Is education really underfunded in resource-rich economies? Evidence from a panel of U.S. states

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Abstract

Existing development literature has argued that natural-resource endowments "curse" economic prosperity by reducing expenditures on education. According to this theory, public and private agents lack sufficient foresight to make optimal economic decisions and become poor as a result. Using a panel of U.S. state-level data, this paper offers evidence to the contrary. Public spending on education in resource-rich states greatly exceeds that in resource-scarce ones, and private education services are imperfectly crowded out as a result. Analyzing a broader set of public education outcomes reveals that relative teacher salaries, public enrollment rates, and teacher-student ratios tend to move pro-cyclically with resource booms and busts. Weaker evidence is provided that graduation rates fall in response to resource booms, perhaps reflecting a rise in the opportunity cost of going to school for working-age students.

Keywords: Natural Resources, Education Expenditures, Education Attainment, Resource Curse.

JEL Classification: Q4; H4; I2

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Children are our most valuable natural resource. Herbert Hoover.

1 Introduction

Natural resources play a critical (and often negative) role in the development process of poor and rich countries (Auty, 1990; Sachs and Warner, 1995, 1999, 2001; Mehlum, Moene and Ragnar, 2006; James and Aadland, 2010; Walker, 2013). A variety of mechanisms have been proposed (e.g., a Dutch Disease (Corden and Neary, 1982; Matsuyama, 1992), resource induced political corruption (Ross, 1999), civil conflict (Collier and Hoeffler, 1998), resource drag (Davis, 2011)). Yet another prominent theory posits that an abundance of natural resources induces slothful behavior and increases the opportunity cost of going to school. To the extent that natural resources generate political corruption and rent seeking opportunities, this may channel public expenditures away from education and towards special interest groups (Bhattacharyya and Hodler, 2010).

The existing literature has studied the relationship between natural resources and both education attainment (e.g., years of formal schooling) and education expenditures, which is often used as a proxy for education quality.[1] Analyzing a cross-section of countries, Gylfason (2001) documents a negative unconditional relationship between resource dependence and education expenditures and specifically argues that:

> *Nations that are confident that their natural resources are their most important asset may inadvertently–and perhaps even deliberately!—neglect the development of their human resources, by devoting inadequate attention and expenditure to education. Their natural wealth may blind them to the need for educating their children.*

Stijns (2005) also examines the relationship between education outcomes and resource-wealth across countries.[2] Similar to Gylfason (2001), he finds that education spending is negatively associated with resource dependence (e.g., the share of natural capital in national wealth) but positively associated with resource abundance (e.g., subsoil wealth per capita).

[1] De Haan (2012), and Holmlund, McNally and Viagrengo (2010) find that school funding is positively associated with test scores in the Netherlands and the UK, respectively. Papke (2004) finds similar results for the state of Michigan, as does Chaudhary (2009). Card and Payne (2002) find that school funding is positively associated with test scores across the U.S. states. Jackson, Johnson and Persico (2015) find that increasing public school funding per student is associated with additional completed years of education, higher resulting wages, and lower poverty rates. There nonetheless remains debate regarding the causal link between school funding and school quality, see for example Hanushek and Kimko (2000) who find that school funding is unrelated to student performance across countries.

[2] Exploiting international data, Smith (2013) finds that resource discoveries are associated with increased education attainment but does not consider the effect of discoveries on education expenditures.

These results highlight the endogenous nature of resource dependence, a point echoed by Brunnschweiller and Bulte (2008). A poor country with weak manufacturing and service sectors will be resource-dependent as a result. To the extent that education is underfunded in poor economies, the negative relationship between resource dependence and education spending is explained as a statistical artifact. This paper benefits from, and builds off of these earlier contributions, utilizing resource abundance as the main explanatory variable.

Using a cross section of U.S. state-level data, Papyrakis and Gerlagh (2007) similarly document a negative and unconditional relationship between resource dependence and education expenditures. They specifically find that expenditures on education services expressed as a share of state GDP in 1986 are negatively correlated with a state's level of resource dependence in the same year.[3] They go on to say that "The schooling variable has the most significant relation to natural resource abundance at the 1% level, and resource abundance alone accounts for 17% of the variation in educational quality across different states." Using education expenditures as a proxy for education quality, they conclude that natural resources—through their negative effect on education expenditures—account for about a quarter of the variation in growth across resource-poor and resource-rich U.S. states.

Such a finding suggests a lack of rationality and foresight on behalf economic agents and policy makers, significant institutional failures, or both. Given that this result is derived using U.S. state data is especially surprising given that institutional quality is strong and homogeneously distributed (relative to that for countries). Further, one may naturally expect governments to increase expenditures on a variety of public goods in response to receiving additional revenue (as was argued by James, 2015)[4]. And this may be especially true for education expenditures as 23 state governments (and all but one major oil producing state) finance public schools (at least in part) using trust land, which in some cases is leased out for the purpose of hydrocarbon exploration and recovery (Lincoln Institute).[5]

However, upon careful inspection, it is revealed that Papyrakis and Gerlagh failed to include the public sector in their analysis. Correcting for this apparent shortcoming, and exploiting both spatial and temporal variation in the data, paints natural resources—and

[3]Papyrakis and Gerlagh define resource dependence as the share of a state's primary sector (agriculture, forestry, fishing and mining) in state GDP.

