the first year of the boom for all shales, I follow Bartik et al. (2019) and use additional temporal variation in the fracking boom within Texas. It is shale-specific and is based on the first date when the fracking potential became public knowledge. The estimates from this approach are very similar to the baseline specification. Next, in Figures A1-A5, I show that replacing my continuous measure of reserves with a set of dummy variables representing different quartiles of reserves per capita does not change the results. The estimates are similar to the preferred specification and grow in magnitude as one moves from the bottom to the top quartile of reserves per capita. Lastly, in Table A1 I show that estimates from logit and probit models are similar to the linear probability model.

7.2 Selective Migration

One concern in studies that analyze impacts of economic shocks on educational outcomes with aggregate data is that the results could be biased by selective migration. Systematic migration into booming areas as a result of improved labor market opportunities has the potential to change the composition of population and lead to biased results. For example, if individuals who are more likely to be absent or drop out of high school relocate to booming areas for work, then these areas may be disproportionately experiencing higher rates of absences and lower graduation rates regardless of the behavior of the pre-existing local population. In my main analysis, I mitigate this concern directly by focusing on high school students who lived in the area since middle school, thus excluding potential migrants from my sample. I perform several additional tests in order to explore the issue of endogenous migration in more detail.

First, because in my dataset the same students are followed over time, I can directly explore whether there is evidence of endogenous migration within Texas. The first two rows of Table 7 show no statistically significant effect of fracking on the probability of moving across both school districts and commuting zones. I also show that my main results are robust to restricting my sample to students who have lived in the same commuting zone since elementary school. This sample is more restrictive due to a smaller number of cohorts which I can track back in time. Nevertheless, in Table A2 I show that the estimates are very similar to the baseline sample in both the magnitude and statistical significance.

Second, I consider whether student demographic characteristics are related to the fracking boom. In panel B of Table 7, I estimate the impact of fracking on student gender, race, gifted status, limited English proficiency, free lunch and special education indicators. The estimates provide little evidence that the boom changed the composition of student cohorts, alleviating concerns about selective migration, demographic shifts and other changes taking place at the same time as the boom. One exception is a decrease in the share of students who receive free lunch, which is consistent with the fact that many families experienced positive income shocks as a result of the boom.

Since my data do not allow me to track students who leave Texas, I cannot directly observe out-of-state migration. In principle, this could lead to bias in my estimation of dropout rates if students who leave the state are more likely to finish high school elsewhere. I explore this possibility by using county migration data from the Internal Revenue Service which is based on year-to-year address changes reported on individual income tax returns. In Figure A8, I present results from estimating equation (1) with out-migration rate as the dependent variable. The estimates show no evidence of changing patterns of out-of-state migration, alleviating the concern that it may be driving high school graduation results.

8 Discussion

My main results showed that the fracking boom caused a decrease in human capital investment among high school students. While I argued 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 discuss the importance of several other channels that may contribute to my findings.

Opportunity cost and returns to schooling. The results in Table 2 showed that the fracking boom substantially increased the opportunity cost of schooling for both men and women of high school age and resulted in lower educational investment. However, if the fracking boom changed the expected labor market premium for high school graduates relative to high school dropouts, this effect could also be contributing to my findings. In Table A3, I explore this possibility by taking advantage of my administrative records and comparing earnings of slightly older individuals in Texas (age 18-22) with and without a high school degree. The dependent variable in this analysis is the difference in log quarterly earnings between these two groups in each commuting zone and year. The estimates in column (1) indicate that the fracking boom did not substantially change the expected earnings gap between high school graduates and dropouts in aggregate. Splitting the estimates by gender suggests the return to a high school degree increased for males but was unchanged for females. Unlike students still enrolled in high school at the time of the boom, these slightly older students had already made their attendance decisions by the time fracking boosted local labor markets. To the extent that the labor market outcomes of these older students helped their younger peers form expectations about their options after graduating, however, they are a useful signal for evaluating the returns to education in early adulthood. While the recency of the boom limit my ability to analyze longer-term labor market outcomes, the fact that my results show no significant change in this earnings gap – if anything, the returns to education seem to increase modestly for men – provides suggestive evidence that students were not choosing to drop out due to a reduction in the expected returns to education.

School resources. Changes in school resources associated with fracking can affect educational outcomes independently from the labor market. Oil and gas production in Texas is taxed at the state level through a single severance tax, and at the local level through property taxes which are levied on the value of a well's oil and gas resources. Since local property taxes provide more than a half of total revenue for schools, expansion of the local tax base may lead to higher school revenues and spending.[28]

Table 8 presents estimates of the effect of fracking on school revenues and expenditures per

[28]While this effect may be offset somewhat by declining residential property values, the evidence of fracking's impact on housing prices is mixed (Muehlenbachs, Spiller and Timmins, 2015).

student. Both revenues experienced a 2.4% increase due to the boom in areas with average reserves compared to areas without any fracking potential. This was also reflected in school spending per student, which rose by more than 2%.[29] Given the evidence that higher school spending has either insignificant or positive effects on human capital formation (Hyman, 2017, Jackson, Johnson and Persico, 2015), 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.

Finally, I explore whether fracking could affect student outcomes via teacher quality using teacher-level data from the TEA, which include detailed outcomes such as an instructor's experience, degree level, and earnings. The estimates in columns (3)-(4) of Table 8 suggest that fracking had no statistically significant impact on teacher quality as measured by the number of teachers in a commuting zone who have an advanced degree or fewer than five years experience. There was also no significant change in earnings, which reflects the fact that teacher salaries are based on a variety of factors and won't always respond immediately to changes in tax revenue.[30] The corresponding event study estimates are presented in Figure X of the appendix. [31]

9 Conclusion

In this paper, I present new evidence that localized improvements in economic conditions can lead to significant changes in educational and labor market outcomes in both the short- and medium-run. I leverage variation in the fracking boom, which has drastically changed the US

[29]These findings are in line with Newell and Raimi, 2015 who document that most county and municipal governments have experienced net financial benefits from the fracking boom.

[30]This is particularly relevant in the case of fracking, the revenue boost from which some areas may perceive to be transitory.

[31]The pattern of event study estimates in panel X reveals that there may have been a small increase in the share of teachers with low level of experience, suggesting that it may be contributing to the overall negative impacts on student outcomes. Existing research however suggests that the magnitude of this effect is too small to explain all of the main findings. For example, Staiger and Rockoff, 2010 find that students assigned to teachers with low experience score 0.1 standard deviations lower on standardized exams. Given a 0.6 pp increase in the share of teachers with less than 5 years of experience estimated in Table 8, a back of the envelope calculation suggests it would translate into only a 0.006 standard deviation decrease in student achievement.

energy industry over the past decade and resulted in significant employment and earnings gains for areas lying on top of previously inaccessible shale reserves. 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.

Using a difference-in-differences research design that exploits geographic variation in the distribution of these previously inaccessible resources, I find that students in areas with high fracking potential experienced higher absence and grade repetition rates, and lower rates of high school graduation. 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 repetition in this context. By directly linking students to their administrative earnings records, I show that improved labor market opportunities for young individuals played a large role in explaining the negative impacts on human capital. 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 that has analyzed the labor market effects of the fracking boom using repeated cross-sectional data such as the ACS.

I also provide new evidence on what types of students respond to local economic shocks. The negative effects on educational outcomes are concentrated among students at the bottom of the ability distribution, a group which I show also experiences the largest increases in employment and earnings in response to the boom. Students at the top of the distribution, on the other hand, were not affected. These results suggest the students who respond to the fracking boom by substituting work for school are primarily those who were also closest to the margin in terms of attendance and graduation.

I show that changes in educational and employment outcomes are likely driven by an increased opportunity cost of attending school rather than a change in returns to education or school resources. This is consistent with prior work which found increased opportunity cost to be the main driver behind educational investment decisions in a variety of other settings, such as the housing boom in the U.S. (Charles, Hurst and Notowidigdo, 2018), trade shocks in Mexico (Atkin, 2016), and road construction in India (Adukia, Asher and Novosad, 2017). Additionally, I show that students exposed to the boom during high school benefit from increased earnings through at least their mid 20s; to my knowledge these are the first long-term, individual-level responses of any sort that have been analyzed in response to fracking. Understanding the long-run effects of resource booms is an important avenue for future research.

Broadly, the results of this study imply that educational decisions of young individuals are responsive to local economic conditions. Even though the earnings of students do not appear to be impacted in the medium run, there may still be reasons for policymakers to discourage dropping out, as high school graduation has been linked to better health outcomes and lower crime rates.[32] It is crucial for policy-makers to know which types of jobs pull students out of school, especially in light of the ongoing tradeoff of nation-wide efforts to boost high school graduation rates and increase shale oil and gas production at the same time. In order to mitigate the negative educational impact but still allow high school students to benefit from the improved labor markets that result from the boom, school officials may consider implementing flexible school schedules, which would enable students to accommodate working while remaining in school. In addition, providing career and technical classes or emphasizing vocational training would make school coursework directly relevant for local jobs available in their communities.

These findings can also help policymakers to better understand the consequences of resource booms. My results suggest that the effects of fracking 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

[32]See, for example, Lochner and Moretti, 2004 and Silles, 2009.

channel even when they lead to lower educational attainment. Ultimately, given the persistent long-run benefits of human capital acquisition, policies which target education may be effective tools for policymakers seeking to create long-run benefits from economic shocks and reduce the volatility of boom-and-bust natural resource cycles.

