UNIVERSITY OF ALBERTA
FACULTY OF ARTS
Department of Economics

Working Paper No. 2015-15

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September 2015

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The Labor Market and School Finance Effects of the Texas Shale Boom on Teacher Quality and Student Achievement

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Abstract

Resource booms can affect student achievement through greater labor demand, where rising wages pull students or teachers out of schools, and through an expanded tax base, where increased school spending alters teacher quality or student productivity. Using shale depth variation across Texas school districts with annual oil and gas price variation, this study finds that resource development slightly decreased student achievement despite providing schools with more money. Vocational and economically disadvantaged students were pulled into the labor market, while teacher turnover and inexperience increased. Schools responded to the tax base expansion by spending more on capital projects but not on teachers. JEL codes: H70, I22, J24, J40, Q33, R23.

Keywords: local labor markets, local school finance, resource booms, teacher quality.

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1 Introduction

Booms in natural resource extraction have been shown to affect local labor markets through a positive shock to labor demand, thereby increasing wages and employment (Black et al., 2005a; Michaels, 2010; Marchand, 2012; Jacobsen and Parker, forthcoming). Resource booms have also been shown to alter local public finances, by expanding the tax base and revenues (Caselli and Michaels, 2013; Carnicelli and Postali, 2014). Both findings hold true for the recent boom in drilling for oil and gas in shale formations, which has its own effects on labor markets (Weber, 2012; Brown, 2014; Fetzer, 2014; Weber, 2014; Munasib and Rickman, 2015) and local public finances (Raimi and Newell, 2014; Weber et al., 2014).

The effects from both of these labor market and finance channels of an energy boom could additionally impact student achievement. Several studies have documented the link between boom-induced wage increases and the timing and accumulation of human capital (Black et al., 2005b; Emery et al., 2012; Kumar, 2014; Weber, 2014), and one study found changes in student exam scores through the local finance effect (Haegeland et al., 2012). However, no study has considered how the labor market and finance channels might also affect teacher quality and then, in turn, student achievement.

In a state like Texas, where the value of oil and gas wells are taxed locally as real property once production begins, a unique situation arises where the shale boom may affect student achievement through both the labor market and school finance channels simultaneously, along with their separate effects through teacher quality. This is especially true since the beginning of the 2000s, when rising energy prices, coupled with the use of hydraulic fracturing and refinements in horizontal drilling, made it profitable to extract crude oil and natural gas from previously unrecoverable shale formations.

By increasing the demand for low-skill labor, a boom in natural resources could encourage students to leave the classroom prior to graduation, while more lucrative job opportunities could also draw teachers out of the education sector. The labor market effects on school-wide student achievement therefore depend on whether primarily high or low performing students or teachers are being pulled from the classroom. At the same time, the growth in drilling from the boom could dramatically increase the taxable value of oil and gas wells and expand the overall property tax base in school districts over energy-rich shale formations, providing a revenue windfall to their schools. This might help to increase student achievement by allowing schools to purchase equipment that enhances learning or pay higher salaries to attract better teachers. Spending additional revenues in ways that improve student achievement may prove difficult, however, when the budget expands rapidly, temporarily, and in large sums, as can happen with resource booms.

The current study has several contributions which add to the literatures linking resource booms to labor markets and school spending and, through those channels, to teacher quality and student achievement. First, the study separately estimates how labor market opportunities directly affect students and teachers, and indirectly affect students through changes in teacher quality. Second, given the effect of drilling on the property tax base, it documents a school finance channel to students, showing the effect of the tax base windfall on school district tax rates, borrowing, and spending across multiple categories, including on teachers. Lastly, the study estimates the overall effect of the resource boom on student achievement, indicating whether schools successfully used their revenue windfall to counteract the labor market pull effect on students and teachers, as well as any changes in their quality.

Empirically, the study exploits school district variation in shale geology across the state of Texas and temporal variation in energy prices over the 2000s. The instrumental variable approach with school district fixed effects provides estimates of how this recent Texas shale boom affected student achievement. The evidence shows that higher wages attracted vocational and economically disadvantaged students into the labor market, while a widening private-public sector wage gap increased teacher turnover and the percentage of inexperienced teachers in the classroom. At the same time, schools in areas with richer shale geology saw a large expansion of their tax base. Districts responded to the tax base expansion by lowering tax rates and spending more on capital projects, but not on teachers. Overall, shale development decreased the percentage of students passing state exams, despite providing schools with abundant resources. The evidence suggests that this overall negative impact of shale development on student achievement stems primarily from the labor market pull effects on teachers and their resulting decline in quality.

2 Literature

2.1 Resource Booms, Labor Markets, and Education

Several recent studies of resource booms document evidence of their extensive effects upon labor markets. Growth in resource extraction can create jobs and raise incomes, drawing workers from near and far. The local employment and earnings impacts of these booms can be large, and can spill over into other local sectors, as found by Black et al. (2005a) for coal counties in the Appalachian region of the United States, and by Marchand (2012) for oil and gas rich areas of Western Canada. And, in the long-term, abundant oil and gas endowments were shown to lead to higher employment, population, and income in the south-central states of the U.S. (Michaels, 2010), while the 1970s oil boom eventually lowered per capita incomes in the western U.S. (Jacobsen and Parker, forthcoming).

The expansion of oil and gas drilling into shale formations in the 2000s has also had substantial labor market effects. Weber (2012) found that the average county experiencing a boom in natural gas production, across the states of Colorado, Texas, and Wyoming, had a $69 million increase in wage and salary earnings. Several studies have also documented the spillover effects, finding that each oil and gas sector job creates around one to two jobs in other sectors of the local economy (Brown, 2014; Fetzer, 2014; Weber, 2014). Munasib and Rickman (2015) provide more mixed findings, however, showing positive and statistically significant spillovers of shale oil and gas production in some regions, but not in others.

Ample evidence shows that extraction booms also influence schooling decisions through their effect on the labor market. Black et al. (2005b) showed that the 1970s boom in coal mining increased the returns to unskilled labor, which caused the youth in Appalachian counties of the U.S. to leave high school for the mines, decreasing high school enrollment. This relates to the work of Kumar (2014), which showed that the 1970s oil boom slowed growth in the relative demand for skills in the U.S. Looking at a similar period in Alberta, Canada, Emery et al. (2012) found that the 1970's oil boom caused males to delay their education, but not decrease their eventual attainment. That said, Weber (2014) showed that the growth in natural gas production over the 2000s did increase the average educational attainment of the adult population, which likely reflects the inflow of immigrants with higher educational attainment than the average local resident.

More generally, natural resource abundance may lower long-term growth by discouraging investments in human capital (Gylfason, 2001; Van der Ploeg, 2011). Increased returns to relatively unskilled labor in the natural resource industries may also help explain why Papyrakis and Gerlagh (2007) found that states with a greater dependence on natural resources had smaller educational service sectors. Under the booming sector model of Corden and Neary (1982), a resource boom will cause labor to move out of the non-booming, tradable-good sector, thereby causing its output to decrease. This prediction could apply to the education sector as well, as long as the boom does not increase the price of its output.

2.2 Local Finances, School Spending, and Student Achievement

Only a handful of recent studies address how natural resources might affect local finances and how that affects school spending, and there is only one that ties it to student achievement. For the U.S., Raimi and Newell (2014) documented the various revenues generated by shale development in eight states and to whom they accrue (such as schools, municipalities, counties, or the state). They show that development may expand the local tax base and directly generate revenues for schools, or it may increase revenue to the state government, which is then redistributed to schools. And, in Texas specifically, Weber et al. (2014) showed that the development of the Barnett Shale caused a large increase in the property tax base, which subsequently increased school revenues per student.

Outside of the U.S., Carnicelli and Postali (2014) found that oil windfalls led Brazilian municipalities to reduce their effort to collect revenue through taxes. Further, Caselli and Michaels (2013) showed that revenues from oil production increased spending on education for Brazilian municipalities, which increased the number of teachers and classrooms per capita, but these effects were small and not robust. Only one study, Haegeland et al. (2012), links resource windfalls to student achievement. They used the location of waterfalls in Norway to estimate how higher revenue from hydro-power plants affected the performance of 16 year olds, finding a statistically significant and positive effect.

Greater revenues, however, do not necessarily mean greater school spending. Local governments could treat tax revenue and grant revenue differently (Turnbull, 1998). Also, additional revenue from one source, such as a federal grant, may or may not crowd out revenue from other sources, such as transfers from the state or local tax collections (Gordon, 2004; Dahlberg et al., 2008; Litschig and Morrison, 2013).

Even if school spending increases, it may not affect student achievement. In a meta-analysis of the previous studies, only a minority of the estimates of this relationship were statistically significant (Hanushek, 2006), but a re-weighting of those estimates could favor a positive relationship (Krueger, 2003). In a recent summation of the literature, Gibbons and McNally (2013) argued that the majority of early studies lacked proper identification, which led to the conclusion that greater school spending had no effect, but more recent studies, employing better research designs, generally show that resources matter. For example, Marlow (2000) showed that higher spending did not improve student performance, and Unnever et al. (2000) found that the resources of school districts were associated with socioeconomic characteristics and student outcomes, but not scores. In contrast, Papke (2005) found that greater school funding increased math test pass rates, and Holmlund et al. (2010) showed that increased school spending consistently improved outcomes at the end of primary school.

Not surprisingly, how the additional school money is spent matters. Sander (1993) found that increased salaries of teachers in Illinois raised ACT scores and the percentage bound for college, while increased pupil-teacher ratios reduced graduation rates and the percentage college bound. Addressing the endogenous relationship between spending and achievement through two-stage least squares, Sander (1999) found that expenditures per student and teacher salary had positive, though modest, effects on test scores. Using a school finance reform that increased education spending, higher teacher salaries and smaller classes both led to increased test scores (Chaudhary, 2009). And, Cobb-Clark and Jha (2013) showed that per pupil spending had only a modest impact on test scores in general, but that greater spending on ancillary teaching staff and school leadership improved scores. Still, greater spending on teachers does not always improve scores (e.g. Hakkinen et al., 2003).

2.3 Why Teacher Quality May Matter

In addition to directly affecting student achievement, better labor market opportunities and greater school spending might influence teacher quality, thereby indirectly affecting students. Because there are no studies that specifically examine the effects of resource booms on teacher quality, either through the labor market or school spending channels, existing research largely ignores the potential for resource-based activities to affect educational attainment in this way. That said, several important studies link labor market conditions to the quality of teachers, and many other studies explore whether teacher quality matters for student achievement.