[4]Couched within a broader analysis of the fiscal response to resource booms, James (2015) documents a positive relationship between severance tax revenue and education expenditures relative to GDP across U.S. states. That paper hypothesizes, incorrectly it turns out, that its results differ from those of Papyrakis and Gerlagh (2007) because of omitted variable bias. This present paper explains these contrasting results.

[5]Revenue generated from, for example, Wyoming's trust lands fund a variety of public institutions including things like the state penitentiary, the state hospital, and public schools. And the vast majority (84%) of that revenue comes from oil and gas royalties (Lincoln Institute).

resource-rich state governments—in a more favorable light. Using a panel of 48 U.S. states, spanning the years 1970-2008, I find that resource-rich governments spend more on education than their resource-scarce counterparts and private expenditures on education are imperfectly crowded out as a result. In fact, averaged from 1970 to 2008, total (private and public) per capita spending on education was about 6% higher in resource-rich states compared to resource-poor ones. This effect is more pronounced during periods in which the price of the resource is relatively high. For example, as a result of the energy-price boom of the early 1980s, in 1984 total education expenditures were 20% higher in resource-rich states than in resource-poor ones. Examining the relationship between oil-wealth and alternative measures of education quality, namely, relative teacher salaries and student-teacher ratios offers some complimentary findings. Relative to teachers in bordering states, teachers in oil-rich states are typically paid more, especially during periods of high oil prices. There is also evidence that the oil bust of the early 1980s caused student-teacher ratios to rise (but no evidence that the oil boom of the late 1970s caused the student-teacher ratio to fall). Public enrollment rates are high in resource-rich states, and this is especially true during oil booms, possibly reflecting the substitutability between public schools and alternative schools (e.g., public and homeschooling) as discussed by Isenberg (2006). While resource booms may make public schools more appealing for parents of young children, they may have the opposite effect on working-age students; there is some evidence that resource booms cause high school students to prematurely drop out of high school.

2 Identification Strategy

The identification consists of estimating three equations. The first is a difference-in-difference equation that allows for a heterogeneous treatment effect. The second equation is essentially a repeated cross section. The third can also be considered a difference-in-difference equation but offers the advantage of providing a point estimate for the effect of a change in the price of oil. The first difference-in-difference specification is given by equation (1) below:

$$\ln(\frac{E_{i,t}}{\text{Pop}_{i,t}}) = \alpha_1 + \sum_{t=1971}^{2008} \beta_{t,1}(Z_t \times D_i) + Z_t + S_i + \epsilon_{i,t,1}, \tag{1}$$

where Z_t and S_i are year and state fixed effects, respectively, and D_i is an indicator variable that defines whether or not a state is "resource rich". Modeled this way, the treatment effect is allowed to vary from year-to-year and highlights any heterogeneity in the effect of positive and negative oil price shocks. In the following subsection, $E_{i,t}$ will be defined as either private, public or total education expenditures and $\text{Pop}_{i,t}$ is the population of state i at time t. Later on the dependent variable will change as the analysis considers a broader set of education outcomes. All prices are real and 2000 is the base year. Using this specification, $\beta_{t,1}$ is interpreted as the treatment effect in year t (the effect of being a resource-rich state) relative to the treatment effect in 1970. The treatment group is defined as those states that are top ten producers of crude oil and natural gas. Rather than defining the treatment group using production data from a single year, it is defined by production levels, averaged from 1970 to 2008. Therefore, top ten producers can be thought of as top ten "average" producers. Treatment states are (in order of average value of production): Texas, Louisiana, California, Oklahoma, New Mexico, Wyoming, Kansas, Colorado, Utah and North Dakota. A series of robustness checks are carried out that demonstrate how sensitive the results are to this baseline treatment definition.

While equation (1) is estimated using fixed effects, remaining concerns of endogeneity are mitigated some by the treatment definition. While government and economic factors may affect energy production at the margin, top state energy producers are largely defined by geology. New Hampshire, for example, is not a top-ten producer of energy, and there is little the state government of New Hampshire can do to change this. Recent legislation in states like New York that have banned the use of hydraulic fracturing has demonstrated the endogenous nature of natural-resource production. Utilizing a continuous measure of resource-production as an explanatory variable may then yield biased coefficient estimates.

The estimation of equation (1) describes how the relative treatment effect changes over time. It does not reveal, however, any information about how much resource-rich states spend on education relative to resource-poor ones. Given this, a variant of equation (1) is estimated that does not include state fixed effects and the treatment effect is estimated for all years, 1970 to 2008. This approach is similar to that used by Papyrakis and Gerlagh who estimate treatment effects using a single year of cross-sectional data. Specifically, variations of equation (2) below are estimated:

$$\ln(\frac{E_{i,t}}{\text{Pop}_{i,t}}) = \sum_{t=1970}^{2008} \beta_{t,2}(Z_t \times D_i) + Z_t + \epsilon_{i,t,2}. \quad (2)$$

Whereas the treatment effect in equation (1) describes the effect of being a resource-rich state at time t relative to the treatment effect in 1970, the treatment effect in equation (2) describes the effect of being a resource-rich state at time t.