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.*

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.

Becker, Gary S. 1964. *Human capital: A theoretical and empirical analysis, with special reference to education.* New York: Columbia University Press.

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.

Bulman, George, Robert Fairlie, Sarena Goodman, and Adam Isen. 2016. "Parental resources and college attendance: Evidence from lottery wins." National Bureau of Economic Research.

Butikofer, Aline, Antonio Dalla Zuanna, and Kjell G Salvanes. 2018. "Breaking the Links: Natural Resource Booms and Intergenerational Mobility." *NHH Dept. of Economics Discussion Paper*, , (19).

Cai, Zhengyu, Karen Maguire, and John V Winters. 2019. "Who benefits from local oil and gas employment? Labor market composition in the oil and gas industry in Texas and the rest of the United States." *Energy Economics*, 84: 104515.

Cameron, Stephen V., and James J. Heckman. 2001. "The dynamics of educational attainment for black, hispanic, and white males." *Journal of Political Economy*, 109(3): 455–499.

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.

Emery, JC Herbert, Ana Ferrer, and David Green. 2012. "Long-term consequences of natural resource booms for human capital accumulation." *ILR Review*, 65(3): 708–734.

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.

Hilger, Nathaniel G. 2016. "Parental job loss and children's long-term outcomes: evidence from 7 million fathers' layoffs." *American Economic Journal: Applied Economics*, 8(3): 247–83.

Hill, Elaine L. 2018. "Shale gas development and infant health: evidence from Pennsylvania." *Journal of health economics*, 61: 134–150.

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.

James, Alexander, and Brock Smith. 2017. "There will be blood: Crime rates in shale-rich US counties." *Journal of Environmental Economics and Management*, 84: 125–152.

Kearney, Melissa S, and Riley Wilson. 2018. "Male earnings, marriageable men, and nonmarital fertility: Evidence from the fracking boom." *Review of Economics and Statistics*, 100(4): 678–690.

Krupnick, Alan J, and Isabel Echarte. 2017. "Economic Impacts of Unconventional Oil and Gas Development." *RFF Report.*

Lee, Jim. 2015. "The regional economic impact of oil and gas extraction in Texas." *Energy Policy*, 87: 60–71.

Lochner, Lance, and Alexander Monge-Naranjo. 2012. "Credit constraints in education." *Annu. Rev. Econ.*, 4(1): 225–256.

Lochner, Lance, and Enrico Moretti. 2004. "The effect of education on crime: Evidence from prison inmates, arrests, and self-reports." *American economic review*, 94(1): 155–189.

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

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

Mincer, Jacob. 1958. "Investment in human capital and personal income distribution." *Journal of political economy*, 66(4): 281–302.

Modestino, Alicia Sasser, Daniel Shoag, and Joshua Ballance. 2016. "Downskilling: changes in employer skill requirements over the business cycle." *Labour Economics*, 41: 333–347.

Morissette, René, Ping Ching Winnie Chan, and Yuqian Lu. 2015. "Wages, youth employment, and school enrollment recent evidence from increases in world oil prices." *Journal of Human Resources*, 50(1): 222–253.

Muehlenbachs, Lucija, Elisheba Spiller, and Christopher Timmins. 2015. "The housing market impacts of shale gas development." *American Economic Review*, 105(12): 3633–59.

Newell, Richard G, and Daniel Raimi. 2015. "Shale public finance: Local government revenues and costs associated with oil and gas development." National Bureau of Economic Research.

Silles, Mary A. 2009. "The causal effect of education on health: Evidence from the United Kingdom." *Economics of Education review*, 28(1): 122–128.

Staiger, Douglas O., and Jonah E. Rockoff. 2010. "Searching for effective teachers with imperfect information." *Journal of Economic perspectives*, 24(3): 97–118.

Tolbert, Charles M, and Molly Sizer. 1996. "US commuting zones and labor market areas: A 1990 update."

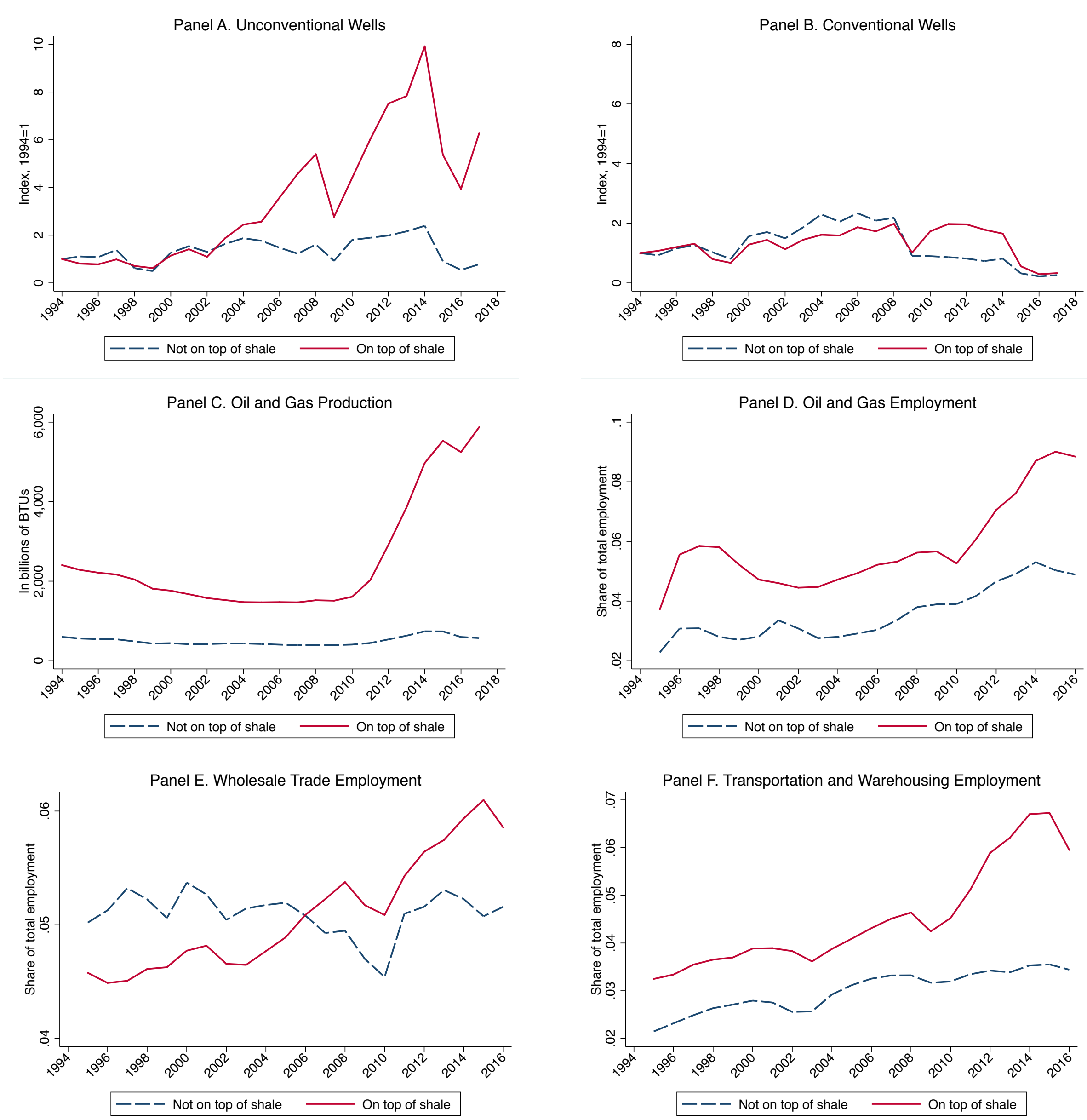
Weber, Jeremy G. 2014. "A decade of natural gas development: The makings of a resource curse?" *Resource and Energy Economics*, 37: 168–183.

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." *IZA Discussion Paper.*

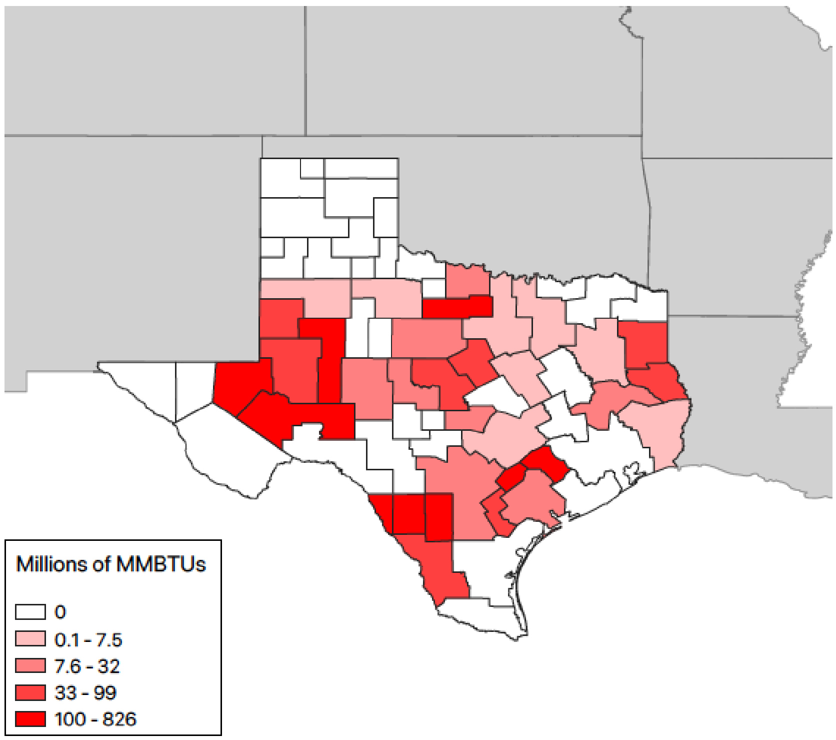
Zuo, Na, Jack Schieffer, and Steven Buck. 2019. "The effect of the oil and gas boom on schooling decisions in the US." *Resource and Energy Economics*, 55: 1–23.