Ample evidence shows that labor market conditions can affect teacher quality. Several studies link the declining quality of teachers in the U.S. from the 1960s to the 1990s to improved labor market opportunities for talented women (Bacolod, 2007; Corcoran et al., 2004; Eide et al., 2004; Stoddard, 2003). In a very recent study, Nagler et al. (2015) use the business cycle to represent the variation in outside opportunities at the beginning of a teacher's career. They show that individuals entering the teaching occupation during a recession are more effective in raising student test scores, suggesting that higher teacher salaries would attract more effective teachers.

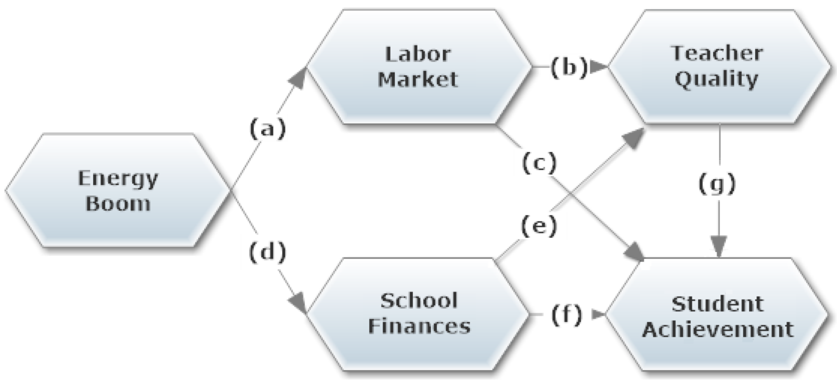
Although Loeb and Page (2000) link higher teacher salaries to students, with a modest reduction in high school drop out rates, raising teacher salaries may not always improve teacher quality, and then student achievement. While higher teaching salaries have been successful in attracting more qualified teachers (Figlio, 1997), this finding does not seem to hold for all schools, such as unionized public schools (Figlio, 2002). In addition, Rothstein (2015) shows that increases to teacher salaries may need to be large to effectively alter teacher quality. Similarly, Cabrera and Webbink (2014) found that a policy that increased the salaries of teachers moving to schools with vulnerable students increased average teacher experience by three years, but had no robust effects on attendance or completion.

When linking teacher quality to student achievement, the literature suggests that traditional measures of teacher quality, such as years of experience or advanced degrees, are often correlated with student test scores, but not always. Goldhaber and Brewer (1997) find that teacher qualifications (certifications, degrees, and experience) matter for student outcomes, as measured by tenth grade math scores, and Rockoff (2004) finds that higher quality among teachers was associated with higher reading and math scores. That said, Rivkin et al. (2005) show that teacher quality has large positive effects on reading and math achievement, but much of the variation in quality is unrelated to education or experience.

Between the two traditional measures, experience seems to matter more than the credentials. Buddin and Zamarro (2009) find that student achievement weakly increases with teacher experience, mainly because of poor student outcomes in the first two years of teaching, while advanced degrees of teachers were unrelated to achievement. Harris and Sass (2011) show that elementary and middle school teacher productivity increases with experience, with the largest gains coming within the first few years, but some gains occurring beyond the first five years. Formal training and previous education, in contrast, had little effect on outcomes, except for middle school math scores.

In the face of teachers leaving the classroom for jobs elsewhere, Hanushek and Rivkin (2010) show that teacher turnover itself harms students, but not as much as previously

Figure 1: Linkages from an Energy Boom to Student Achievement



Notes: Each letter, (a) through (g), represents a relationship referenced in the literature review to be estimated later in this study.

suggested, because the most productive teachers are the ones that tend to stay. That said, Staiger and Rockoff (2010) explain that teacher turnover is costly, not because of the direct hiring costs of a replacement, but because student achievement declines when experienced teachers are replaced with the inexperienced.

3 Empirical Approach

3.1 Mechanisms Guiding the Empirical Framework

The growth in resource extraction during times of high energy prices, and the related prosperity of those energy resources, may affect student achievement through two basic channels: the labor market and school finances. These two channels may have multiple and competing effects on schools and, more specifically, on the students and teachers within them. The various pathways associated with these channels are visually depicted in Figure 1, with each linkage to be estimated labeled with a letter. The first two links (a and d) represent the initial effects of an energy boom on the labor market and school finances.

By demanding more labor, the shale boom should lead to higher wages (link a) which may, in turn, affect student achievement either directly (link c) or indirectly through teacher quality (link b, and then g). The direct effect of the labor market on students reflects the greater opportunity costs of remaining in school. A higher average local wage could encourage students to take a job, which might cause them to miss class time or dropout altogether. If labor market opportunities tend to attract the lower performing students, the average achievement of the remaining students may actually increase through changes in student composition alone. This might be expected if many of the jobs associated with shale drilling require little formal education and attract less academically-oriented students.

For teachers, rising local wages also imply a greater opportunity cost of staying in the classroom, but only if districts do not increase teacher salaries to stay competitive with those outside opportunities. In practice, formula-based teacher salaries, or public sector salaries in general, are unlikely to keep pace with private sector wage growth during boom times. Even if teachers find the newly created non-teaching jobs unattractive, more expensive housing rents and local services mean that, without pay increases, the real teacher wages will decline, encouraging them to live and work in areas outside of the boom. As with students, the pull of the labor market may be strongest for certain types of teachers, affecting their composition, and thereby altering the average education and experience of a district's teachers. If, for example, the teachers who leave for outside opportunities are replaced by less experienced teachers, average teacher experience would decline, potentially lowering student achievement.

The shale boom should also generally lead to greater revenue and spending for schools (link d). There is an obvious reason to expect that a drilling boom might improve school finances in states where oil and gas wells are taxed as real property. Property taxes provide the majority of revenues for most schools. If the value of producing from oil and gas wells is taxable, then more wells and/or higher energy prices will expand the tax base. In Texas, independent appraisers assign a value to a producing well based on the discounted flow of profits that it is expected to generate. Assessors use price projections and expected production from existing wells to determine expected profits. Wells are reassessed annually as they mature and prices change.[1] It is not a forgone conclusion, however, that an expanded tax base will increase school revenues. If voters are well informed and the tax rates reflect the optimal demand for public services, a revenue windfall to the local government could cause policy makers to decrease the tax rate in order to offset the windfall, leaving the government with just enough funds to provide the existing level of service.

As with the labor market channel, school spending may affect student achievement either directly (link f) or indirectly through changes in teacher quality (link e, and then g). Given the inconclusive literature on school resources and student achievement, it is not assured that schools will spend resource windfalls productively. Such revenues can quickly increase or decrease, often unexpectedly, tracking the booms and busts in drilling and energy prices. Resource windfalls also come without conditions, similar to most state and federal grants for education. With substantial revenue coming in easily, quickly, and with no conditions, school districts may find themselves unprepared to use the money well, with few people qualified to evaluate the merits of spending options. Local policy makers (possibly with support from their constituents) may spend much of the additional revenues in ways that have little effect on student achievement, such as on gyms or football stadiums, rather than on hiring more and better teachers, which is more likely to improve student outcomes.

3.2 Estimation and Interpretation

Similar to many previous studies, such as Unnever et al. (2000), this study uses the school district as the unit of analysis. Across the literature, the variation used for identification ranges from the individual level to the state level, with classrooms, schools, districts, and counties lying in between those extremes. Although less aggregated data could potentially provide greater precision of the estimated effect of school resources on student achievement (see Hanushek et al., 1996), a district-level analysis best suits the resource shock of the

[1]Details regarding oil and gas property tax assessment in Texas can be found at http://www.isouthwestdata.com/.

current study, because the property tax base and tax rates vary across school districts, and not within them.[2] For the following estimation procedures, the linkages of the empirical framework are examined using all districts within the state (including crude oil, natural gas, and non-shale districts), and for oil and non-shale districts together excluding gas districts.[3]

The core empirical strategy is based on interacting time-invariant resource endowments with changing market conditions and follows the approach taken from other resource-related studies, such as Black et al. (2005a) for coal dependence and coal prices, Angrist and Kugler (2008) for coca cultivation and coca price, and Michaels (2010) for oil endowments and time effects. Specifically, the direct linkages from the shale value to both the labor market and school finances (links a and d in Figure 1) are estimated with the fixed effects approach:

$$Outcome_{dy} = \alpha + \sum_{t} \beta_t \left(Price_y \times DepthTercile_{t(d)} \right) + District_d + Year_y + \varepsilon_{dy} \qquad (1)$$

where *Outcome* is the outcome of interest, which varies by both district, d, and year, y.[4] *Price* is the national energy price for either crude oil or natural gas, depending on whether a district is over either a major oil play or a major gas play. In both cases, the price level is normalized by the average annual price observed over the study period.[5] *DepthTercile* is a vector of three binary variables representing each tercile, t, of the distribution of shale depth in kilometers. A district's shale depth only varies by geography, not time, and serves as a proxy for shale oil or gas endowments. These depth tercile variables always equal zero for non-shale districts. *District* and *Year* are vectors of binary fixed effects for all school

[2]More specifically, Hanushek et al. (1996) showed that the level of data aggregation and the magnitude and statistical significance of the estimates of school resources on achievement are linked, due to an increase in omitted variable bias with aggregation.

[3]Districts in a small shale play across three counties, and for which geologic data were unavailable, have also been excluded from both of these sets.

[4]A first-difference approach was also used: $\Delta Outcome_{dy} = \alpha + \sum_{t} \beta_t \left(\Delta Price_y \times DepthTercile_{t(d)} \right) + Year_y + \varepsilon_{dy}$, where the outcome and controls are in annual changes, the district fixed effects are eliminated through differencing, and the year fixed effects now refer to consecutive year pairings, with the first pair 2000-2001 left out of the equation.

[5]Alternatively, binary indicators for the boom, stagnation, and bust periods could be used instead of a price variable, similar to the approach of Black et al. (2005a).

districts and all years, with the year 2000 being excluded to set up the comparison.

The interaction between price and depth tercile can be considered as a proxy for the value of shale resources within a district in a given year, and it is closely related to changes in labor demand and the oil and gas property tax base. Oil and gas in deeper shale tend to be under greater pressure, which leads to more prolific wells and greater resource recovery (EIA/ARI, 2013). Across the major shale formations in the U.S., Brown et al. (2015) find that a ten percent increase in average depth is associated with a seven percent increase in the ultimate recovery of a typical county well. Rising prices motivate the drilling of new wells and increase the value of existing wells, both of which would increase the oil and gas tax base. Increases in drilling would also increase labor demand. Differences in shale geology across districts should therefore be an important factor for labor markets and school finances, and these differences will be accentuated by high energy prices.