A final equation is estimated that interacts the indicator variable, D_i, with the price of oil.[6] This estimation has the advantage of exploiting reasonably exogenous variation in the value of resource production (oil price) and provides a point estimate for the effect of increasing the

[6] The price of oil is real (2000 is the base year) and reflects imported crude prices.

oil price on education expenditures. This final specification is given by equation (3) below:

$$\ln(\frac{E_{i,t}}{\text{Pop}_{i,t}}) = \alpha_2 + \beta_3(D_i \times \text{Oil Price}_t) + Z_t + S_i + \epsilon_{i,t,3}. \tag{3}$$

The direct and time-invariant effect of being a major oil producer is captured by state fixed effects, S_i, while variation in the price of oil is captured by year fixed effects, Z_t. The coefficient on the interaction term, $D_i \times \text{Oil Price}_t$ then captures the effect of a change in the price of oil that is specific to key energy-producing states.

3 Data

Following Papyrakis and Gerlagh, private education expenditures are defined as "education services". The BEA reports this data as a sub-category of "Private, Non Farm Earnings" and specifically defines education services as "establishments that provide instruction and training in a wide variety of subjects. This instruction and training is provided by specialized establishments, such as schools, colleges, universities, and training centers." The definition goes on to read that, "BEA reports only private schools in its education services industry corresponding to NAICS code 61...". This education services data is published by the BEA, Regional Database and is available at bea.gov.

State-level public education expenditure data were collected from the Census Bureau, Federal State & Local Government Database and is available at census.gov/govs/local.[7] This data describes total (elementary and higher education) state-level education expenditures and does so going back to 1970. One benefit of such a long panel is that it allows the identification to exploit both positive (approximately 1970 to 1980) and negative (approximately 1980 to 1990) variation in resource production. This permits the analysis to say something meaningful about potential asymmetry in the government response to positive and negative resource shocks.

Total education expenditures are defined as the sum of private and public education expenditures. State expenditures make up the large majority of total education spending. In fact, averaged across all U.S. states, in 2008, state spending was more than 80% of total education spending. As will be discussed in the next section, a larger share of education spending

[7] While state-level governments pay for a majority of higher education, this is not always the case for K-12, for which local governments can pick up (depending on the state) a significant portion of the bill. As a robustness check, county-level education expenditures are added to the baseline, state-level expenditures. This county-level data is however incomplete; not all counties are reported and the data is not available for the entire sample period. Nonetheless, defining public education expenditures using both county and state-level expenditures does not change the results in any meaningful way. These alternative results are available from the author upon request.

is public in resource-rich states—especially when the price of the resource is relatively high. For example, in 1984 (the cusp of the energy price boom of the early 1980s), nearly 98% of education expenditures in Wyoming came from the state. Similar figures are found when looking at other states as well (e.g., North Dakota and New Mexico).

Oil and gas production data were collected from the Energy Information Administration (EIA) and is available at eia.gov. This is also the source for energy price data that was used in the estimation of equation (3). Figure 1 provides a graphical description of the value of oil and gas production for the entire United States from 1970 to 2008.[8] The value of energy production is the sum of the value of oil and gas production: oil production × oil price + gas production × gas price. Nominal prices were converted to real ones using the CPI and 2000 is used as the base year. Unsurprisingly, the value of energy production largely rises and falls in tandem with the price of oil; spiking in the early 1970s, falling in the mid 1980s and rising again in the mid 2000s.

4 Results

This section begins by reporting the results from the estimation of equation (1) having defined $E_{i,t}$ as public education expenditures. The results are given in Figure 2a. Recall that for this specification treatment effects are expressed relative to the treatment effect in 1970. The relative treatment effect starts near zero and begins to increase almost immediately. However, it does not become significant until around 1982. In 1984 it reaches a maximum of .15, implying that public education spending per capita in treatment states was 15% higher than what it would have been without the energy price boom. After 1984, the treatment effect begins to fall and becomes insignificant in 1987 and remains so for the remainder of the period considered.

Figure 2b presents the results from the estimation of equation (2) where $E_{i,t}$ is still defined as total public education expenditures. Recall that for this specification the treatment effect is not evaluated relative to the treatment effect in 1970 as it was in the previous specification. The annual treatment effect nonetheless follows a similar trend. It is similarly maximized in 1984, at which point the treatment effect is about .30, implying that in 1984 resource-rich state governments spent nearly 30% more on education per capita than resource-poor states did. Also note that, compared to the relative treatment effects, the annual treatment effects are shifted up by about 10%. In fact, the average annual treatment effect is .167, implying that, averaged from 1970 to 2008, resource-rich state governments spent about 17% more on education per capita than resource-poor state governments did.

[8] The price of oil is defined as the domestic first-purchase price of crude oil and the price of gas is defined as the well-head natural gas price.

Having established that public education is well funded in resource-rich states, I turn my attention to the private sector. The results from the estimation of equation (1) and (2) are given in Figures 3a and 3b, respectively. Discussing first the results from Figure 3a, the relative treatment effect is insignificant for all periods. There is some qualitatively significant variation in the estimate though. For example, the relative treatment effect was -.077 in 1986. This may reflect within-state crowding out by the enhanced provision of public education services but the effect is statistically insignificant. Turning to the annual treatment effect (Figure 3b), private spending on education services is relatively low in resource-rich states and this is true for all years. Like the relative treatment effect, the annual treatment effect is quite stable, hovering close to -.40 for all years.