Figure 1: Oil and Gas Drilling, Production and Employment in Texas



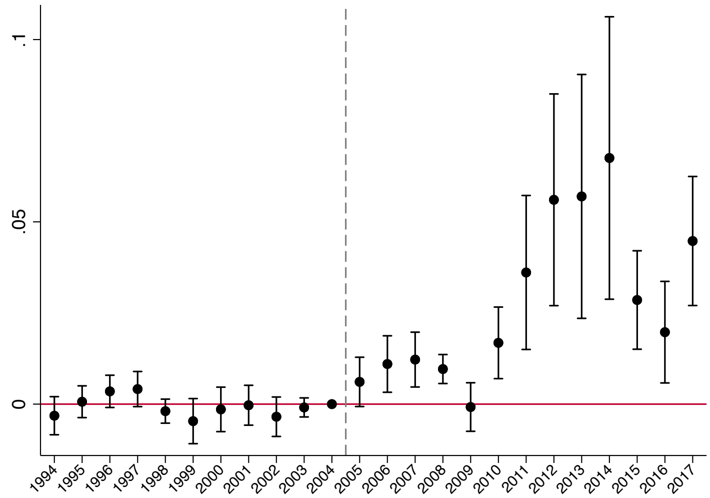
Notes: This figure displays the average number of new unconventional wells drilled in panel A, new conventional wells drilled in panel B, oil and gas production in panel C, share of employment in oil and gas industry (NAICS 211) in panel D, share of employment in wholesale trade (NAICS 42) in panel E, and share of employment in transportation and warehousing (NAICS 48-49) in panel F in Texas. These statistics are presented separately for commuting zones that lie on top of shale formations and those that do not. The data are from DrillingInfo, Texas Railroad Commission, and the Quarterly Workforce Indicators.

Figure 2: Predicted Shale Oil and Gas Reserves per Capita



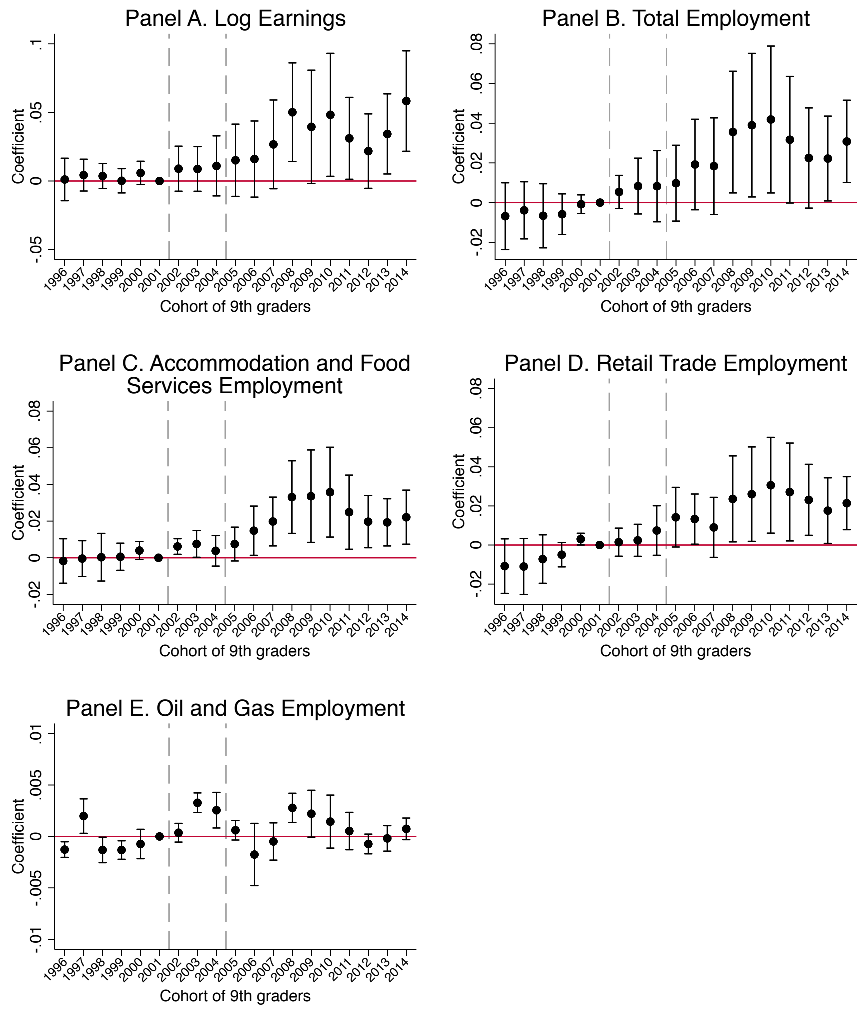
Notes: This figure reports shale oil and gas reserves divided by 1995 population for each commuting zone in Texas. Estimates of shale oil and gas reserves were calculated by overlaying shapefiles of shale plays with shapefiles of commuting zones, and allocating estimates of play reserves to commuting zones based on the fraction of each play that they contain. The data are from the U.S. Energy Information Administration and the Census Bureau.

Figure 3: The Effect of the Fracking Boom on Oil and Gas Drilling



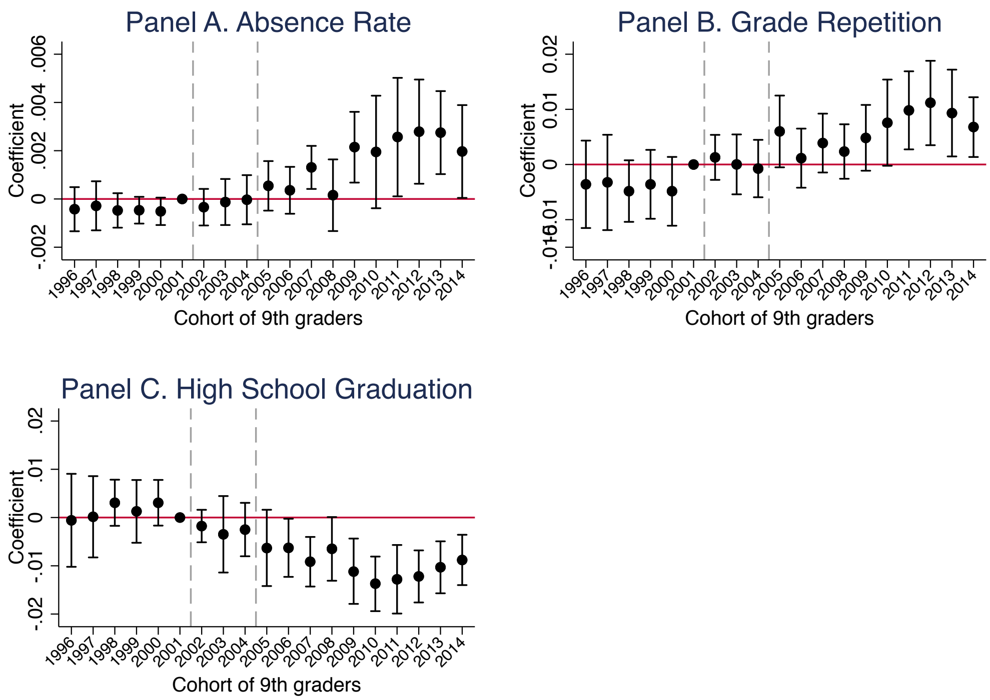
Notes: This figure reports estimated coefficients on interactions between year indicators and predicted shale oil and gas reserves per capita (β_k) from regression equation (1). The dependent variable is the number of newly drilled oil and gas wells. All estimates are relative to the last year (2004) before the boom. 95% confidence intervals for standard errors clustered at commuting zone level are displayed around each point estimate. The data are from DrillingInfo and the U.S. Energy Information Administration.