Despite the inclusion of district fixed effects, the coefficient on the interaction term, β, is identified through variation across time and across districts. The district fixed effect controls for additive time-invariant differences across districts. However, it does not control for multiplicative effects, such as a temporal shock that impacts districts differently based on a time-invariant characteristic, such as shale depth. The interaction term will, therefore, differ across districts in each year, and this difference will change from year to year based on changes in energy prices. Put differently, the effect of being in a particular depth tercile is conditional on the price of energy.

The coefficient, β, measures the effect of a one unit increase of the interaction between price and depth tercile. Regardless of how it is implemented, the district fixed effects model is equivalent to demeaning each variable by its district-specific average value across time. The demeaned version of the interaction variable will equal zero when the price of energy equals the period average price, and it will equal one when a district is in the given depth tercile and the price of energy is double the period average price. This can be seen by expressing the demeaned interaction term as:

$$\left(\frac{p_t}{\bar{p}} - \frac{1}{T}\sum_t^T \frac{p_t}{\bar{p}}\right) \times DepthTercile = \left(\frac{p_t}{\bar{p}} - 1\right) \times DepthTercile \tag{2}$$

Put simply, β captures the effect within a given shale tercile in times of high energy prices.

The regressions based on equation (1) will show how areas with better shale geology had larger changes in their tax base (and wages and school spending) in times of high energy prices. An instrumental variable approach is then used to estimate the effects of variables related to the labor market channels (links b and c) or the school finance channels (links e and f in Figure 1) on other outcomes of interest, such as teacher quality or student achievement. The base second-stage regression takes the form:

$$Outcome_{dy} = \alpha + \beta \cdot Channel_{dy} + District_d + Year_y + \varepsilon_{dy} \tag{3}$$

where *Channel* represents intermediate variables related to shale development that are thought to affect education outcomes, such as the average local wage, the wage gap relevant for teachers, school spending per student, and various measures of teacher quality. In each case, the interaction between the price of crude oil (or natural gas) and shale depth (in its continuous form) serves as the instrument for each channel variable.

In the first-stage, the coefficient on the interaction between the energy price and the continuous form of depth is interpreted as the effect of the price of energy doubling for a district with one kilometer of shale depth, instead of for a district within a given depth tercile. Using depth as a continuous variable improves the strength of the first-stage, relative to the tercile approach of equation (1). In most of the cases further pursued, this price-depth interaction, referred to as shale value, will have a statistical relationship with the channel variable that is sufficiently strong enough to dismiss concerns about weak instrument bias.

4 Data and Descriptive Statistics

4.1 Data Sources

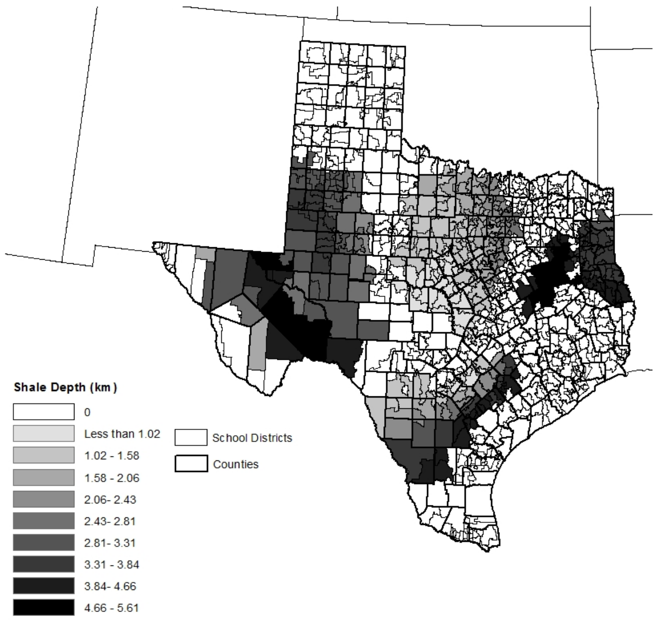
Texas has roughly five million primary and secondary school students (5,000,470), in more than nine thousand schools (9,317), across more than one thousand schooling districts (1,031), in over two-hundred and fifty counties (254). The full sample includes 1,012 independent school districts for which shale depth and financial data were available beginning in the year 2000 (98.1 percent of all available districts), with fifty-two percent of all districts in the sample being over one of the four major shale formations in Texas: the Barnett, the Eagle Ford, the Haynesville, and the Permian. All of the variables are measured at the district level, except for non-teacher wages which are measured at the county level, with districts being geographically smaller and contained within counties.

These districts are followed over fourteen years, from 2000 to 2013, a period which coincides with an expansion of oil and gas drilling in shale, rising crude oil prices, and a boom and bust in natural gas prices.[6] Energy prices are from the Energy Information Administration, using the national first-purchase price for crude oil and the national wellhead price for natural gas. These prices, as well as all other monetary variables, are in constant 2010 dollars. Crude oil prices rose from 2002 to 2008, but declined in 2009, and then continued to increase from 2010 to 2013. Natural gas prices increased from 2002 to 2005, held somewhat steady until 2008, and then plummeted and remained low afterward. These trends can be seen later on in the study, in the descriptive Figures 3a and 3b for oil and gas, respectively.

Data on shale depth, which serves as a proxy for shale oil and gas endowments, come from Los Alamos National Laboratories and cover the four major shale formations. The average shale depth in a district provides a continuous measure of shale richness, because deeper shale is generally associated with more productive wells. The average district in shale areas has a depth of around 2,500 meters (with a standard deviation of 1,250 meters).

[6] The data for 2014 can be included in late 2015, when the latest wage data are available, resulting in fifteen years of data.

Figure 2: Texas School Districts and Average Shale Depth



Notes: Authors' calculations based on data from Los Alamos National Laboratories. School districts have thin borders, while counties have thick borders. Shale depth is in kilometers. The Barnett and Eagle Ford formations are located in the north and south of the state, while the Haynesville and Permian formations are found in the east and west, respectively.

Figure 2 shows the district delineation and variation in shale depth across districts. The Barnett and Eagle Ford formations are located in the north and south of the state, while the Haynesville and Permian are found in the east and west, respectively. The Barnett and Haynesville formations produce almost entirely natural gas, whereas the Eagle Ford and Permian primarily produce crude oil.

The district-level characteristics of teachers and students, including those for student achievement, come from the Snapshot School District Profiles of the Texas Education Agency. Teacher variables include the student-teacher ratio, the teacher turnover rate (percentage from the prior year that did not return in the current year), years of teaching experience, and the percentages of teachers with less than five years of experience and with an advanced degree. Measures related to student achievement include the attendance and completion rates and the percentages of students passing state standardized tests (also shown separately for math and reading), taking college entrance exams (SAT or ACT), and meeting the college entrance exam criteria (1110 on SAT or 24 on ACT). Student characteristics include the percentages of students enrolled in English as a Second Language (ESL) or in vocational or technical (votech) programs, as well as those economically disadvantaged or gifted.

Appendix Table A1a displays the summary statistics for the teacher and student data in the base year of 2000. Across oil, gas, and non-shale districts, teacher turnover ranges from 15.0 to 16.5 percent, the average teacher had 12 to 13 years of experience, with 28.9 to 32.3 percent having less than five years of experience, and 18 and 20 percent having advanced degrees. Teachers in oil districts had the least amount of advanced degrees and the most experienced teachers, while teacher turnover was highest in the non-shale districts. Student attendance and completion rates were similar across district types, at 96 percent and 86 percent, respectively. The student composition was 4 to 7 percent ESL, 21.4 to 26.7 percent votech, 41.9 to 55.3 percent economically disadvantaged, and a consistent 8 percent gifted. Oil districts had the highest percentages of all categories, but the differences were largest for the percentage of economically disadvantaged students at 55 percent, compared with 42 and 48 percent for gas and non-shale districts, and for the percentage of votech students at 26.7 percent, versus 23.6 and 21.4 for gas and non-shale. Oil districts also had a slightly lower percentage of students passing state tests and taking and meeting the criterion for the SAT/ACT, by 1 to 4 percentage points, as compared with gas and non-shale districts.

Data for the non-teacher wages come from the Bureau of Economic Analysis and include the average compensation per job (average wage), per private sector job (private wage), per public sector job based on all state and local government jobs (public wage), which are all measured at the county level. The average difference is then calculated between the private and public sector wage (wage gap). The average teacher wage is from the Snapshot School District Profiles of the Texas Education Agency and is reported at the district level. All wages are in 2010 dollars. School district property tax rates and debt data come from the Texas Bond Review Board, while the tax base and school spending data come from the Public Education Information Management System of the Texas Education Agency. Twelve financial variables are considered: the total tax base (broken into oil-and-gas and non-oil-and-gas), total debt, property tax rate, total revenues, total spending, payroll spending, and non-payroll spending (broken into capital, debt, and other). All school financial variables, except for the tax rate, are reported as dollars per student.

Appendix Table A1b provides descriptive statistics for wages, school finances, and spending in 2000. For all districts, the average private sector job received $28,490, about $14,000 less than the average public sector job, with an even larger difference in oil districts. However, the standard deviation for private wages is more than twice that of public wages for all district types, which is instead lower for oil districts. This difference could partially be due to public sector jobs being primarily full-time, whereas private jobs are a mix of full-time and part-time. The average teacher earned more than the average wage, at roughly $46,000 annually. The median school district had a similar tax base of about $240,000 per student. The mean tax base was much larger at about $310,000 per student, which varies across district types. Some of this difference is driven by skewness in the oil and gas property tax base, which is expected, as it is geologically determined. For example, the mean oil district had about $172,000 as its oil and gas tax base, compared to around $20,000 for its median district. For the average district, property was taxed at 1.45 percent, generating roughly $5,000 per student through property taxes or about half of total revenues. Most of the spending for the average district, about two-thirds, went to payroll, with other spending being the next largest category, followed by spending on capital and then debt.