It may seem that, because private education expenditures in resource-poor states exceeds that in resource-rich ones by such a large margin (close to 40%), total education expenditures would follow a similar trend. However, private education expenditures make up a rather small share of total education spending (on average less than 20%). I formally test whether total education spending in resource-scarce states exceeds that in resource-poor ones by re-estimating equations (1) and (2) defining $E_{i,t}$ as total (private and public) education expenditures. The results are given in Figures 4a and 4b. Starting with the results from the estimation of equation (1) and referencing Figure 4a, the relative treatment effect for total spending follows a similar trend as that for public education spending. This is unsurprising as there is little variation in the relative treatment effect for private spending (and hence variation in total spending is largely due to variation in public spending). The annual treatment effect (Figure 4b) is positive for most years (albeit only significantly so from around 1980 to 1986). Averaged across all years, the annual treatment effect is 8.2%, implying that on average, education spending per capita is about 8% higher in resource-rich states compared to resource-poor ones.

The results from the estimation of equation (3), which are given in Table 1, compliment the previous findings. For public education expenditures, the interaction of D_i and Oil Price_t enters positive (.0007) and is significant at the 5% confidence level. This implies that a \$10.00 increase in the price of oil induces a .7% increase in public education spending per capita. The interaction term for private education expenditures is both qualitatively and quantitatively insignificant. Finally, there is additional evidence that total education spending is elevated in oil-rich states, particularly when the price of oil is high. Referencing column 3 in Table 1, the interaction term enters positive (.0007) and is significant at the 5% confidence level.

The fact that the treatment effect for public education expenditures is sensitive to the oil boom of the late 1970s, whereas that for private education expenditures is not, may help uncover the underlying causal mechanism. Suppose that public and private schools serve as substitutes for homeschooling. A resource boom that increases local wages and lowers unemployment rates effectively raises the opportunity cost of homeschooling from the parent's perspective. In this context, if the documented variation in public education expenditures is solely demand driven, one may naturally expect to see similar variation in private education expenditures. Given that this is not the case suggests that variation in public education expenditures is in fact supply driven and supports the idea that governments simply spend more when they have more revenue to spend. And, as was discussed in the introduction of this paper, there are reasons to think this would specifically be true for public education spending, as all but one treatment state is mandated to fund public education through trust lands, the revenue from which often comes from the leasing of land for the purpose of hydrocarbon exploration and recovery (Lincoln Institute).

5 Robustness Checks

A series of alternative models are estimated that illustrate the robustness of the baseline set of results outlined above. First, equations (1), (2) and (3) are re-estimated controlling for region by year fixed effects. This affirms that the earlier results are not due to unobserved time-variant factors that are region specific. For example, national economic recessions and expansions may heterogeneously affect the sparsely populated states in the mountain west relative to those more heavily populated ones on the east coast. To the extent that such unobserved factors are spuriously correlated with energy deposits, this could bias the results. Figure 5 describes the 4 regions: West, Midwest, South, and Northeast. The results, which are given in Figures 6-8 and in Table 2, are quite similar to the baseline set of results. There is relatively little variation in private expenditures, even during the energy boom of the late 1970s. This is not the case for public expenditures, which begin to increase significantly in the early 1980s.

While the baseline estimation equations are specifically designed to minimize potential bias created by endogeneity and reverse causality, the definition of D_i, the indicator variable that defines the treatment group, is admittedly subjective. In light of this, a variety of methods are used to assign states to the treatment group. First, the cutoff used to define the treatment group is constrained to include only the top five state oil and gas producers (in rank order: Texas, Louisiana, California, Oklahoma, New Mexico) rather than the top ten. This assures that the results are not specific to the cutoff used for the baseline estimations. Equations (1), (2) and (3) are also estimated having defined the treatment group as top five average producers of oil and gas per capita (those states in rank order or: Wyoming, Louisiana, New Mexico, Oklahoma and Texas).[9] Turning first to the results having defined the treatment group as top

[9] Models were also estimated using energy production per dollar of GDP, but the results are not reported

five oil and gas producers, the results are again quite similar to the baseline ones. Discussing the results from the estimation of equation (3) in Table 3, the coefficient on the interaction term $D_i \times \text{Oil Price}_t$ is roughly twice as large as that in the baseline specification. This implies that, for top 5 oil and gas producing states, a $1.00 increase in the price of oil results in a .11% increase in education expenditures, per capita. However, this result is not robust to defining treatment states as top five energy producers per capita. Referencing Table 4, the coefficient on the interaction term is .0005, slightly smaller than that corresponding to the baseline specification.

6 Alternative Measures of School Quality

Following the existing literature (see for example Card and Krueger, 1992), education quality is alternatively measured using 1) relative teacher salaries and 2) the student—teacher ratio. Data for each of these variables were collected from the NCES, State Comparisons of Education Statistics (1969-70 to 1996-97). This data is only available for public schools.

Relative teacher salaries are measured in two different ways. First, the average teacher salary is expressed relative to the average annual income in state i and year t. Second, average teacher salary is expressed relative to that in all non-treatment border states. For example, for this second specification, relative teacher salary in Louisiana in year t is expressed as the average teacher salary in Louisiana in year t, divided by the teacher salary averaged across both Mississippi and Arkansas, but not Texas because Texas is a treatment state. As in Card and Krueger (1992), relative teacher salaries are thought to be a better gauge of teacher quality than absolute measures as high relative wages may attract more productive labor.