Figure 4: The Effect of the Fracking Boom on Student Employment, Age 14-18



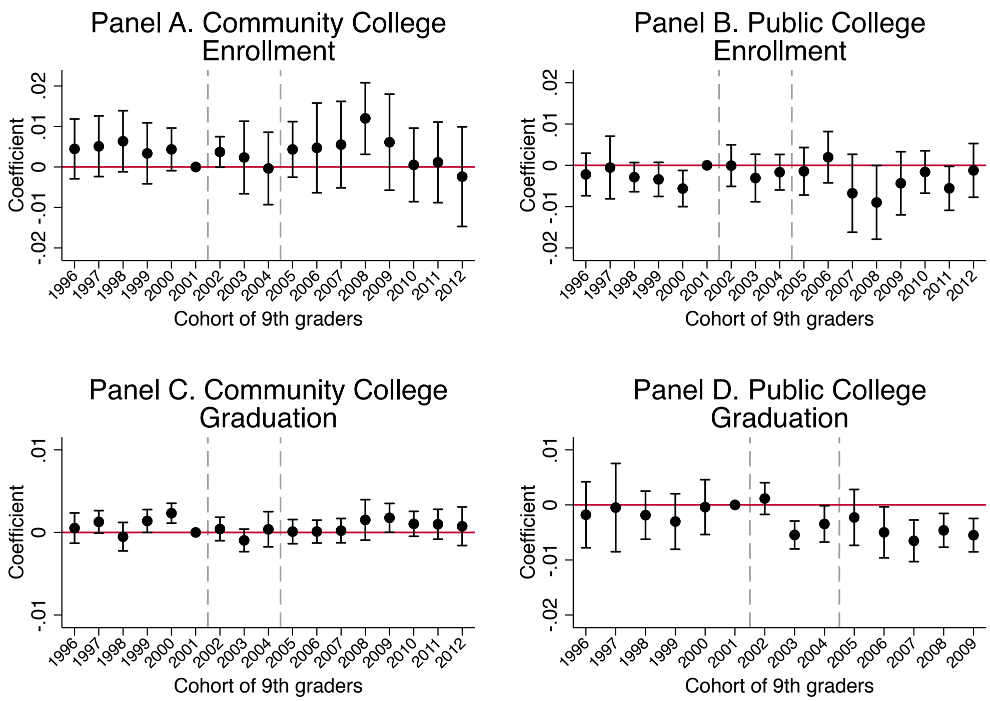
Notes: This figure reports estimated coefficients on interactions between year indicators and predicted shale oil and gas reserves per capita (β_k) from regression equation (1). The dependent variables are the log quarterly earnings (panel A), probability of being employed for at least one quarter in any industry (panel B), in accommodation and food services (Panel C), in retail trade (Panel D), and in oil and gas (Panel E). Cohorts that begin grade 9 in 2001 are the omitted category. Cohorts of students that begin high school in 2005 or later are considered fully treated, while cohorts that begin high school before 2001 are considered untreated. The region between two dashed vertical lines represents cohorts that are partially treated. The regression also includes individual-level demographic controls, cohort fixed effects, commuting zone fixed effects, and 1995 commuting zone characteristics interacted with cohort fixed effects. 95% confidence intervals for standard errors clustered at commuting zone level are displayed around each point estimate. The data are from the Texas Education Agency and the Texas Workforce Commission, provided by the Texas Education Research Center.

Figure 5: The Effect of the Fracking Boom on High School Outcomes



Notes: This figure reports estimated coefficients on interactions between year indicators and predicted shale oil and gas reserves per capita (β_k) from regression equation (1). The dependent variables are the absence rate in high school (panel A), grade repetition in high school (panel B), and high school graduation (panel C). Cohorts that begin grade 9 in 2001 are the omitted category. Cohorts of students that begin high school in 2005 or later are considered fully treated, while cohorts that begin high school before 2001 are considered untreated. The region between two dashed vertical lines represents cohorts that are partially treated. The regression also includes individual-level demographic controls, cohort fixed effects, commuting zone fixed effects, and 1995 commuting zone characteristics interacted with cohort fixed effects. 95% confidence intervals for standard errors clustered at commuting zone level are displayed around each point estimate. The data are from the Texas Education Agency provided by the Texas Education Research Center.

Figure 6: The Effect of the Fracking Boom on College Enrollment and Graduation, by College Type



Notes: This figure reports estimated coefficients on interactions between year indicators and predicted shale oil and gas reserves per capita (β_k) from regression equation (1). The dependent variables are enrollment into community college in the next two years after expected high school graduation (panel A), enrollment into a four-year public university in the next two years after expected high school graduation (panel B), graduation from community college in four years (panel C), and graduation from a public university in six years (panel D). Cohorts that begin grade 9 in 2001 are the omitted category. Cohorts of students that begin high school in 2005 or later are considered fully treated, while cohorts that begin high school before 2001 are considered untreated. The region between two dashed vertical lines represents cohorts that are partially treated. The regression also includes individual-level demographic controls, cohort fixed effects, commuting zone fixed effects, and 1995 commuting zone characteristics interacted with cohort fixed effects. 95% confidence intervals for standard errors clustered at commuting zone level are displayed around each point estimate. The data are from the Texas Education Agency and the Texas Higher Education Coordinating Board, provided by the Texas Education Research Center.

Table 1: Summary Statistics

	Reserves per capita		
Variable	All	Below median	Above median
	(1)	(2)	(3)
Educational outcomes			
HS graduation rate	0.71	0.71	0.72
	(0.45)	(0.45)	(0.45)
Absence rate	0.06	0.06	0.06
	(0.07)	(0.07)	(0.07)
Grade repetition rate	0.23	0.24	0.23
	(0.42)	(0.42)	(0.42)
Enrollment in public 4-year college	0.20	0.21	0.19
	(0.40)	(0.41)	(0.39)
Enrollment in community college	0.37	0.37	0.37
	(0.48)	(0.48)	(0.48)
Graduation from public 4-year college	0.14	0.14	0.13
	(0.34)	(0.35)	(0.34)
Graduation from community college	0.01	0.01	0.01
	(0.11)	(0.10)	(0.11)
Labor market outcomes			
Employed, age 14-18	0.73	0.72	0.76
	(0.44)	(0.45)	(0.43)
Quarterly earnings (excl. 0s), age 14-18	1,506.6	1,498.0	1,519.5
	(1,030.5)	(1,041.5)	(1,013.6)
Quarterly earnings (incl. 0s), age 14-18	502.1	480.0	536.9
	(1,011.1)	(1,017.3)	(1,000.3)
Employed, age 24-25	0.70	0.68	0.71
	(0.46)	(0.47)	(0.45)
Quarterly earnings (excl. 0s), age 24-25	5,933.5	6,001.9	5,830.2
	(4491.6)	(4,583.7)	(4,346.9)
Quarterly earnings (incl. 0s), age 24-25	3,821.9	3,795.4	3,863.6
	(4,523.2)	(4,594.1)	(4,408.7)
Student demographics			
Male	0.49	0.49	0.49
	(0.50)	(0.50)	(0.50)
White	0.53	0.50	0.57
	(0.50)	(0.48)	(0.50)
Black	0.13	0.15	0.11
	(0.34)	(0.35)	(0.31)
Hispanic	0.32	0.32	0.31
	(0.46)	(0.47)	(0.46)
Gifted	0.12	0.11	0.13
	(0.32)	(0.32)	(0.33)
Special education	0.06	0.06	0.07
	(0.24)	(0.23)	(0.25)
Economically disadvantaged	0.33	0.32	0.34
	(0.47)	(0.47)	(0.47)
1995 commuting zone characteristics			
Population density	57.31	68.45	46.18
	(100.25)	(129.3)	(58.8)
Share hispanic	0.30	0.28	0.32
	(0.24)	(0.22)	(0.26)
Share black	0.07	0.07	0.07
	(0.06)	(0.07)	(0.06)
Share male	0.50	0.50	0.50
	(0.02)	(0.01)	(0.02)
Unemployment rate	6.45	6.17	6.74
	(4.68)	(3.71)	(5.53)
Median household income	26,143.8	26,603.1	25,684.6
	(4,885.3)	(5,414.4)	(4,333.2)
Number of students	198,129	121,239	76,890

Notes: The table reports means and standard deviations (in parentheses) for student and commuting zone characteristics in 1995. Columns (2)-(3) split the sample into commuting zones with below and above median reserves. The data are drawn from the Texas Education Research Center and the Census Bureau.

Table 2: The Effect of the Fracking Boom on Earnings and Employment, Ages 14-18

	Full sample	Men	Women	Quartile of grade 6 test score distribution			
				Q1 (Bottom)	Q2	Q3	Q4 (Top)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Panel A. Log Earnings				
Fully treated	0.032**	0.034**	0.030**	0.029**	0.029**	0.034**	0.033*
	(0.014)	(0.016)	(0.012)	(0.012)	(0.014)	(0.014)	(0.017)
Partially treated	0.007	0.014	-0.001	0.001	0.007	0.013**	0.009
	(0.007)	(0.009)	(0.006)	(0.012)	(0.008)	(0.006)	(0.007)
Observations	3,310,087	1,630,674	1,679,413	799,442	847,204	848, 965	814,476
			Panel B. Earnings, Including Zeros				
Fully treated	26.16*	27.81	24.36*	34.54**	29.95*	20.15	16.07
	(14.96)	(17.40)	(14.96)	(15.86)	(15.84)	(13.87)	(16.11)
Partially treated	14.94	18.03	11.52	20.46	15.95	10.04	13.58
	(10.94)	(12.61)	(9.54)	(13.58)	(11.58)	(9.82)	(10.80)
Baseline mean	*464.4*	*485.1*	*444.4*	*448.3*	*479.6*	*485.0*	*444.9*
			Panel C. Retail Trade Employment				
Fully treated	0.026**	0.026**	0.026**	0.029***	0.014**	0.009*	0.008*
	(0.012)	(0.013)	(0.012)	(0.010)	(0.06)	(0.005)	(0.004)
Partially treated	0.009	0.007	0.011	0.010	0.005	0.001	0.003
	(0.007)	(0.007)	(0.007)	(0.007)	(0.004)	(0.005)	(0.003)
Baseline mean	*0.32*	*0.32*	*0.31*	*0.29*	*0.33*	*0.34*	*0.31*
			Panel D. Accommodation and Food Services Employment				
Fully treated	0.022**	0.024**	0.021**	0.028***	0.023**	0.017	0.017
	(0.011)	(0.012)	(0.010)	(0.010)	(0.010)	(0.012)	(0.011)
Partially treated	0.005	0.005	0.006	0.002	0.006	0.006	0.008
	(0.006)	(0.06)	(0.006)	(0.008)	(0.006)	(0.007)	(0.006)
Baseline mean	*0.38*	*0.36*	*0.39*	*0.39*	*0.40*	*0.38*	*0.33*
			Panel E. Oil and Gas Employment				
Fully treated	0.001	0.001	0.000**	0.001	0.002***	0.001	-0.000
	(0.001)	(0.002)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Partially treated	0.003***	0.005***	0.000	0.001	0.005***	0.002**	0.002**
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Baseline mean	*0.003*	*0.005*	*0.002*	*0.004*	*0.003*	*0.003*	*0.003*
Observations	4,689,163	2,319,532	2,369,631	1,172,283	1,172,295	1,172,295	1,172,300