4.2 Descriptive Figures

The oil and gas tax base can be viewed as a measure of the drilling boom. Growth in this base depends on increases in either the number of producing wells or in the value of what they produce, with both usually occurring at the same time. Over the study period, the average school district in the oil plays (Eagle Ford and Permian) experienced a dramatic increase in its oil and gas tax base, increasing from about $170,000 in 2000 to more than

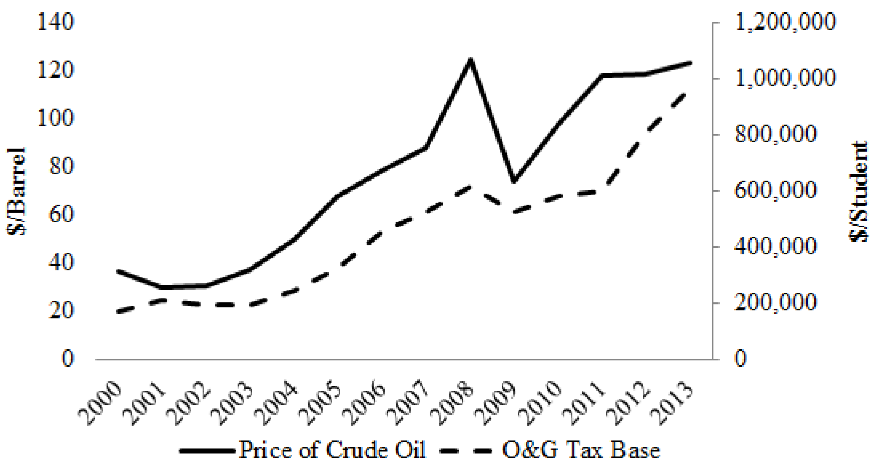
$960,000 in 2013 (Figure 3a). The increase in this tax base tracked the price of crude oil, which quadrupled in real terms over the same time. This is unsurprising because higher oil prices increase the value of existing wells and encourage the drilling of new ones, which will enter the tax base upon commencement of production. Similarly, the oil and gas tax base in the average district in the natural gas plays (Barnett and Haynesville) followed the price of natural gas (Figure 3b). However, the boom in the price of natural gas was less dramatic, and it busted in 2009. The oil and gas tax based followed suit, tripling from 2000 to 2008 ($30,000 to $106,000) and then declining by 40 percent by 2013.

Additional descriptive statistics indicate that both the labor market and school finance channels were clearly at work in the oil districts. Initially, the average oil district had an average wage that was about 11 percent less than the average non-shale district (Figure 4a). By 2013, when the oil and gas tax base was about five times higher, the difference had switched, with oil districts having an average wage about 2 percent higher than non-shale districts. As the tax base expanded, so did spending per student relative to non-shale districts. Over 14 years, the real difference in spending between oil and non-oil districts increased from $600 to $3,600 per student, in favor of oil districts. This is quite large considering that the average district only spent about $10,000 per student in 2000.

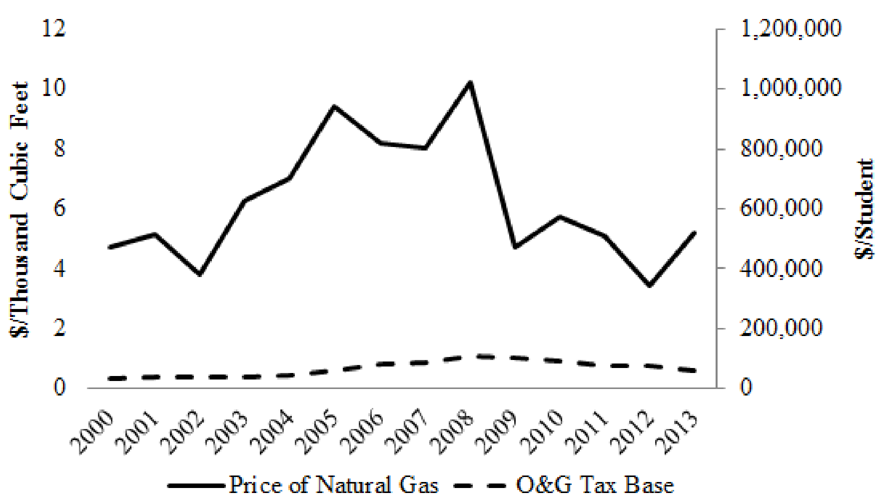
Gas districts experienced little or no change in wages and spending relative to non-shale districts (Figure 4b). The difference in wages remained roughly constant over the study period. The lack of a wage effect is likely an artifact of the larger labor markets in eastern Texas, particularly in the Barnett Shale, which encompasses the Dallas-Fort Worth metropolitan area. The finding is also consistent with Weber (2014), which found very small wage effects associated with the expansion of shale gas drilling in counties of the south-central U.S. (including Texas). Regarding school spending, the somewhat expanded tax base appears to have had only a small and delayed effect. This smaller spending effect in gas districts likely reflects the much smaller increase (in levels) as compared to oil districts, where the tax base reached nearly $1 million per student. Because of the limited labor market and

Figure 3: Energy Prices and the Oil and Gas Tax Base

a. Crude Oil



b. Natural Gas



Notes: Authors' calculations based on data from the Energy Information Administration (energy prices) and the Public Education Information Management System of Texas Education Agency (oil and gas tax base). Energy prices are the national first-purchase price for crude oil and the national wellhead price for natural gas, both in constant 2010 dollars. The oil and gas tax base is the assessed value (for property tax purposes) of all producing oil and gas wells in the district.

spending effects in the gas districts, the subsequent analysis focuses on comparisons using all districts and then with the oil and non-shale districts together (omitting gas districts).

It is worth noting that not all of the expansion in the tax base, labor demand, or spending reflects drilling in shale. The growth in drilling in the oil formations in the early to mid-2000s primarily reflect the expansion of conventional drilling caused by rising oil prices. The Permian basin, in particular, has a history of conventional oil production from strata above the shale. In many areas, shale has served as the source rock for hydrocarbons that have historically been extracted through conventional methods at strata closer to the surface. That said, there is no reason to expect different effects from wage growth (or spending growth) caused by drilling in conventional formations versus drilling in shale formations.

5 Regression Results

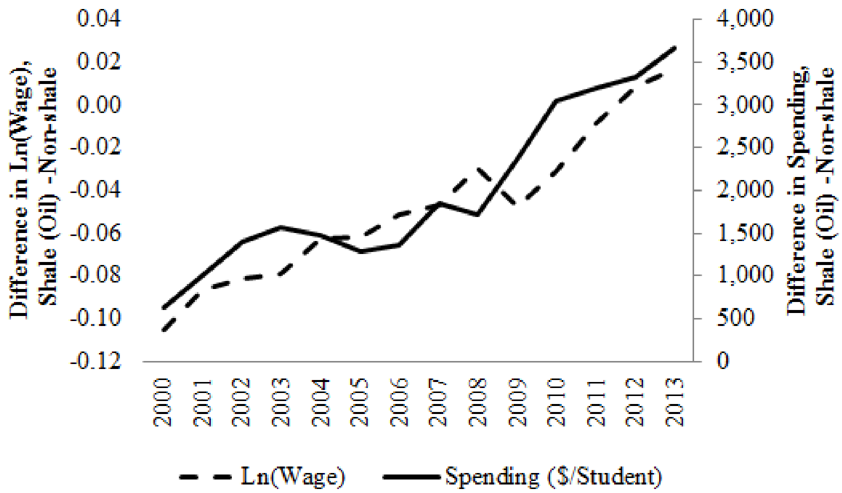
5.1 Labor Market Effects

Any effects of the labor market channel on student achievement are likely to occur through changes in the composition of either students or teachers. Higher wages could directly affect the achievement of enrolled students, for example, by pulling lower-performing (or higher-performing) students from the classroom and into the labor market. Student achievement could also be indirectly impacted by the labor market, by higher wages pulling primarily experienced (or inexperienced) teachers out of classrooms in the same manner. In this particular case, the overall impact of the labor market on student achievement would be ambiguous under both matched scenarios, as students would have gotten better (worse), but their teachers would have gotten worse (better). If the overall impact were known, however, the dominant competing effect could be established.

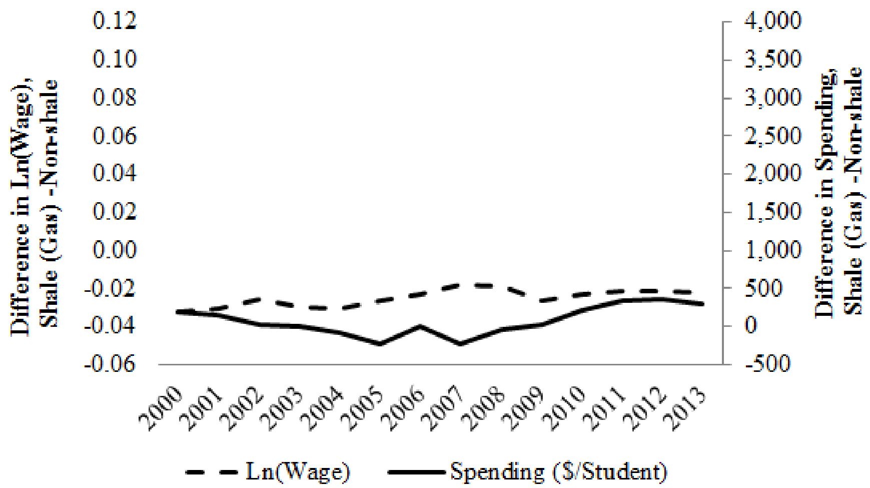
In order to determine just how the labor market affects teachers and students, through links (b) and (c), the effects of shale value on the labor market must first be estimated (link a). The shale boom's effect is considered on several industry-specific wages. First,

Figure 4: Differences in Wages and School Spending between Shale and Non-Shale Districts

a. Crude Oil



b. Natural Gas



Notes: Authors' calculations based on data from the Bureau of Economic Analysis (wages) and the Public Education Information Management System of Texas Education Agency (spending). Wages reflect the average wage in a district's county in constant 2010 dollars. Spending is in terms of dollars per student.

the average wage across all sectors is used to represent the overall labor market effects of the shale boom. Second, wages are presented separately for the public and private sectors, with the public sector wage most relevant for teachers and the private sector wage most relevant for students. Third, the wage difference between the private and public sector is calculated and the actual teacher wages are presented. While the teacher wage cannot be used as an explanatory variable in the second stages that follow later on in the analysis, due to endogeneity issues, it is presented here for descriptive purposes. The wage difference between private and public sectors, on the other hand, is used in its place for the teacher quality linkage, as the explanatory variable in link (b) and then the instrument for link (g).

The ordinary least squares (OLS) coefficients for these wages with shale value, in both tercile and continuous forms, are displayed in Table 1. At higher prices and depth, wages rose for all but teachers, with few exceptions, and the wage gap widened between private and public sectors, more so for areas with deeper shale. When the oil price was double the average price across all years, oil districts with the deepest shale experienced a 10.7 percent increase in wages, as compared to non-shale districts. This sector wage gap widened in oil districts, even slightly more than the average wage increased, possibly because teacher wages slightly decreased, perhaps reflecting the replacement of higher-wage experienced teachers with lower-wage inexperienced ones. Districts in the deepest tercile had a 12.5 percent increase in the gap relative to non-shale districts. Using continuous shale depth, one kilometer in depth was associated with a 3.0 percent increase in average wages and a 3.2 percent increase in the wage difference, holding price constant at double the period average price.