All three estimation equations (1-3) are estimated for both the log-normalized relative teacher salary and the log-normalized student-teacher ratio. The results for relative teacher salary are given in Figures 15 and 16 and columns 1 and 2 of Table 5. Starting with teacher salary relative to average state income (Figure 15, panel (a)), the treatment effect starts to rise around 1972, peaks in 1986, and then falls. From panel (b) though, relative to average state income, teachers in treatment states receive about the same amount as the controls in any given year. From Figure 16, there is however evidence that, relative to average (non-treatment) border state teacher salaries, teachers in treatment states are paid more than teachers in control states. Further, the treatment effect in panel (a) of Figure 16 peaks in 1982 at about 5% (significant at the 5% confidence level), roughly coinciding with peak oil prices for that time. From panel (b) of Figure 16, governments of oil-rich states typically pay teachers more (relative to border state teacher salaries), though this result is only significant in

in the appendix because they are so similar to those produced using the per capita definition.

the early 1980s when the price of oil was unusually high. Finally, the estimation of equation (3) corroborates these findings. A \$10.00 increase in the price of oil increases the average teacher salary (relative to that in non-treatment border states) in treatment states by 0.6%. These results are generally complimented by the robustness checks that were carried out for the main set of results in section 5.

The estimated treatment effects for student-teacher ratios and given in Figure 17 and the last column of Table 5. There is no evidence that the oil price boom of the late 1970s resulted in lower teacher-student ratios in treatment states. In fact, from 1970-1979, there is little deviation in the treatment effect in either estimation equation (1) or (2). However, from 1980 to 1986, a period that coincides with the oil-price bust, the treatment effect precipitously rises. This suggests asymmetry in the public response to positive and negative oil-revenue shocks. Existing student-teacher ratios are maintained during resource booms, but they fall during resource busts. From panel (a), the treatment effect plateaus around 1986 at roughly 6%. Given that the student-teacher ratio in the average treatment state is 19, a 6% increase implies an increase of about 1.14 students per teacher.

Taken together, the alternative measures of education quality offer more of a mixed bag of evidence regarding the quality of education provided in oil-rich U.S. states. While teachers appear to be paid more in oil-rich states (relative to teachers in neighboring, non-oil-rich states), rising oil prices had little observed impact on student-teacher ratios, though falling oil prices do appear to put upward pressure on the student-teacher ratio in treatment states.

6.1 School Enrollment & Graduation Rates

According to Isenberg (2006), public schools serve as potential substitutes for both home-schooling (especially for children from relatively poor households) and private schools (especially for students from relatively wealthy households). According to this theory, given the enhanced public education spending in treatment states, public (private) K-12 school enrollment rates should be relatively high (low) in resource-rich states, especially during resource booms. This theory is tested by re-estimating all three estimation equations after replacing the dependent variable with K-12 public and private school enrollment rates. Enrollment data were collected from the Southern Regional Education Board (SREB).[10] Private school enrollment data is incomplete. Missing data points were linearly interpolated for the years 1971-1974, 1976, 1977, and 1981-1988. This data also spans the years 1970-2007, rather than 1970-2008 as with the public enrollment data.

[10]SREB enrollment data can be found here: http://www.sreb.org/post/public-pre-kindergarten-elementary-and-secondary-school-enrollment.

Alternatively, resource booms may also increase local wages, which will increase the opportunity cost of attending school for working age students (Black, McKinnish, and Sanders, 2005). According to this theory, school enrollment rates for working age individuals should decrease during resource booms. This theory is explored by replacing the dependent variable in all three estimation equations with high school graduation rates (defined as the number of high school graduates in year t relative to the number of high school seniors in year $t-1$). This data is only available for the years 1970-2003.[11]

The results for enrollment rates are given in Figure 18 and 19 and the first two columns of Table 6. There are a few interesting features of these results. The first is that the treatment effect for public school enrollment rates appears to increase in tandem with the timing of the energy boom, a result that (at first glance) seems at odds with Black, McKinnish and Sanders (2005) who find that the coal boom in Appalachia pulled young people out of school prematurely. But of course the large majority of K-12 students are not of working age. The second interesting feature of Figure 18 is that oil-rich states appear to have higher public school enrollment rates for all years, though this result is only significant during periods of especially high oil prices (the lat 1970s and early 1980s). From Figure 19, the treatment effect for private school enrollment rates is quite unresponsive to oil booms and busts. However, from panel (b) of Figure 19, private school enrollment rates are, in any given year, significantly lower in treatment states compared to control states. This compliments the earlier postulation that public education expenditures crowd out private education services. Private school spending is lower in treatment states, so perhaps it's unsurprising that private school enrollment is lower as well. According to Isenberg (2006), these results reflect the substitutability between public and private schools that is enhanced as public school quality increases.

These results are moderately complimented by the estimation of equation (3). While the treatment effects have the expected sign (that for public school enrollment rates is positive while that for private school enrollment rates is negative), both of the these results are statistically insignificant. However, the treatment effect for public school enrollment is significant at the 12.5% confidence level, and becomes significant at the 10% confidence level after defining treatment states as top per capita oil producers.