Notes: This table reports difference-in-differences estimates of the effect of the fracking boom on high school students' employment and earnings at age 14-18. The unit of analysis is at the student-cohort-commuting zone level. In columns (5)-(8), the ability quartiles are assigned based on 6th grade test scores on the state standardized exam. "Partially treated" and "Fully treated" rows report coefficients on the interaction terms between predicted shale reserves and an indicator variable for entering high school in 2001-2004, and an indicator variable for entering high school in 2005 or later, respectively. Commuting zone fixed effects, cohort fixed effects, and 1995 commuting zone characteristics interacted with cohort 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 3: The Effect of the Fracking Boom on Academic Outcomes in High School

	Full sample	Men	Women	Quartile of grade 6 test score distribution			
				Q1 (Bottom)	Q2	Q3	Q4 (Top)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
			Panel A. Absence rate				
Fully treated	0.002**	0.002**	0.002*	0.003***	0.002*	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Partially treated	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Baseline mean	*0.06*	*0.06*	*0.06*	*0.08*	*0.06*	*0.05*	*0.04*
			Panel B. Grade repetition				
Fully treated	0.010**	0.012**	0.008**	0.014**	0.009	0.006*	0.004
	(0.005)	(0.006)	(0.003)	(0.006)	(0.006)	(0.004)	(0.002)
Partially treated	0.004	0.005	0.003	0.004	0.004*	0.002	0.000
	(0.003)	(0.003)	(0.003)	(0.005)	(0.002)	(0.003)	(0.001)
Baseline mean	*0.21*	*0.22*	*0.19*	*0.36*	*0.22*	*0.15*	*0.10*
			Panel C. High school graduation				
Fully treated	-0.011**	-0.014**	-0.008**	-0.019***	-0.007	-0.006**	-0.004*
	(0.004)	(0.005)	(0.003)	(0.007)	(0.006)	(0.003)	(0.002)
Partially treated	-0.004	-0.007	-0.001	-0.009	-0.001	0.001	0.001
	(0.004)	(0.004)	(0.004)	(0.005)	(0.003)	(0.004)	(0.001)
Baseline mean	*0.75*	*0.72*	*0.77*	*0.57*	*0.73*	*0.81*	*0.88*
Observations	4,689,163	2,319,532	2,369,631	1,172,283	1,172,295	1,172,295	1,172,300

Notes: This table reports difference-in-differences estimates of the effect of the fracking boom on high school students' academic outcomes. The unit of analysis is at the student-cohort-commuting zone level. In columns (5)-(8), the ability quartiles are assigned based on 6th grade test scores on the state standardized exam. "Partially treated" and "Fully treated" rows report coefficients on the interaction terms between predicted shale reserves and an indicator variable for entering high school in 2001-2004, and an indicator variable for entering high school in 2005 or later, respectively. Commuting zone fixed effects, cohort fixed effects, and 1995 commuting zone characteristics interacted with cohort 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 College Enrollment and Graduation

	Full sample	Men	Women	Quartile of grade 6 test score distribution			
				Q1 (Bottom)	Q2	Q3	Q4 (Top)
			Panel A. Community college enrollment				
Fully treated	-0.000	-0.001	0.001	-0.008	-0.003	0.006	0.012
	(0.005)	(0.004)	(0.006)	(0.006)	(0.005)	(0.005)	(0.010)
Partially treated	-0.002	-0.004	0.000	-0.008*	0.001	-0.001	0.006
	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)	(0.008)
Baseline mean	*0.40*	*0.36*	*0.43*	*0.24*	*0.38*	*0.50*	*0.50*
Observations	4,065,674	2,004,086	2,061,588	1,016,412	1,016,422	1,016,413	1,016,427
			Panel B. Public university enrollment				
Fully treated	-0.001	0.000	-0.002	-0.002	-0.001	-0.000	0.011**
	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.005)
Partially treated	0.001	-0.001	0.003	0.001	0.001	-0.000	0.005
	(0.003)	(0.002)	(0.004)	(0.002)	(0.002)	(0.003)	(0.005)
Baseline mean	*0.20*	*0.18*	*0.21*	*0.04*	*0.11*	*0.23*	*0.39*
Observations	4,065,674	2,004,086	2,061,588	1,016,412	1,016,422	1,016,413	1,016,427
			Panel C.Community college graduation				
Fully treated	-0.000	0.000	-0.000	0.001	-0.001	-0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Partially treated	-0.001*	-0.001	-0.001	0.001	-0.000	-0.002*	-0.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Baseline mean	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*
Observations	4,065,674	2,004,086	2,061,588	1,016,412	1,016,422	1,016,413	1,016,427
			Panel D. Public college graduation				
Fully treated	-0.004**	-0.003**	-0.004*	-0.002***	-0.003**	-0.004*	-0.001
	(0.002)	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)	(0.003)
Partially treated	-0.001	-0.001	-0.001	-0.001	0.000	-0.001	-0.001
	(0.002)	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)	(0.004)
Baseline mean	*0.14*	*0.11*	*0.16*	*0.02*	*0.07*	*0.16*	*0.30*
Observations	3,176,071	1,553,015	1,623,056	794,013	794,020	794,013	794,025

Notes: This table reports difference-in-differences estimates of the exposure to the fracking boom during high school on college enrollment and graduation. The unit of analysis is at the student-cohort-commuting zone level. In columns (5)-(8), the ability quartiles are assigned based on 6th grade test scores on the state standardized exam. "Partially treated" and "Fully treated" rows report coefficients on the interaction terms between predicted shale reserves and an indicator variable for entering high school in 2001-2004, and an indicator variable for entering high school in 2005 or later, respectively. Commuting zone fixed effects, cohort fixed effects, and 1995 commuting zone characteristics interacted with cohort 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 at Age 24-25

	Employed	Earnings incl. 0s	Log earnings						
						Quartile of predicted college-going			
	All	All	All	Men	Women	Q1 (Bottom)	Q2	Q3	Q4 (Top)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Reserves×Post	0.003	77.48**	0.015***	0.010**	0.020***	0.016***	0.022***	0.027***	0.005
	(0.006)	(36.63)	(0.004)	(0.005)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)
Baseline mean	*0.69*	*3,853.2*	*8.35*	*8.45*	*8.26*	*8.16*	*8.31*	*8.43*	*8.51*
Observations	3,176,071	3,176,071	2,188,836	1,056,766	1,132,070	523,365	555,997	563,677	545,797

Notes: This table reports difference-in-differences estimates of the exposure to the fracking boom during high school on earnings at age 24-25. The unit of analysis is at the student-cohort-commuting zone level. In columns (6)-(9), the quartiles of college-going are assigned based on the prediction generated by using students' pre-boom 6th grade standardized test scores and demographic characteristics. Commuting zone fixed effects and cohort 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: Sensitivity of the Main Results to Alternative Specifications

	Absence	Repetition	HS grad.	Employed	Log earn.	Community college Enrol.	Community college Grad.	Public university Enrol.	Public university Grad.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A. Baseline model									
Fully treated	0.002**	0.010**	-0.011**	0.030*	0.060**	0.001	-0.000	-0.001	-0.004**
	(0.001)	(0.005)	(0.004)	(0.017)	(0.028)	(0.006)	(0.001)	(0.003)	(0.002)
Partially treated	0.000	0.004	-0.004	0.011	0.017	0.000	-0.001*	0.001	-0.001
	(0.001)	(0.003)	(0.004)	(0.010)	(0.018)	(0.004)	(0.001)	(0.003)	(0.002)
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	
Panel B. Dropping controls									
Fully treated	0.002**	0.011**	-0.011**	0.036*	0.090**	0.006	0.001	0.004	-0.001
	(0.001)	(0.005)	(0.005)	(0.019)	(0.037)	(0.006)	(0.001)	(0.003)	(0.002)
Partially treated	0.001	0.003	-0.006	0.019	0.045*	-0.000	-0.001	0.001	-0.002
	(0.001)	(0.002)	(0.004)	(0.013)	(0.027)	(0.004)	(0.000)	(0.002)	(0.002)
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	
Panel C. Areas with non-zero reserves per capita									
Fully treated	0.002*	0.006	-0.007*	0.029	0.065**	0.004	0.001	0.001	-0.005**
	(0.001)	(0.004)	(0.003)	(0.018)	(0.034)	(0.006)	(0.001)	(0.003)	(0.002)
Partially treated	0.000	0.004	-0.004	0.009	0.019	-0.000	-0.000	-0.000	-0.001
	(0.001)	(0.003)	(0.005)	(0.011)	(0.021)	(0.003)	(0.000)	(0.003)	(0.002)
Observations	2,673,893	2,673,893	2,673,893	2,673,893	1,836,420	2,318,017	2,318,017	2,318,017	1,810,101
Panel D. Differential timing by shale play									
Fully treated	0.002**	0.009**	-0.010**	0.032*	0.066**	0.002	0.000	0.000	-0.003*
	(0.001)	(0.004)	(0.004)	(0.018)	(0.031)	(0.005)	(0.001)	(0.002)	(0.001)
Partially treated	0.000	0.005	-0.005	0.016	0.024	-0.002	-0.000	-0.001	-0.001
	(0.000)	(0.003)	(0.004)	(0.011)	(0.019)	(0.003)	(0.000)	(0.003)	(0.002)
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	