To estimate the effect of changing wages on students and teachers, shale value, which is measured by the interaction between energy prices and shale depth, is used as an instrument for the local wage and for the wage gap under equation (2). The private wage best represents the opportunity costs facing students, while the sector wage gap best represents that facing teachers. Therefore, the effects of the private wage on student attendance, completion, and composition, are estimated, along with the effect of the wage difference on teacher

Table 1: Shale Value Effects on Wages

	All districts				Oil and non-shale districts			
	Price x dt1	Price x dt2	Price x dt3	Price x depth	Price x dt1	Price x dt2	Price x dt3	Price x depth
Average wage (log)	0.025***	0.036***	0.060***	0.016***	0.063***	0.074***	0.107***	0.030***
	(0.010)	(0.008)	(0.007)	(0.002)	(0.018)	(0.014)	(0.012)	(0.003)
				[84.409]				[103.680]
Private sector wage (log)	0.001	0.050***	0.059***	0.014***	0.040	0.114***	0.139***	0.035***
	(0.016)	(0.017)	(0.014)	(0.004)	(0.033)	(0.033)	(0.027)	(0.007)
				[14.578]				[26.843]
Public sector wage (log)	0.017***	0.004	0.012***	0.003***	0.029***	-0.004	0.014**	0.003*
	(0.005)	(0.004)	(0.003)	(0.001)	(0.009)	(0.007)	(0.007)	(0.002)
Private - public wage gap (log)	-0.016	0.047**	0.047***	0.012***	0.011	0.118***	0.125***	0.032***
	(0.017)	(0.018)	(0.013)	(0.004)	(0.034)	(0.036)	(0.025)	(0.007)
				[10.073]				[23.811]
Average teacher wage (log)	0.000	-0.003	-0.017***	-0.003***	-0.005	-0.008	-0.018**	-0.005***
	(0.005)	(0.004)	(0.005)	(0.001)	(0.008)	(0.008)	(0.008)	(0.002)

Notes: Authors' calculations based on multiple sources of data (see Data Sources and the Appendix tables). All districts and Oil and non-shale districts are the observation sets. Price x dt1, Price x dt2, and Price x dt3 represent the interaction between the normalized price of energy (either crude oil or natural gas) and an indicator variable for a school district being in the first, second, or third shale depth tercile, all of which are included as independent variables in the same regression. Price x depth represents continuous shale value as an independent variable in a distinct regression, which serves as the first-stage for estimating the private - public wage gap effects on teacher quality (Table 3). The row variables represent the dependent variables for distinct regressions. (log) denotes the natural logarithm of a variable. All regressions include school district and year fixed effects. For the year fixed effects, the first year (2000) is excluded. Stars denote the statistical significance of the coefficients (*** $p<0.01$, ** $p<0.05$, * $p<0.10$). Robust standard errors, clustered by district, are provided in parentheses. F-stats are provided in brackets.

composition and quality. The OLS results from Table 1, using depth in its continuous form, represent the first-stage of the IV results presented next (Tables 2 and 3). This shale value serves as a moderate to strong instrument for the private wage and sector wage gap, with the first-stage F-statistics ranging from roughly 10 to 27.

The instrumental variable (IV) estimates of higher private wages on students are provided in Table 2. Increased private wages due to the shale oil boom lowered the number of students, student attendance rates, and high school completion rates. Boom-induced private wage growth was also associated with a decline in the percentages of students enrolled in English as a second language (ESL) and vocational-technical (votech) programs, as well as with a larger decline in economically disadvantaged students. For the sample of oil and non-shale districts, for example, a 10 percent increase in the average wage was associated with a 5 to 7 percentage point decrease in economically disadvantaged students. The percentage of gifted students also declined on average, but these estimates are statistically insignificant.

The decline in economically disadvantaged students could reflect their pull into the labor market or the increased household incomes from boom-induced wage growth pushing them above this status. However, the decline in the total number of students, as well as in ESL and votech students, suggests that the estimates reflect the drawing of a particular student type into the labor market: those with the highest discount rates or with the lowest gain from continued education. Compared to the average student, ESL, votech, and economically disadvantaged students are arguably more likely to pursue low-skill labor opportunities and less likely to perform well on standardized tests. This suggests a negative selection effect, which should lead to a higher average performance among remaining students in a district.

A widening gap between the private sector wage and the public sector wage affects teacher composition and quality, as shown in Table 3. The first and third columns reflect the results when the wage gap is instrumented by continuous shale value (i.e. Price x depth), while the second and fourth columns show the un-instrumented effects of the sector wage gap on teachers. Looking at the IV results (first and third columns), an increase in the wage gap

Table 2: Private Wage Effects on Student Attendance, Completion, and Composition

	All districts	Oil and non-shale districts
	Private wage (log)	Private wage (log)
Number of students (log)	-1.115***	-0.802***
	(0.385)	(0.251)
Attendance rate (%)	-0.024**	-0.011**
	(0.009)	(0.005)
Completion rate (%)	-0.325***	-0.143**
	(0.124)	(0.069)
ESL students (%)	-0.293***	-0.175***
	(0.088)	(0.048)
Votech students (%)	-0.208**	-0.211***
	(0.096)	(0.069)
Economically disadvantaged (%)	-0.764***	-0.487***
	(0.222)	(0.123)
Gifted students (%)	-0.060	-0.027
	(0.047)	(0.032)

Notes: Authors' calculations based on multiple sources of data (see Data Sources and the Appendix tables). All districts and Oil and non-shale districts are the observation sets. Private wage is the key independent variable. The row variables represent the dependent variables for distinct regressions. (log) denotes the natural logarithm of a variable. (%) denotes a variable in percentage terms. All regressions include school district and year fixed effects. For the year fixed effects, the first year (2000) is excluded. Stars denote the statistical significance of the coefficients (*** p<0.01, ** p<0.05, * p<0.10). Robust standard errors, clustered by district, are provided in parentheses.

due to the shale boom led to fewer teachers in the classroom, more teacher turnover, and more teachers with less than five years of experience. A 10 percent increase in the wage gap led to a 2.0 to 3.5 percentage point increase of teachers with less than five years of experience across district types. These results hold when looking at the effect of any change in the wage gap; not just those driven by the shale boom.

It is very possible that, while teachers are being pulled from schools by an increasing relative wage gap, they may not actually be taking higher paying non-teaching jobs (see Scafidi et al., 2006). The energy boom may affect teachers by providing a higher paying job for their spouse or other household member, allowing teachers to leave their profession (at

Table 3: Private - Public Wage Gap Effects on Teacher Quality

	All districts		Oil and non-shale districts	
	Private - public wage gap (log)		Private - public wage gap (log)	
Number of teachers (log)	-1.453***	-0.056**	-0.845***	-0.047*
	(0.520)	(0.025)	(0.248)	(0.027)
Teacher turnover rate (%)	0.201*	0.036***	0.144**	0.036***
	(0.115)	(0.009)	(0.067)	(0.010)
		[17.477]		[14.162]
Teacher experience (years) (log)	-0.393	-0.015	-0.198	-0.044
	(0.284)	(0.025)	(0.161)	(0.027)
		[0.353]		[2.519]
Teachers with < 5 years experience (%)	0.353*	0.028**	0.204**	0.044***
	(0.189)	(0.014)	(0.098)	(0.015)
		[4.018]		[8.454]
Teachers with advanced degree (%)	0.140	-0.035***	0.009	-0.035***
	(0.135)	(0.008)	(0.073)	(0.009)
		[17.319]		[15.582]

Notes: Authors' calculations based on multiple sources of data (see Data Sources and the Appendix tables). All districts and Oil and non-shale districts are the observation sets. Private - public wage gap is the key independent variable. The row variables represent the dependent variables for distinct regressions. The first and third column estimates are based on an instrumental variable approach, where the private - public wage gap is instrumented with continuous shale value (Price x depth). The second and fourth column estimates serve as the first-stage for estimating the teacher quality effects on student achievement (Table 6). (log) denotes the natural logarithm of a variable. (%) denotes a variable in percentage terms. All regressions include school district and year fixed effects. For the year fixed effects, the first year (2000) is excluded. Stars denote the statistical significance of the coefficients (*** p<0.01, ** p<0.05, * p<0.10). Robust standard errors, clustered by district, are provided in parentheses. F-stats are provided in brackets.

least temporarily), in order to spend more time at home with their families. In this case, overall household income is increased and the household's marginal utility of additional income is reduced. Another explanation, that does not require teachers actually taking outside jobs, involves a decline in real wages brought about by greater living costs. Teachers who are not homeowners could find their rent increasing dramatically, as well-paid oil and gas workers move into the area. Any disamenities associated with drilling, including dust, noise, and truck traffic, would also lower the quality of life and encourage teachers to move elsewhere for jobs that pay similar nominal wages.

5.2 School Finance Effects

In order to determine just how the spending channel affects teachers and students, through links (e) and (f), the effects of shale value on school finances and spending must first be estimated (link d). The shale boom's effect is considered through three different tax base variables: total, oil and gas, and non oil and gas. The estimates for the oil and gas tax base directly relate to the previous trends shown in Figures 3 and 4 of the descriptive statistics. Then, the finance variables of total debt, the tax rate, and total revenues are considered. Lastly, total spending is shown and separated into payroll and non-payroll spending, which is further separated into capital, debt, and other spending. The results from estimating equation (1) for link (d), using these school finance and spending variables as outcomes, are shown in Tables 4a and 4b, respectively.

The first three rows of Table 4a indicate that, during times of higher oil prices, oil and non-shale districts with deeper shale experienced larger increases in their total tax base, which is almost entirely explained by the increases in the oil and gas tax base. When the price of oil was double the period average price, these districts in the deepest shale tercile (dt3) had an oil and gas tax base nearly a million dollars per student higher than in non-shale districts and about $700,000 higher than districts in the second shale tercile (dt2). In contrast, shale value was largely uncorrelated with changes in the non-oil-and-gas tax base. The economically insignificant relationship between shale value and the non-oil-and-gas tax base indicates that the timing and geography of the housing boom and bust of the 2000s were not associated with shale depth and energy prices.