Finally, the results for graduation rates are given in Figure 20 and the last column of Table 6. While there is significant variation in the treatment effect from one year to another, in both panel (a) and (b), the treatment effect is insignificantly different from zero in every year with the exception of 1981, coinciding with peak oil prices for that time period. In fact, in 1981 the treatment effect is -5%, indicating that graduation rates were reduced by 5% as a result of the

[11] Data describing the number of high school graduates were collected from NCES Historical Tables and is available here: https://nces.ed.gov/surveys/annualreports/historicaltables.asp.

booming oil industry in treatment states. From the last column of Table 6, a $10.00 increase in the price of oil results in a 0.3% decrease in the graduation rate in treatment states.

Taken together, these results indicate that public schools are relatively well funded in oil-rich U.S. states and that this is especially the case during the oil-price boom of the late 1970s and early 1980s. There is additional evidence that teachers in oil-rich states are paid relatively well, which in theory should attract more capable and productive educators. Consistent with the prediction of Isenberg (2006), the resulting high level of public school quality in oil-rich states appears to have attracted students away from private schools, and perhaps also from homeschooling as well. Though, there is evidence that booming resource sectors cause graduation rates to fall, likely reflecting rising local wages which increase the opportunity cost of remaining in school.

7 Conclusion

Existing development literature argues that natural resources may impede economic growth and development by reducing expenditures on education (Gylfason, 2001; Papyrakis and Gerlagh, 2007). This paper builds upon this earlier work by focusing on the relationship between natural resources and both private and public education expenditures. Alternative measures of educaiton quality are also explored, namely, relative teacher salaries and student-teacher ratios. A broader set of education outcomes are also considered including public and private school enrollment rates and high school graduation rates.

Natural resources fuel public education expenditures and private expenditures are imperfectly crowded out as a result. Averaged from 1970 to 2008, total per capita education expenditures were about 8% greater in resource-rich states compared to resource-poor ones. And this effect is amplified during periods in which the price of energy is high. In 1984, for example, total education spending per capita in resource-rich states was nearly 20% greater than in resource-poor ones. There is also evidence that teachers in oil-rich U.S. states are paid more than teachers in bordering, oil-poor states. However, student-teacher ratios, another postulated proxy of school quality, appears to have been unaffected by the oil boom, and increased during the subsequent oil-price bust of the early 1980s. There is evidence that the additional public school funding attracted students away from private schools (perhaps reflecting high public school quality); public (private) school enrollment rates are significantly higher (lower) in oil-rich U.S. states. However, there is also evidence that booming oil sectors (that may raise local wages and increase the opportunity cost of going to school) incentivize working-age students to drop out of school prematurely (a result consistent with the findings of Black, McKinnish and Sanders, 2005).

Having documented a robust positive relationship between resource wealth and public education expenditures, one may naturally wonder whether the added spending had any observable effect on learning or labor market outcomes. Linking oil wealth to things like standardized test scores, college enrollment rates, and labor market outcomes such as unemployment rates and lifetime earnings are important areas of future research. Expanding this analysis to the international level is also an important step (though some work has already been done in this area, see for example Stijns, 2005). Institutional quality (which varies more widely across countries than across U.S. states) may be an important factor to consider when applying this methodology to the international scene.

8 References

Auty, Richard M. (1990). Resource-based industrialization: Sowing the oil in eight developing countries. Oxford: Clarendon Press.

Bhattacharyya, Sambit and Roland Hodler. (2010). Natural resources, democracy and corruption. *European Economic Review*, 54, 608-621.

Brunnschweiler, C. and Bulte, E. (2008). The resource curse revisited and revised: a tail of paradoxes and red herrings. *Journal of Environmental Economics and Management*, 55, 248-264.

Black, D., McKinnish, T., and Sanders, S. (2005). Tight labor markets and the demand for education: Evidence from teh coal boom and bust. *Indus. & Lab. Rev.* 59, 3.

Card, D. and Abigail Payne. (2002). School finance reform, the distribution of school spending, and the distribution of student test scores. *Journal of Public Economics*, 83(1), 49-82.

Card, D. and Alan Krueger. (1992). Does school quality matter? Returns to education and the characteristics of public schools in the United States. *The Journal of Political Economy*, 100(1), 1-40.

Chaudhary, Latika. (2009). Education inputs, student performance and school finance reform in Michigan. *Economics of Education Review*, 28, 90-98.

Collier, P. and Hoeffler, A. (1998). On economic causes of civil war. *Oxford Economic Papers*, 56, 563-595.

Corden, M. Nearly, P. (1982). Booming sector and deindustrialization in a small open economy. *The Economic Journal*, 92, 825-848.

Davis, G. (2011). The resource drag. *International Economics and Economic Policy*, 8(2), 155-176.

De Haan, Monique. (2012). The effect of additional funds for low-ability pupils—a nonparametric bounds analysis. CESifo.

Gylfason, T. (2001). Natural resources, education and economic development, *European Economic Review*, 45, 847-859.

Hanushek, Eric, and Dennis Kimko. (2000). Schooling, labor-force quality, and the growth of nations. *American Economic Review*, 1184-1208.

Holmlund, Helena, Sandra McNally and Martina Viarengo. (2010). Does money matter for schools? *Economics of Education Review*, 29(6), 1154-1164.

Isenberg, E. (2006). The choice of public, private, or home schools (Occasional Paper No. 132). New York: National Center for the Study of Privatization in Education, Teachers, College, Columbia University.

Jackson, Kirabo, Rucker Johnson and Claudia Persico. (2015). The effects of school spending on educational and economic outcomes: Evidence from school finance reforms. No. w20847. National Bureau of Economic Research.