Notes: This table checks the sensitivity of the main difference-in-differences estimates to alternative specifications. The unit of analysis is at the student-cohort-commuting zone level. Panel A reports estimates from the main specification. Panel B reports estimates without student and commuting zone covariates. Panel C focuses on a subsample of commuting zones with non-zero shale reserves. Panel D explores alternative assumptions about the timing of the boom. "Partially treated" and "Fully treated" rows report coefficients on the interaction terms between predicted shale reserves and an indicator variable for entering high school in 2001-2004, and an indicator variable for entering high school in 2005 or later, respectively. Commuting zone fixed effects, cohort fixed effects, and 1995 commuting zone characteristics interacted with cohort 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 Student Migration and Demographics

	Baseline mean	Partially treated	Fully treated
		Panel A. Migration	
Prob. of changing school districts	0.14	-0.002	-0.001
		(0.001)	(0.001)
Prob. of changing commuting zones	0.06	0.001	-0.000
		(0.001)	(0.001)
		Panel B. Cohort composition	
Male	0.50	0.002	-0.000
		(0.001)	(0.001)
White	0.57	0.005*	0.003
		(0.002)	(0.005)
Hispanic	0.28	-0.003	-0.003
		(0.002)	(0.005)
Black	0.13	-0.001	0.002
		(0.001)	(0.001)
Special education	0.07	0.000	-0.000
		(0.002)	(0.002)
Gifted	0.14	-0.004	-0.003
		(0.003)	(0.004)
ESL	0.02	-0.002	-0.006
		(0.002)	(0.004)
Free lunch	0.32	-0.001	-0.018*
		(0.003)	(0.010)
Observations	4,689,163		

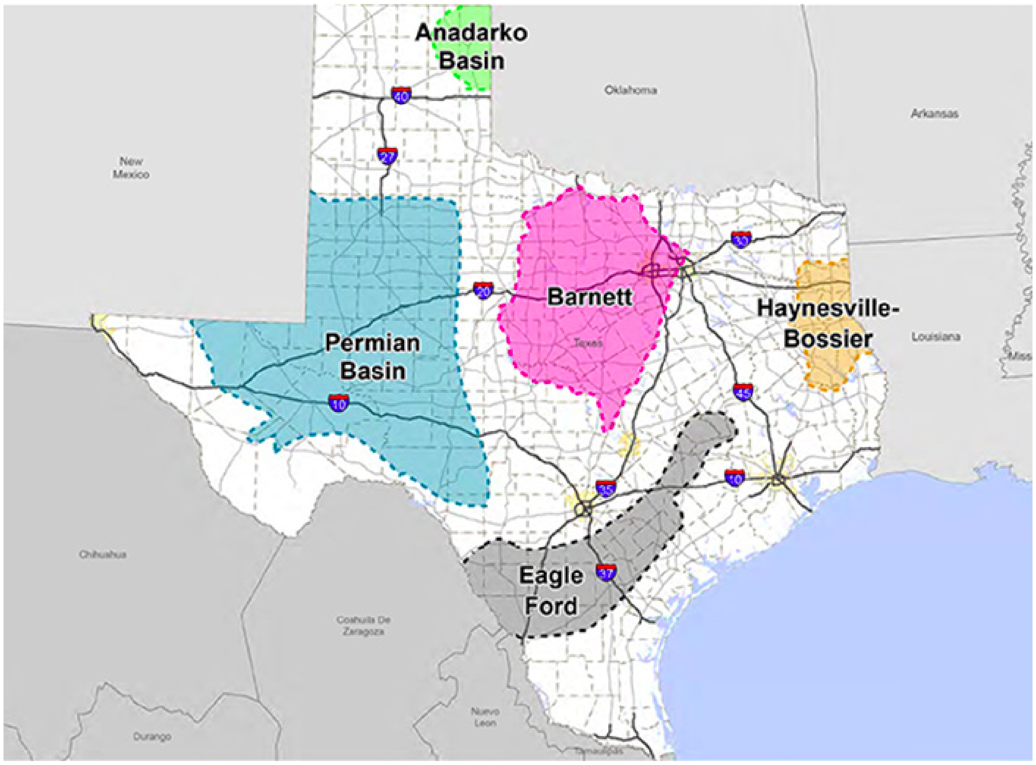
Notes: This table reports difference-in-differences estimates of the effect of the fracking boom on student migration and demographics. The unit of analysis is at the student-cohort-commuting zone level. "Partially treated" and "Fully treated" rows report coefficients on the interaction terms between predicted shale reserves and an indicator variable for entering high school in 2001-2004, and an indicator variable for entering high school in 2005 or later, respectively. 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 School Resources

	Log Revenue per student	Log Expenditure per student	Teachers		
			% Adv. degrees	% Exper.<5 years	Log Earnings
	(1)	(2)	(3)	(4)	(5)
Reserves×Post	0.024**	0.028***	-0.001	0.006	-0.004
	(0.009)	(0.008)	(0.004)	(0.004)	(0.004)
Baseline mean	*9.71*	*9.75*	*0.24*	*0.49*	*10.41*
Observations	1,364	1,364	6,241,106	6,241,452	6,240,831

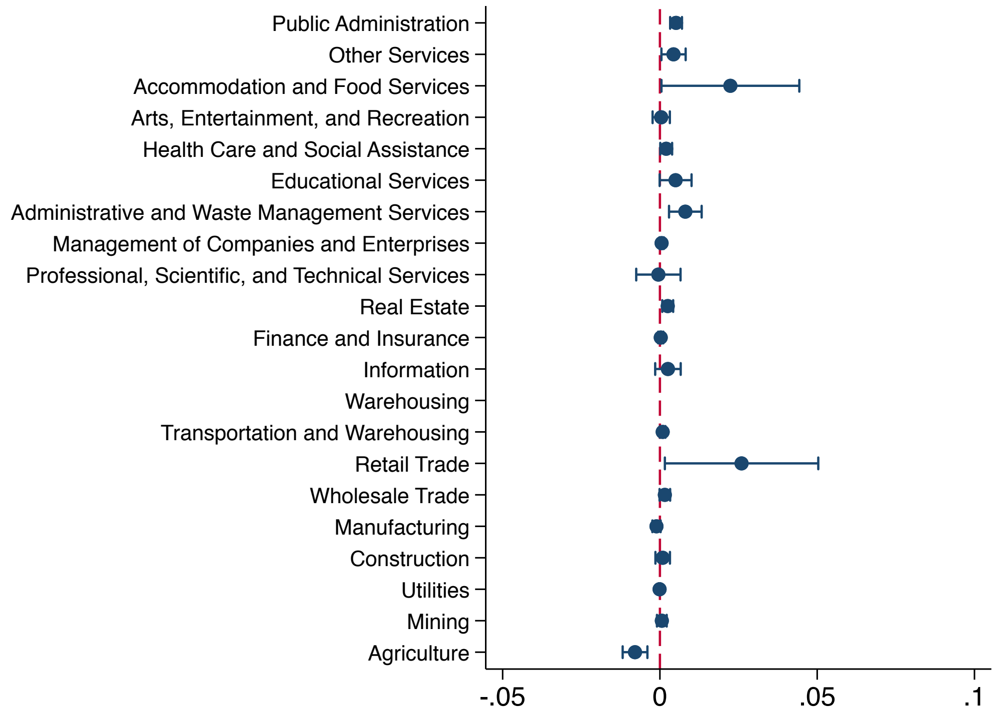
Notes: This table reports difference-in-differences estimates of the effect of the fracking on school resources. Columns (1) and (2) use school district financial data and columns (3)-(5) use individual-level data on teacher characteristics from the TEA. Commuting zone fixed effects and cohort fixed effects are included in all specifications. Standard errors, shown in parentheses, are clustered at commuting zone level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure A1: Shale Formations in Texas



Notes: This figure displays five major shale formations in Texas. Source: Texas Department of Transportation.

Figure A2: The effect of the fracking boom on student employment, by industry



Notes: This figure reports difference-in-differences estimates of the effect of the fracking boom on the probability of employment of high school students by major industries. Student demographic controls, commuting zone fixed effects and year fixed effects are included in all specifications. 95% confidence intervals for standard errors clustered at commuting zone level are displayed around each point estimate. The data are from the Texas Education Agency and the Texas Workforce Commission, provided by the Texas Education Research Center.