Similar to what Weber et al. (2014) found for the Barnett Shale in Texas, school districts responded to the greater tax base, in part, by lowering property tax rates, as shown in the later three rows of Table 4a. At a high oil price, districts in the deepest shale tercile had a property tax rate that was 0.044 percentage points lower than non-shale districts. They also increased their borrowing relative to non-shale districts by $9,000 per student. Despite the decline in tax rates, the logarithm of revenues per student increased in shale districts,

Table 4a: Shale Value Effects on School Finances

	All districts			Oil and non-shale districts		
	Price x dt1	Price x dt2	Price x dt3	Price x dt1	Price x dt2	Price x dt3
Total tax base	176,497***	172,274**	508,123***	260,677**	318,945**	990,548***
	(60,513)	(71,068)	(127,651)	(130,459)	(148,342)	(260,537)
Oil and gas tax base	130,624***	184,247***	454,547***	195,072***	346,724***	931,494***
	(34,112)	(61,254)	(120,486)	(72,148)	(128,055)	(245,069)
Non oil and gas tax base	45,873	-11,973	53,576***	65,605	-27,779	59,054*
	(40,585)	(16,029)	(18,185)	(86,758)	(28,765)	(34,593)
Total debt	1,648	172	4,499***	3,575	1,272	9,024***
	(1,572)	(1,121)	(1,701)	(3,068)	(1,667)	(3,186)
Tax rate (%)	-0.023**	0.000	-0.033***	-0.037**	0.003	-0.044**
	(0.010)	(0.010)	(0.010)	(0.018)	(0.017)	(0.019)
Total revenues (log)	0.024**	0.030***	0.057***	0.023	0.050***	0.113***
	(0.012)	(0.011)	(0.014)	(0.022)	(0.019)	(0.026)

Notes: Authors' calculations based on multiple sources of data (see Data Sources and the Appendix tables). All districts and Oil and non-shale districts are the observation sets. Price x dt1, Price x dt2, and Price x dt3 represent the interaction between the normalized price of energy (either crude oil or natural gas) and an indicator variable for a school district being in the first, second, or third shale depth tercile, all of which are included as independent variables in the same regression. The row variables represent the dependent variables for distinct regressions. (log) denotes the natural logarithm of a variable. (%) denotes a variable in percentage terms. All regressions include school district and year fixed effects. For the year fixed effects, the first year (2000) is excluded. Stars denote the statistical significance of the coefficients (*** p<0.01, ** p<0.05, * p<0.10). Robust standard errors, clustered by district, are provided in parentheses.

and more so in areas with deeper shale. Districts in the third tercile experienced a revenue increase of about 11 percent relative to non-shale districts and about 6 percent higher than districts in the second depth tercile.

The greater revenues, shown in Table 4a, translated into similar increases in spending, shown in Table 4b, with districts in the deepest shale increasing spending by 12 percent relative to non-shale districts. During high oil prices, capital spending in districts in the deepest shale tercile (dt3) more than doubled relative to non-shale districts (0.85 log points). Consistent with the finding that outstanding debt increased, spending to service debt also grew, although this increase is less economically important, as debt spending is by far the smallest of the four spending categories. In stark contrast, shale value was uncorrelated with payroll, the largest spending category, as well as with other spending. This suggests that school districts spent the additional revenues on capital and debt expenses, and not on teachers or any other expense.

Given that the continuous form of shale value is later used as an instrument for the explanatory school spending variables, the first-stage continuous results are shown in the fourth columns for each sample of districts in Table 4b. In times of high oil prices, each kilometer of shale depth increases total spending by around 1 percent for all districts and by 3.4 percent for oil and non-shale districts. The spending effect magnitudes are higher and more significant for non-payroll spending, with 2.1 and 7.6 percent increases for all districts and oil and non-shale districts. Consistent with the tercile results, there is no increase in payroll spending. The first-stage F-statistic is sufficiently strong for non-payroll spending for oil and non-shale districts (27.7), but not for all districts (3.9). More importantly, the estimates show that shale value was unrelated to payroll spending (F-statistics of 0.34 and 0.01). Thus, the effect of spending on teacher quality, link (e), is not at all present.

The IV estimates of non-payroll spending on student achievement (link f), using the continuous form of shale value as the instrument, are shown in Table 5. Increased spending attributable to the shale boom is associated with declines in the percentage of students passing state tests, more so for math than for reading, but no statistically significant changes in college preparedness. In general, a 10 percent increase in non-payroll spending is associated with a 1 to 2 percentage point decrease in the passing rates. One explanation for the negative result is that the extra money available to school districts is spent in ways that distract students from learning, such as sports and new buildings, rather than on in ways that enhance productivity, such as higher teacher salaries.

Another, more likely, explanation is that the instrumental variable fails to satisfy the exclusion restriction needed to isolate the effect of greater spending. This is because oil prices and shale depth can affect student achievement through other channels, such as by affecting teachers through the labor market. As shown in Table 4, shale value was associated

Table 4b: Shale Value Effects on School Spending

	All districts				Oil and non-shale districts			
	Price x dt1	Price x dt2	Price x dt3	Price x depth	Price x dt1	Price x dt2	Price x dt3	Price x depth
Total spending (log)	0.018	0.023	0.037*	0.009*	0.040	0.076***	0.122***	0.034***
	(0.019)	(0.020)	(0.022)	(0.005)	(0.032)	(0.029)	(0.035)	(0.007)
				[2.970]				[23.780]
Payroll spending (log)	-0.004	-0.002	-0.003	-0.001	-0.023	-0.003	0.006	0.000
	(0.010)	(0.009)	(0.009)	(0.002)	(0.018)	(0.012)	(0.017)	(0.003)
				[0.349]				[0.016]
Non-payroll spending (log)	0.033	0.062	0.085*	0.021**	0.097	0.179***	0.272***	0.076***
	(0.042)	(0.041)	(0.045)	(0.010)	(0.069)	(0.064)	(0.074)	(0.014)
				[3.902]				[27.731]
Capital spending (log)	0.082	0.137	0.280**	.	0.236	0.384*	0.855***	.
	(0.132)	(0.128)	(0.131)		(0.193)	(0.204)	(0.196)	
Debt spending (log)	-0.017	0.103	0.210*	.	0.186	0.320**	0.682***	.
	(0.086)	(0.086)	(0.107)		(0.156)	(0.152)	(0.240)	
Other spending (log)	-0.002	0.015	0.011	.	0.002	0.026	0.009	.
	(0.017)	(0.018)	(0.018)		(0.026)	(0.028)	(0.033)	

Notes: Authors' calculations based on multiple sources of data (see Data Sources and the Appendix tables). All districts and Oil and non-shale districts are the observation sets. Price x dt1, Price x dt2, and Price x dt3 represent the interaction between the normalized price of energy (either crude oil or natural gas) and an indicator variable for a school district being in the first, second, or third shale depth tercile, all of which are included as independent variables in the same regression. Price x depth represents continuous shale value as an independent variable in a distinct regression, which serves as the first-stage for estimating the non-payroll spending effects on student achievement (Table 5). The row variables represent the dependent variables for distinct regressions. (log) denotes the natural logarithm of a variable. All regressions include school district and year fixed effects. For the year fixed effects, the first year (2000) is excluded. Stars denote the statistical significance of the coefficients (*** $p<0.01$, ** $p<0.05$, * $p<0.10$). Robust standard errors, clustered by district, are provided in parentheses. F-stats are provided in brackets.

Table 5: Non-Payroll Spending Effects on Student Achievement

	All districts	Oil and non-shale districts
	Non-payroll spending (log)	Non-payroll spending (log)
Passing state tests (%)	-0.169*	-0.083***
	(0.099)	(0.029)
Passing state reading tests (%)	-0.149*	-0.046**
	(0.080)	(0.019)
Passing state math tests (%)	-0.167*	-0.085***
	(0.098)	(0.027)
Taking SAT/ACT exams (%)	0.320	0.082
	(0.195)	(0.052)
Meeting SAT/ACT criterion (%)	-0.127	-0.037
	(0.100)	(0.033)

Notes: Authors' calculations based on multiple sources of data (see Data Sources and the Appendix tables). All districts and Oil and non-shale districts are the observation sets. Non-payroll spending is the key independent variable. The row variables represent the dependent variables for distinct regressions. All estimates are based on an instrumental variable approach, where non-payroll spending is instrumented with continuous shale value (Price x depth). (log) denotes the natural logarithm of a variable. (%) denotes a variable in percentage terms. All regressions include school district and year fixed effects. For the year fixed effects, the first year (2000) is excluded. Stars denote the statistical significance of the coefficients (*** p<0.01, ** p<0.05, * p<0.10). Robust standard errors, clustered by district, are provided in parentheses.

with a widening private-public wage gap, an increase in the teacher turnover rate, and an increase in the percentage of teachers with less than five years of experience. The estimates linking non-payroll spending to student achievement suggest that any possible positive effect of school finances on student achievement (link f) is likely overcome by the negative effects of the labor market on teacher quality (link b), leading to further negative effects of teacher quality on student achievement (link g), which is the focus of the next subsection.

5.3 The Link between Teachers and Students

Much was found for the labor market effects of the shale boom on the composition of students and teachers. The estimates suggest a negative selection into the labor market for students: the share of students likely to have lower academic performance declined, as evidenced by the declines in the percentages of ESL, votech, and economically disadvantaged students. The opposite occurred for teachers, with a positive selection into the labor market: those leaving schools were more likely to be higher-performing teachers, as evidenced by a decline in average experience and more teachers with less than five years of experience. Moreover, teacher turnover increased, reducing the district-specific experience of the average teacher.

The final link (g) relates changes in teacher quality stemming from the shale boom to changes in student achievement. Because districts spent their revenue windfalls on capital and debt expenses, and not on payroll, all of the changes in teacher quality stemming from the boom, and their effects on student performance, will solely come through the labor market channel (links b and g). The estimation approach for this channel uses the difference between the average wage for all private sector employees minus the average wage for public sector employees, which would include most teachers, as the instrument for teacher quality. This is similar in logic to the instrument used in Hanushek et al. (2014), as they instrument teacher skills with the relative position of public sector employees in the wage distribution of private sector college graduates, excluding all teachers.

Recalling the results from columns 1 and 3 in Table 3, shale-related increases in the private-public wage gap led to greater teacher turnover and more teachers with less than 5 years of experience. The decrease in average experience and the percentage of teachers with advanced degrees, however, were statistically insignificant. Thus, only some of the teacher-quality effects described below can be confidently applied to the shale boom. The apriori expectations are that greater teacher turnover and more teachers with less than five years of experience would reduce test scores and the percentage of students taking and meeting the criterion of the SAT/ACT. Experience and more teachers with advanced degrees, on the other hand, would have improved test scores and college preparedness. The IV results for teacher quality on student achievement, where changes in teacher quality are instrumented with the wage gap, are displayed in Table 6. These coefficient estimates match expectations.