James, A., Aadland, D. (2010). The curse of natural resources: an empirical investigation of U.S. counties. *Resource and Energy Economics*, 33(2), 440-453.

Matsuyama, K. (1992). Agricultural productivity, comparative advantage, and economic growth. *Journal of Economic Theory*, 58, 317-334.

Mehlum, H., Moene, K., Torvik, R. (2006). Institutions and the resource curse. *Economic Journal*, 116, 1-20.

Michaels, G. (2011). The long term consequences of resource-based specialization. *The Economic Journal*, 121(551), 31-57.

Papke, Leslie. (2005). The effects of spending on test pass rates: evidence from Michigan. *Journal of Public Economics*, 89, 821-839.

Papyrakis, E. and Gerlagh, R. (2007). Resource abundance and economic growth in the U.S. *European Economic Review*, 51(4), 1011-1039.

Ross, M.L. (1999). The political economy of the resource curse. *World Politics*, 51, 297-322.

Sachs, J.D. and Warner, A.M. (1995). Natural resource abundance and economic growth. *National Bureau of Economic Research* Working Paper No. 5398.

Sachs, J.D. and Warner, A.M. (1999). The big push, natural resource booms and growth. *Journal of Development Economics*, 59, 43-76.

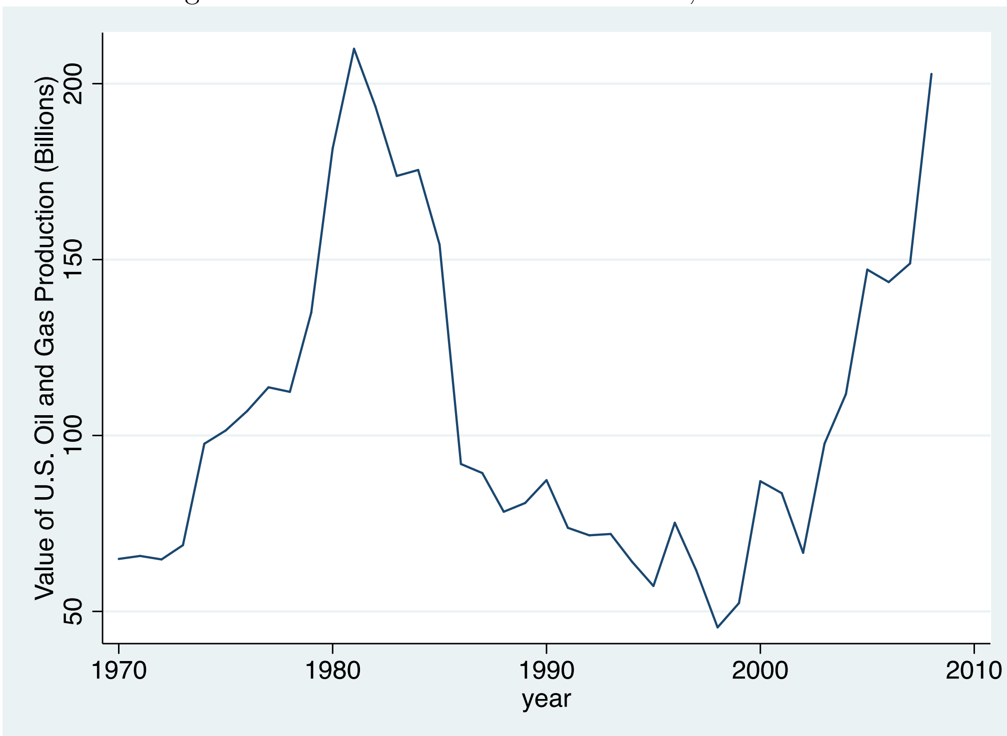
Sachs, J.D. and Warner, A.M. (2001). The curse of natural resources. *European Economic Review*, 45, 827-838.

Smith, Brock. (2013). The resource curse exorcised: Evidence from a panel of countries. No. 13-3. Working Papers, University of California, Department of Economics.

Stijns, Jean-Philippe. (2005). Natural resource abundance and human capital accumulation." *World Development*, 34(6), 1060-1083.

Walker, Anne. (2013). An Empirical Analysis of the Resource Curse Channels in the Appalachian Region. *Morgantown, WV, West Virginia University.*

Figure 1: U.S. Oil and Gas Production, 1970 - 2008



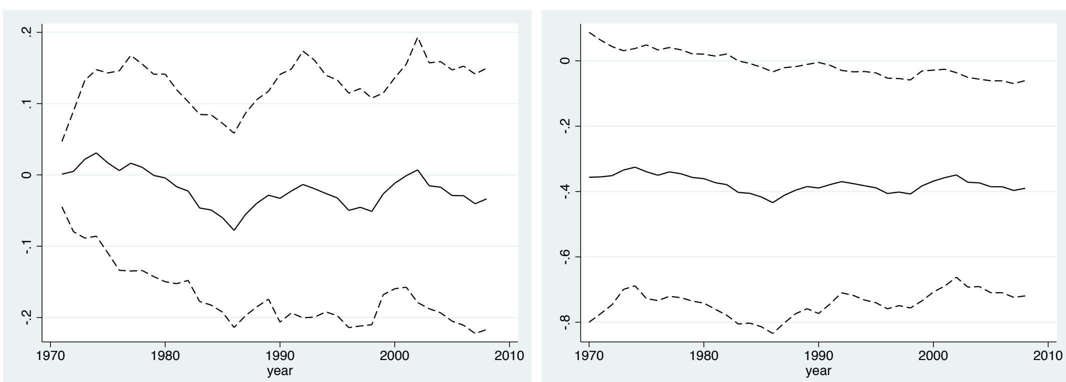
Note: Production and price data were taken from the Energy Information Administration. Oil prices reflect crude, first purchase prices. Natural gas prices reflect well head prices. Nominal prices were converted to real using the CPI and the base year is 2000.