Figure A3: The effect of the fracking boom on absence rate in 9th grade, by quartile of predicted shale reserves per capita

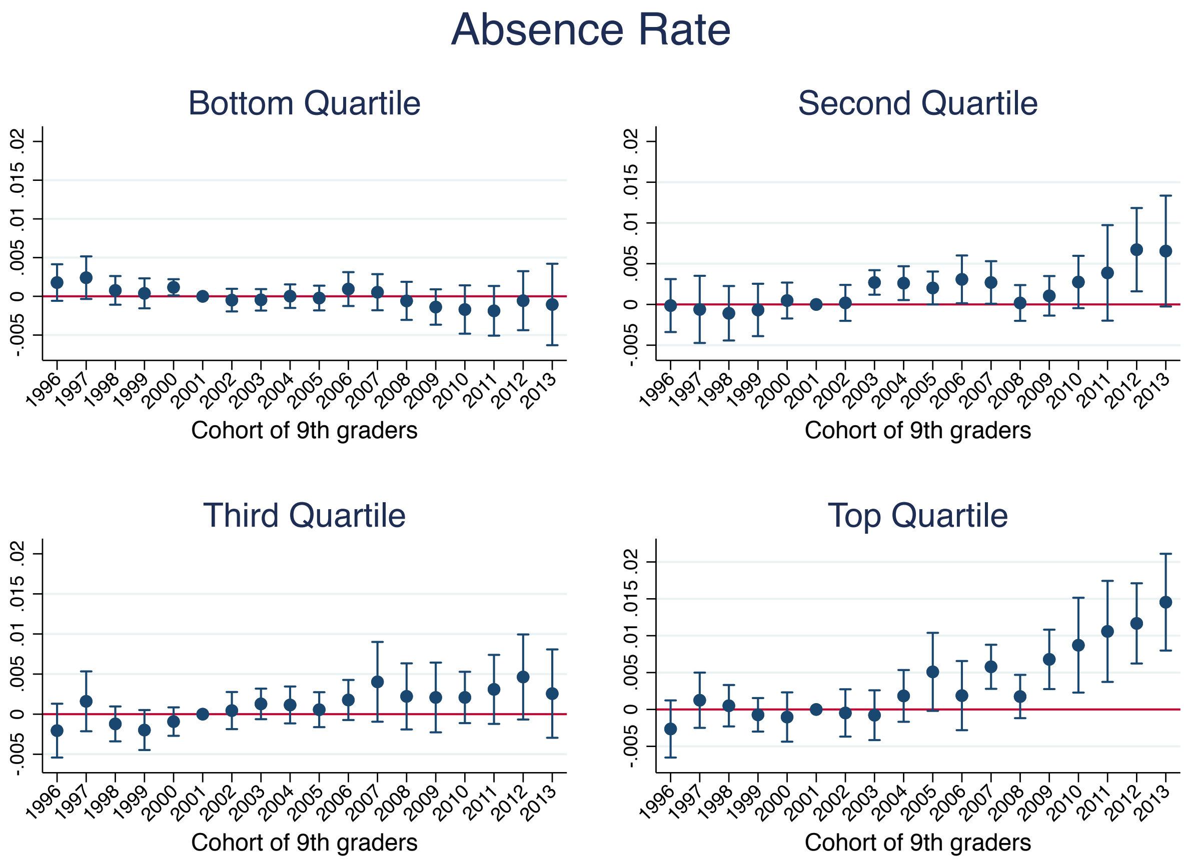


Figure A4: The effect of the fracking boom on grade repetition, by quartile of predicted shale reserves per capita

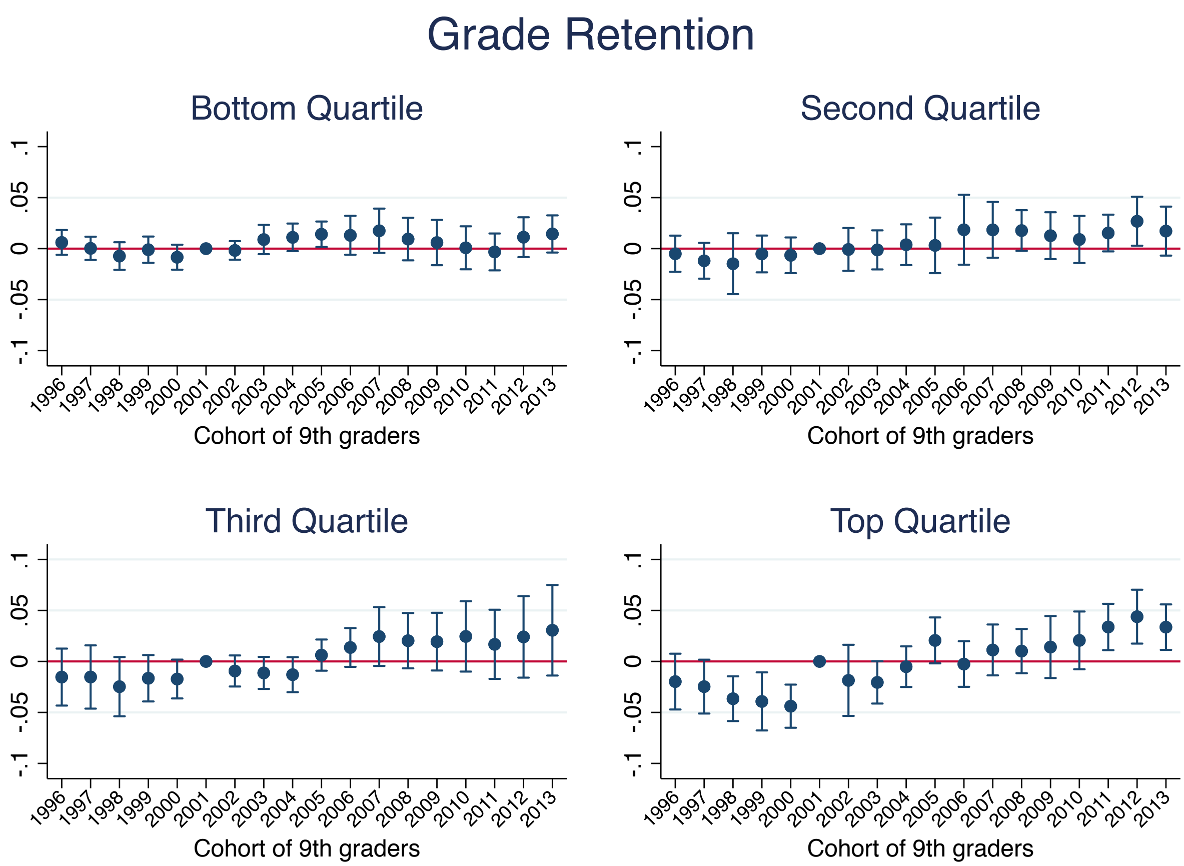


Figure A5: The effect of the fracking boom on high school graduation, by quartile of predicted shale reserves per capita

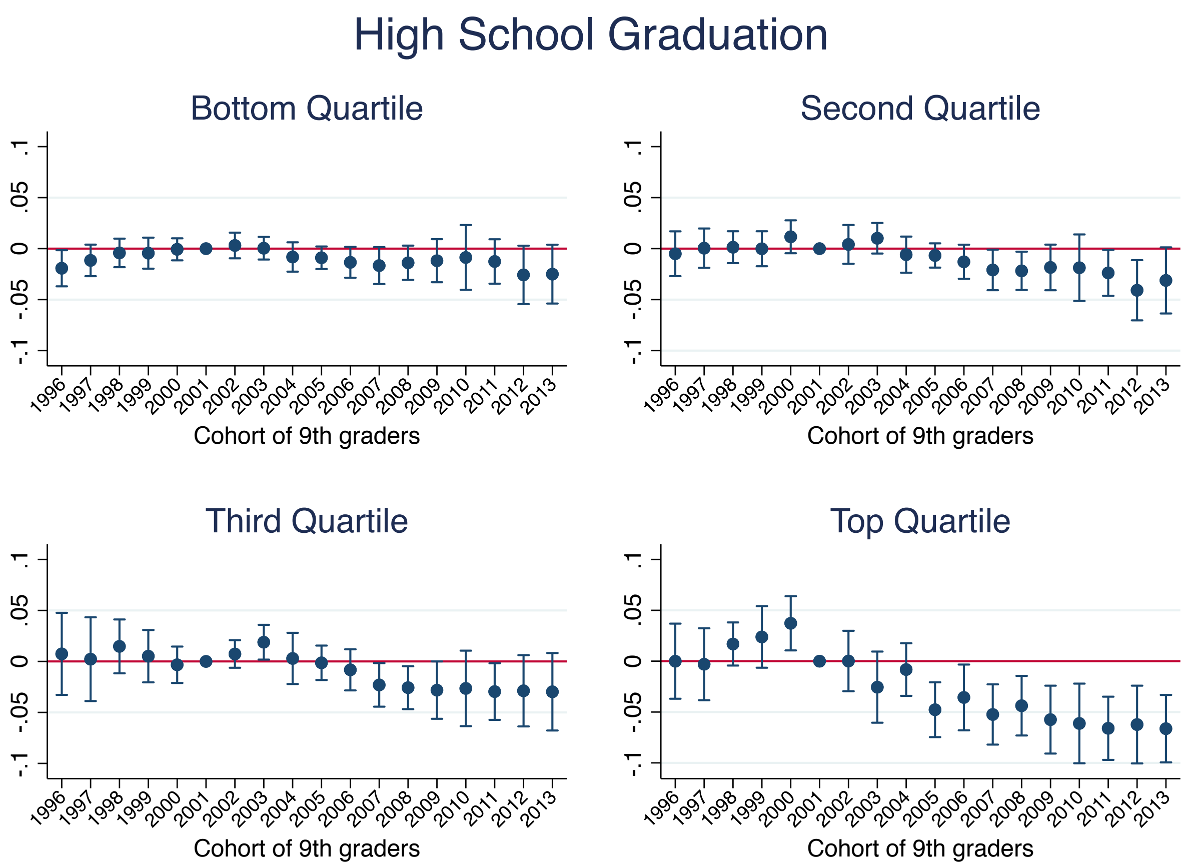


Figure A6: The effect of the fracking boom on log(earnings) during high school, by quartile of predicted shale reserves per capita