First, the wage-gap-induced increases in teacher turnover lowered student performance on state tests, slightly more so for math than for reading, and lowered the percentage of students taking the SAT/ACT. Across all districts, a 10 percentage point increase in the teacher turnover rate caused an 8.4 percentage point reduction in students passing state tests and a 13.6 percentage point reduction in students taking the SAT/ACT. Second, the sign and significance of the estimates of teachers with less than five years of experience on student achievement are similar to the effects of greater turnover. Here, a 10 percentage point increase in less experienced teachers causes a 10.7 percentage point reduction in students passing state tests and a 12.2 percentage point reduction in students taking the SAT/ACT. Experience, in general, also appears to improve student performance for state standardized tests and the college preparatory exams, but these estimates should be discounted, because their first stage was too weak to produce credible estimates. Third, teachers with more advanced degrees also improved student achievement for all outcomes, except for the percentage of students meeting the SAT/ACT criterion. Across all districts, a ten percentage point increase in teachers with advanced degrees leads to an 8.7 percentage point increase in students passing state tests and an 11.8 percentage point increase in students taking the SAT/ACT exams.

The IV estimates of the effect of teacher quality on student achievement arguably represent the lower-bound effects. Results that were previously discussed showed that shale value is correlated with increases in the wage gap (Table 1) and with changes in student composition (Table 2). The wage gap should, therefore, also be correlated with changes in student composition. However, the changes in student composition documented in Table 2, such as fewer economically disadvantaged students, would likely improve the average achievement of remaining students, masking some of the effect of declining teacher quality.

5.4 Overarching/Reduced-form Effects

Given all of the linkages estimated throughout the previous tables, one might wonder how the shale boom affected student achievement, regardless of whether it comes through the labor market or school spending channel. Thus far, it seems as though the overall net effect of

Table 6: Teacher Quality Effects on Student Achievement

	Teacher turnover rate (%)		Teacher experience (years) (log)		Teachers with < 5 years experience (%)		Teachers with advanced degree (%)	
	All districts	Oil and non-shale	All districts	Oil and non-shale	All districts	Oil and non-shale	All districts	Oil and non-shale
Passing state tests (%)	-0.842***	-0.709**	2.121	0.596	-1.071*	-0.585**	0.877**	0.742**
	(0.290)	(0.302)	(3.648)	(0.404)	(0.606)	(0.280)	(0.347)	(0.359)
Passing state reading tests (%)	-0.583***	-0.516**	1.330	0.425	-0.739*	-0.430**	0.611**	0.541**
	(0.218)	(0.232)	(2.027)	(0.276)	(0.420)	(0.212)	(0.253)	(0.265)
Passing state math tests (%)	-0.665**	-0.577**	1.641	0.482	-0.851*	-0.479*	0.706**	0.618*
	(0.271)	(0.291)	(2.736)	(0.338)	(0.506)	(0.260)	(0.325)	(0.349)
Taking SAT/ACT exams (%)	-1.361**	-1.630**	1.527	0.963*	-1.223*	-1.105**	1.189**	1.461**
	(0.665)	(0.767)	(1.426)	(0.573)	(0.678)	(0.518)	(0.530)	(0.634)
Meeting SAT/ACT criterion (%)	-0.095	-0.074	0.220	0.058	-0.116	-0.058	0.094	0.072
	(0.449)	(0.529)	(1.064)	(0.426)	(0.562)	(0.429)	(0.461)	(0.545)

Notes: Authors' calculations based on multiple sources of data (see Data Sources and the Appendix tables). The column headings denote the key independent variables for distinct regressions. All districts and Oil and non-shale districts are the observation sets. The row variables represent the dependent variables for distinct regressions. All estimates are based on an instrumental variable approach, where the measures of teacher quality are instrumented with the private - public wage gap. (log) denotes the natural logarithm of a variable. (%) denotes a variable in percentage terms. All regressions include school district and year fixed effects. For the year fixed effects, the first year (2000) is excluded. Stars denote the statistical significance of the coefficients (*** p<0.01, ** p<0.05, * p<0.10). Robust standard errors, clustered by district, are provided in parentheses.

the shale boom on student achievement would be negative, with greater spending on capital projects distracting students or the labor market driving more experienced teachers out of the classroom and increasing teacher turnover. The only positive effect for school districts could come from the boom drawing lower-performing students into the labor market, thereby changing the composition of enrolled students by truncating the lower tail of performers.

The overarching effects of shale value on student achievement, using the tercile approach, are displayed in Table 7. These estimates are assumed to be the combined net effect of the spending and labor market channels. The results indicate that greater shale value lowered the percentage of students passing state tests overall, and for both reading and math separately. Considering the statistically significant estimates, in times of high energy prices, shale districts experienced a 0.9 to 2.8 percentage point reduction in students passing state exams, relative to non-shale districts. This negative effect is not monotonic with respect to shale depth, as it is typically larger and more statistically significant in the first and second terciles than in the third. The percentages of students taking the SAT/ACT test and meeting the SAT/ACT criterion seem to only be affected in the lowest tercile across all districts, with an increase in test participation, but a decline in performance.

These reduced-form results cast additional light on the changes in student and teacher composition. While both the number of students and the number of teachers decline when moving to deeper terciles of depth, the number of teachers declines more than the number of students for all but the top tercile. The significant magnitudes range from a 2.4 to 10.3 percent reduction in the number of teachers to a 5.8 to 11.1 percent reduction in the number of students. This growth difference in the number of students and teachers is largest for the lowest tercile which, in turn, increases the student-teacher ratio.

The different student achievement results across shale terciles may reflect differential changes in student and teacher composition. Compared to teachers, high-school students are presumably less able to pursue labor market opportunities that require moving from home. Teachers in the shallow shale terciles may pursue opportunities several counties away,

Table 7: Shale Value Effects on Student Achievement

	All districts			Oil and non-shale districts		
	Price x dt1	Price x dt2	Price x dt3	Price x dt1	Price x dt2	Price x dt3
Student-teacher ratio	0.191*	0.087	-0.012	0.288	0.065	-0.083
	(0.113)	(0.092)	(0.097)	(0.210)	(0.151)	(0.172)
Number of students (log)	-0.010	-0.022	-0.065***	-0.033	-0.058**	-0.111***
	(0.018)	(0.014)	(0.013)	(0.036)	(0.026)	(0.027)
Number of teachers (log)	-0.024*	-0.027**	-0.063***	-0.056**	-0.062**	-0.103***
	(0.014)	(0.013)	(0.013)	(0.025)	(0.026)	(0.026)
Passing state tests (%)	-0.014**	-0.012*	-0.008	-0.021**	-0.027**	-0.016*
	(0.006)	(0.006)	(0.006)	(0.010)	(0.011)	(0.010)
Passing state reading tests (%)	-0.011***	-0.009**	-0.012***	-0.015**	-0.017**	-0.006
	(0.004)	(0.004)	(0.004)	(0.006)	(0.007)	(0.007)
Passing state math tests (%)	-0.014**	-0.010	-0.009	-0.028***	-0.028**	-0.015*
	(0.006)	(0.007)	(0.006)	(0.011)	(0.012)	(0.009)
Taking SAT/ACT exams (%)	0.020*	0.013	0.014	0.015	0.006	0.026
	(0.012)	(0.012)	(0.010)	(0.021)	(0.020)	(0.018)
Meeting SAT/ACT criterion (%)	-0.015**	-0.013	-0.006	-0.012	0.001	-0.016
	(0.007)	(0.008)	(0.007)	(0.011)	(0.013)	(0.011)

Notes: Authors' calculations based on multiple sources of data (see Data Sources and the Appendix tables). All districts and Oil and non-shale districts are the observation sets. Price x dt1, Price x dt2, and Price x dt3 represent the interaction between the normalized price of energy (either crude oil or natural gas) and an indicator variable for a school district being in the first, second, or third shale depth tercile, all of which are included as independent variables in the same regression. The row variables represent the dependent variables for distinct regressions. (log) denotes the natural logarithm of a variable. (%) denotes a variable in percentage terms. All regressions include school district and year fixed effects. For the year fixed effects, the first year (2000) is excluded. Stars denote the statistical significance of the coefficients (*** $p<0.01$, ** $p<0.05$, * $p<0.10$). Robust standard errors, clustered by district, are provided in parentheses.

where the shale is deeper, while students may not. This would mean that districts in shallow shale districts suffered from greater teacher turnover and fewer experienced teachers, but they did not benefit from having lower-performing students drawn into the labor market. Districts in deeper shale, in contrast, appear to have experienced the two competing labor market effects to a similar degree.

5.5 Robustness Checks

While the fixed effects approach was used throughout the presented analysis, a first-difference model was additionally employed. Both of these approaches provide unbiased and consistent coefficient estimates under the same assumptions; namely that the covariates or instrumental variable are uncorrelated with the error term in previous, contemporary, or future periods. The interpretation of the coefficients between the two models is slightly different, however, because the shale value variables are now in terms of annual changes relative to the period average price. To be precise, in the first-difference model, Price x depth becomes $\left(\frac{p_t - p_{t-1}}{\bar{p}}\right) \times Depth$, instead of $\left(\frac{p_t}{\bar{p}} - \frac{1}{T}\sum_t^T \frac{p_t}{\bar{p}}\right) \times Depth = \left(\frac{p_t}{\bar{p}} - 1\right) \times Depth$, as in the fixed effects model. Thus, the first-difference approach assumes that year-to-year changes in price are more important for shale development, whereas the fixed effects approach assumes that the current price relative to the average price over all periods better captures incentives for development. Because of this difference in interpretation, only the relative statistical significance of the estimates is compared.

The first-difference results for oil and non-shale districts show similar effects of shale value on wages and on teachers and students. They also show an additional effect of the wage gap on average teacher experience. However, the first-stage link of the wage gap (from any source) to changes in teacher quality is weaker, making it difficult to estimate the effects of teacher quality on achievement using this approach. The effects on school finances and spending are also generally similar to those from the fixed effects approach, with shale value associated with expansions in the oil and gas tax base and non-payroll spending. The overall effects are less precisely estimated, but show a similar pattern of districts in shallower shale experiencing more negative effects on student achievement.[7]

Although the main results of the paper were estimated for all districts, and then just for the oil and non-shale districts, additional results were also produced using only oil districts, and then separately using only gas districts. Limiting the samples to only within shale variation is another attractive robustness check, because it is robust to economic shocks that affected shale and non-shale areas differently, other than those associated with energy development. Its weakness, however, is that districts in a shallower part of the shale might experience labor market spillovers from nearby districts with deeper shale, whereas non-shale districts presented a cleaner comparison, in that they will typically not be adjacent to shale areas and are therefore less likely to be affected by geographic spillovers. It should be noted that, when using only the oil districts, the lowest tercile is eliminated, so comparisons are made with it instead of with the non-shale districts.

In the only oil districts, the estimates based on continuous shale value show similarly strong wage effects and a widening wage gap. The changes in student composition are qualitatively similar, but less precisely estimated and lose statistical significance. Non-payroll spending continues to increases with shale value, but it has no effect on student achievement. Shale value continues to reduce teacher quality, as measured by the percentage of teachers with advanced degrees. A widening wage gap (regardless of source) reduces teacher quality for all measures, which all have a negative effect on at least one measure of student achievement. The overarch effect, based on shale terciles, suggests that districts in shallower terciles had worse student achievement than those in the deepest tercile, although this is not statistically significant. The results based only on gas districts, on the other hand, bear little resemblance to the main results. Almost all of the previous statistically significant effects disappear. This finding supports the validity of the empirical approach. Given the negligible finance and labor market effects in gas districts, as shown in Figures 3 and 4, there

[7] These first-difference results are available upon request.

should be no clear effects of shale value on teacher quality or student achievement.[8]

6 Conclusion

Natural resource booms can discourage investments in education, by increasing the opportunity cost for students to stay in school, especially for students who highly discount the future. Previous studies found that such booms led to permanent or temporary declines in high school enrollment (Black et al., 2005b; Emery et al., 2012). These booms could also alter the opportunity cost for teachers to stay in the classroom, which the previous literature has not explored. Additionally, in places where oil and gas wells are taxed as real property, natural resource booms might provide schools with revenue windfalls, as schools are mostly funded by local property taxes. Using school districts across Texas, a state where oil and gas wells enter the property tax base once production begins, this study disentangles the effects of the most recent shale boom on teacher quality and student achievement through these separate labor market and school spending channels.

During times of higher energy prices in the 2000s, districts with more shale resources experienced greater growth in private sector wages, which in turn decreased student attendance and completion rates, as well as changed the composition of the student body toward fewer ESL, votech, and economically disadvantaged students. At the same time, the gap between private and public sector wages increased, leading to more teacher turnover and more inexperienced teachers in the classroom, which then reduced student pass rates on state exams. School districts responded to the exogenous expansion in their tax base by lowering their tax rates, and borrowing and spending more, primarily on capital, but not at all on teachers. The Texas shale boom also decreased student achievement overall, indicating that school districts failed to overcome the labor market pull on teachers and their compositional decline in quality, despite the changes in student composition and additional spending.

The evidence supports the literature in several ways. First, it shows that teacher quality

[8] The results for only oil districts and only gas districts are available upon request.

matters for student achievement. The shale boom led to districts having teachers with less overall experience and less district-specific experience, as evidenced by a higher turnover rate. These changes in teacher quality, in turn, lowered pass rates on state exams. Second, the shale boom enticed students into the labor market who likely have higher discount rates and lower academic performance than the average student. This compositional effect, which should otherwise improve the average performance of enrolled students, did not overcome the decline in teacher quality. Third, this study adds to the literature on school resources and student achievement, by providing evidence that schools can use additional funds in a variety of ways, not all of which may improve performance. School districts in Texas, for example, spent their tax base windfalls on capital projects and tax rate reductions. Overall, these findings suggest that the education sector acts as the lagging sector in Corden and Neary's model, with its output declining as the booming sector demands more labor.

Not all energy-rich states rich have policies like Texas. Other states, such as Louisiana and Pennsylvania, currently exclude oil and gas wells from property taxes. These states, as well as others, have policies that generate public revenues from oil and gas development, but these funds typically enter the state's general budget, and may entirely bypass the education sector. This study indicates that, while Texas school districts had the resources to help mitigate the labor market pull on teachers, their resources were instead used in ways that were less likely to promote student achievement. One might expect an even greater decline in student achievement in states that lack this spending channel altogether. These differences across states highlight how policies can shape the relationship between natural resource extraction, human capital development, and long-term growth, especially for the recent wave of shale oil and gas development in the U.S. Unless funding is allocated disproportionately to districts where the production occurs, and is used to improve teacher quality, rising wages may reduce student performance as districts struggle to retain teachers.

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Table A1a: Descriptive Statistics for Teachers and Students

	All districts (909-1,012 districts) (248 counties max.)			Oil districts (138-148 districts) (61 counties max.)			Gas districts (238-261 districts) (64 counties max.)			Non-shale districts (532-603 districts) (123 counties max.)		
	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median
Student-teacher ratio	12.7	2.3	12.8	12.1	2.3	12.0	12.5	2.1	12.7	12.9	2.4	13.1
Teacher turnover rate (%)	16.0	7.6	15.0	15.7	7.9	14.5	15.0	7.6	14.3	16.5	7.5	15.6
Teacher experience (years)	12.1	2.3	12.2	12.6	2.2	12.9	12.0	2.4	12.2	12.0	2.3	12.1
Teachers with < 5 years experience (%)	31.7	11.5	30.9	28.9	10.8	28.5	31.9	11.7	31.1	32.3	11.4	31.4
Teachers with advanced degree (%)	19.4	9.6	18.7	18.1	8.2	17.5	19.9	10.2	19.3	19.4	9.7	18.7
Attendance rate (%)	96.0	0.9	96.0	95.9	1.0	95.9	96.1	0.8	96.1	96.0	0.8	96.0
Completion rate (%)	86	10	87	87	12	89	86	11	88	86	8	87
ESL students (%)	6.0	8.9	3.0	6.8	6.9	5.0	3.8	5.0	2.0	6.8	10.4	3.0
Votech students (%)	22.7	10.0	23.0	26.7	9.7	27.0	23.6	9.5	23.0	21.4	9.9	22.0
Economically disadvantaged (%)	46.9	19.1	46.7	55.3	16.4	54.9	41.9	16.3	41.8	47.1	20.1	47.1
Gifted students (%)	7.9	3.8	7.3	8.0	3.4	7.4	7.9	3.7	7.2	7.8	4.0	7.2
Passing state tests (%)	82.6	8.7	83.8	81.1	9.0	83.1	84.0	8.1	85.3	82.4	8.9	83.5
Passing state reading tests (%)	89.4	6.5	90.4	88.1	6.5	89.5	90.5	5.7	91.5	89.2	6.7	90.4
Passing state math tests (%)	89.8	6.3	90.8	89.2	6.7	90.8	90.5	6.0	91.7	89.6	6.4	90.5
Taking SAT/ACT exams (%)	60.2	15.9	60.0	59.1	15.2	57.0	59.9	17.0	60.0	60.6	15.6	60.3
Meeting SAT/ACT criterion (%)	18.9	13.1	18.8	17.3	12.1	17.2	20.9	13.1	22.1	18.4	13.3	17.6

Notes: Authors' calculations based on data from the Snapshot School District Profiles of the Texas Education Agency in the base year of 2000. All districts, oil districts, gas districts, and non-shale districts are the observation sets. Oil districts are over one of the two shale formations with crude oil (Eagle Ford and Permian), while gas districts are over one of the two shale formations with primarily natural gas (Barnett and Haynesville). The district numbers with complete data vary across variables, with the district ranges presented for each observation set. SD is the standard deviation. (%) denotes a variable in percentage terms. ESL is English as a Second Language. Votech is vocational and technical.

Table A1b: Descriptive Statistics for Wages, School Finances, and Spending

	All districts (1,010-1,012 districts) (248 counties total)			Oil districts (148 districts) (61 counties total)			Gas districts (259-261 districts) (64 counties total)			Non-shale districts (603 districts) (123 counties total)		
	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median	Mean	SD	Median
Average wage	40,575	8,623	38,299	36,937	4,519	36,090	40,255	8,740	38,024	41,606	9,085	39,062
Private sector wage	28,490	9,761	26,272	24,572	5,169	23,656	27,805	10,336	25,669	29,749	10,089	27,941
Public sector wage	42,601	4,502	41,866	42,257	4,301	41,548	42,687	4,413	41,830	42,648	4,591	42,027
Private - public wage gap	-14,110	7,489	-15,163	-17,685	4,572	-17,395	-14,882	7,565	-15,828	-12,899	7,713	-14,003
Average teacher wage	46,018	2,939	45,863	47,307	3,411	46,850	45,416	2,676	45,544	45,960	2,829	45,917
Total tax base	341,111	373,804	238,116	413,963	396,244	247,848	309,096	305,387	239,333	337,088	392,783	237,277
Oil and gas tax base	64,859	241,242	1,976	172,505	310,173	19,516	30,310	143,062	1,966	53,392	248,812	714
Non oil and gas tax base	276,252	240,664	212,401	241,458	174,154	195,031	278,786	239,685	212,039	283,696	254,353	216,356
Total debt	7,459	10,721	4,157	3,209	5,125	0	9,074	12,141	4,836	7,803	10,829	4,999
Tax rate (%)	1.453	0.145	1.469	1.452	0.117	1.480	1.458	0.150	1.470	1.452	0.148	1.460
Total revenues	10,584	5,284	9,687	11,172	3,426	9,980	10,112	2,147	9,633	10,644	6,469	9,635
Total spending	11,360	5,288	10,298	11,549	3,209	10,854	11,112	3,424	10,207	11,421	6,272	10,216
Payroll spending	7,105	2,680	6,701	7,727	1,772	7,361	6,791	1,192	6,576	7,089	3,247	6,659
Non-payroll spending	4,255	3,585	3,393	3,822	1,878	3,385	4,321	2,946	3,375	4,332	4,113	3,397
Capital spending	1,516	2,683	702	1,089	1,315	552	1,669	2,532	687	1,554	2,973	752
Debt spending	509	596	421	321	444	180	532	487	478	544	660	451
Other spending	2,230	1,505	1,949	2,412	913	2,155	2,120	757	2,005	2,234	1,827	1,886

Notes: Authors' calculations based on data from the Bureau of Economic Analysis (non-teacher wages), the Snapshot School District Profiles of the Texas Education Agency (teacher wage), the Texas Bond Review Board (property tax rates and debt), and the Public Education Information Management System of the Texas Education Agency (tax base and school spending) in the base year of 2000. All districts, oil districts, gas districts, and non-shale districts are the observation sets. Oil districts are over one of the two shale formations with crude oil (Eagle Ford and Permian), while gas districts are over one of the two shale formations with primarily natural gas (Barnett and Haynesville). The district numbers with complete data vary across variables, with the district ranges presented for each observation set. SD is the standard deviation. (%) denotes a variable in percentage terms. All wage variables are in dollars per year and refer to the wage in the district's county, except for the teacher wage, which is district-specific. All school finance and spending variables are in terms of dollars per student, except for the tax rate, which is a percentage.

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