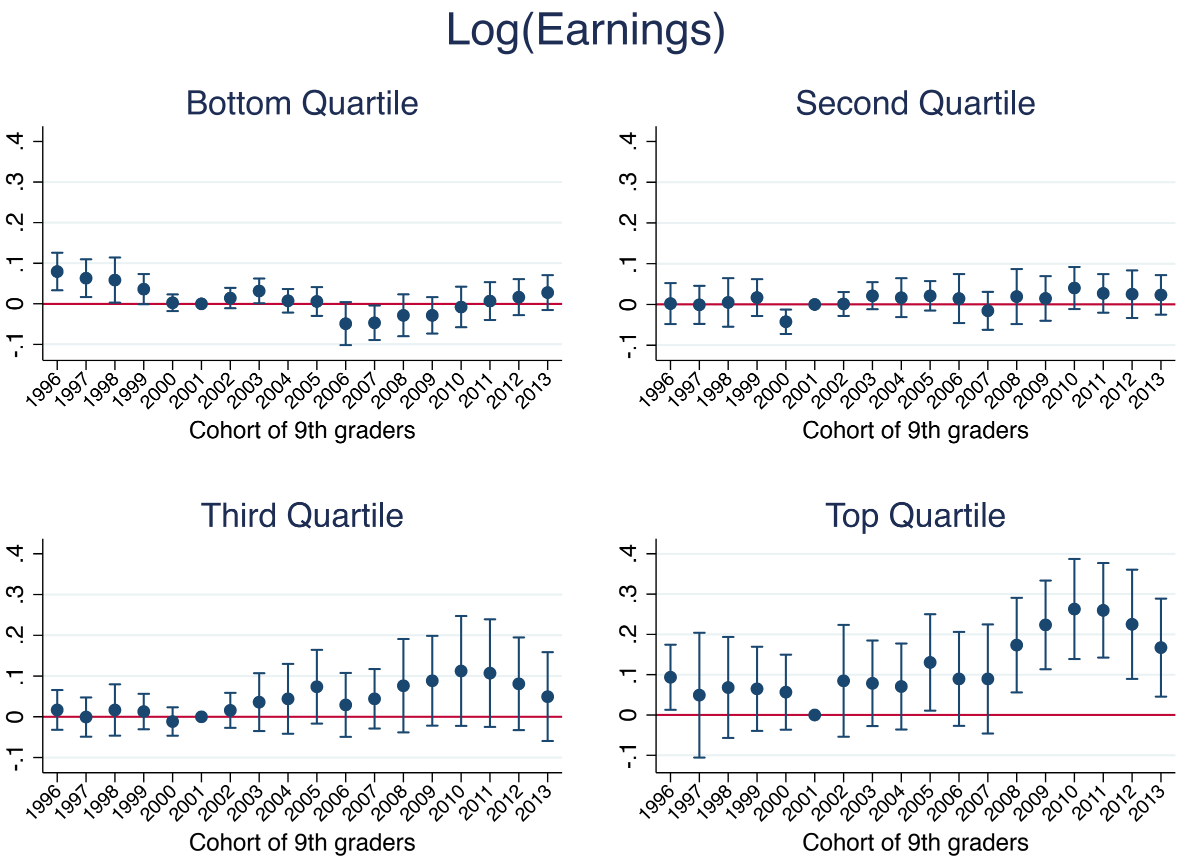
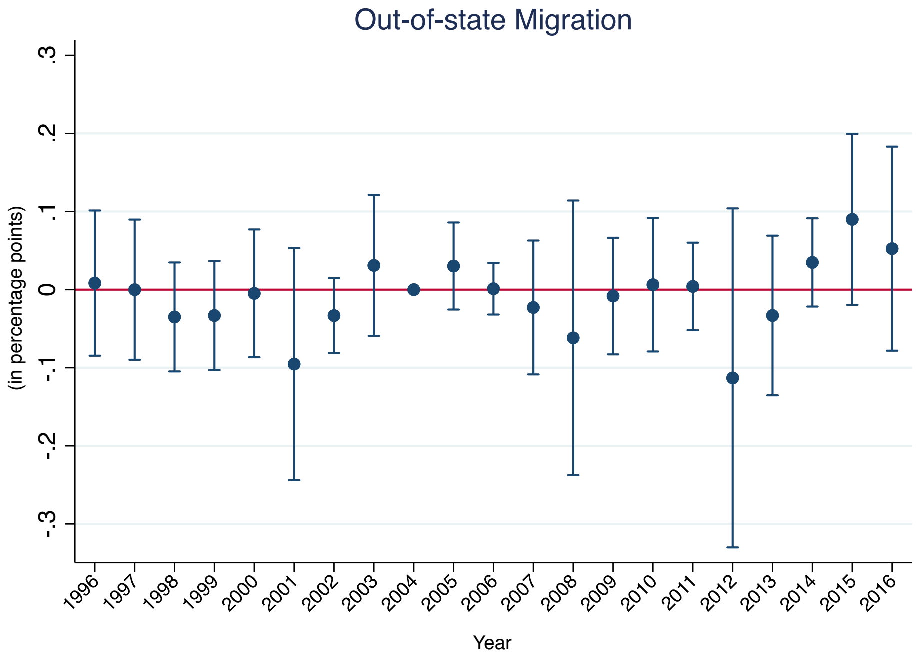


Figure A7: The effect of the fracking boom on probability of being employed during high school, by quartile of predicted shale reserves per capita

Figure A8: The effect of the fracking boom on out-of-state migration rate in TX



Notes: This figure reports estimated coefficients on interactions between year indicators and predicted shale oil and gas reserves per capita (β_k) from regression equation (1). The dependent variables is the out-migration rate, calculated by dividing the number of out-of-state migrants by the total population in 1995. Year 2004, the last year before the beginning of the boom, is the omitted category. 95% confidence intervals for standard errors clustered at commuting zone level are displayed around each point estimate. The data are from the IRS SOI Tax Stats.

Table A1: Sensitivity of the Main Results to Logit and Probit Specifications

					Community college		Public university	
	Absence	Retention	HS grad.	Employed	Enrollment	Graduation	Enrollment	Graduation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(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

Notes: This table checks the sensitivity of the main difference-in-differences estimates to using logit and probit specifications. The unit of analysis is at the student-cohort-commuting zone level. "Partially treated" and "Fully treated" rows report the coefficients on the interactions between predicted shale reserves and an indicator variable for entering high school between 2001 and 2004 and an indicator variable for entering high school in 2005 or later, respectively. 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 A2: Sensitivity of the Main Results to Alternative Specifications - CHANGE

	Absence	Retention	HS grad.	Employed	Log earn.	Community college Enrol.	Community college Grad.	Public university Enrol.	Public university Grad.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A. Baseline model									
Reserves × Post	0.002**	0.010**	-0.011**	0.030*	0.032**	0.001	-0.000	-0.001	-0.004**
	(0.001)	(0.005)	(0.004)	(0.017)	(0.014)	(0.006)	(0.001)	(0.003)	(0.002)
Observations	4,689,163	4,689,163	4,689,163	4,689,163	3,310,087	4,065,674	4,065,674	4,065,674	3,176,071
Panel B. Subsample: same commuting zone since grade 1									
Reserves × Post	0.002***	0.006*	-0.007***	0.021***	0.027***	0.003	0.001	-0.003	-0.003**
	(0.000)	(0.003)	(0.002)	(0.008)	(0.009)	(0.003)	(0.001)	(0.002)	(0.001)
Observations	2,113,559	2,113,559	2,113,559	2,113,559	1,451,550	1,738,853	1,738,853	1,738,853	1,220,488

Notes: This table checks the sensitivity of the main difference-in-differences estimates to alternative specifications. The unit of analysis is at the student-cohort-commuting zone level. Panel A reports estimates from a subsample of commuting zones with non-zero shale reserves. Panel B reports estimates from a model which includes interactions between indicators for quartiles of the reserves distribution (instead of a continuous measure) with year dummies. 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 A3: The Effect of the Fracking Boom on Returns to High School Degree, Age 18-22

	Full Sample	Men	Women
	(1)	(2)	(3)
Reserves×Post	0.010	0.018**	0.002
	(0.007)	(0.007)	(0.009)
Observations	1,178	1,178	1,178

Notes: This table reports difference-in-differences estimates of the effect of the exposure to the fracking boom during high school on earnings 6 years after expected high school graduation. The dependent variable is X. The unit of analysis is at the commuting zone-year level. Commuting zone fixed effects and year fixed effects are included in all specifications. Standard errors, shown in parentheses, are clustered at commuting zone level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$