Figure 2: Public Education Expenditures

(a) Relative Treatment Effects (b) Annual Treatment Effects

Note: Panel (a) gives the results from the estimation of $\beta_{t,1}$ in equation (1) which includes state and year fixed effects. Panel (b) give the results from the estimation of $\beta_{t,2}$ in equation (2) and includes year fixed effects. Both treatment effects are maximized in 1984. The dependent variable is the natural log of public education expenditures per capita. 5% confidence intervals are given. For both panels $N = 1872$. For Panel (a), $R^2 = .898$, for Panel (b), $R^2 = .587$.

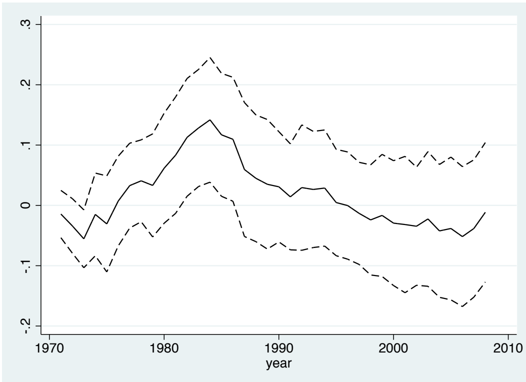
Figure 3: Private Education Expenditures



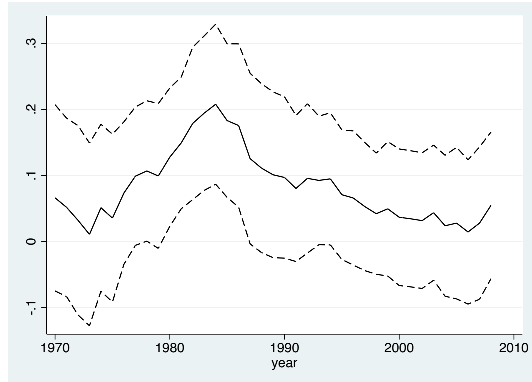
(a) Relative Treatment Effects (b) Annual Treatment Effects

Note: Panel (a) gives the results from the estimation of $\beta_{t,1}$ in equation (1) which includes state and year fixed effects. Panel (b) give the results from the estimation of $\beta_{t,2}$ in equation (2) and includes year fixed effects. The dependent variable is the natural log of private education expenditures per capita. 5% confidence intervals are given. For both panels, $N = 1872$. For Panel (a), $R^2 = .982$, for Panel (b), $R^2 = .294$.

Figure 4: Total Education Expenditures



(a) Relative Treatment Effects



(b) Annual Treatment Effects

Note: Panel (a) gives the results from the estimation of $\beta_{t,1}$ in equation (1) which includes state and year fixed effects. Panel (b) give the results from the estimation of $\beta_{t,2}$ in equation (2) and includes year fixed effects. The dependent variable is the natural log of private and public education expenditures per capita. 5% confidence intervals are given. For both panels, $N = 1872$. For Panel (a), $R^2 = .917$, for Panel (b), $R^2 = .657$.

Table 1: Estimation of equation (3)

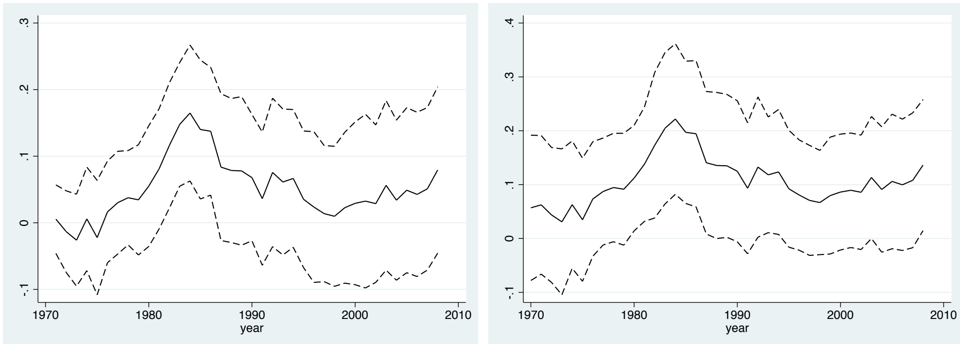
	Public	Private	Total
$D_i \times$ Oil Price	.0007**	.0000	.0007**
	(.0003)	(.0004)	(.0003)
R^2	.894	.982	.912
N	1,872	1,872	1,872

Note. *,**,*** correspond to 10%, 5% and 1%, respectively. Standard errors are clustered at the state level and are given in parenthesis below the coefficient estimates. "Public" corresponds to state-level education expenditures per capita. "Private" corresponds to private-sector education expenditures per capita. "Total" corresponds to state and private education expenditures per capita. State and year fixed effects are included in all regressions.

9 Appendix: Results from Robustness Checks

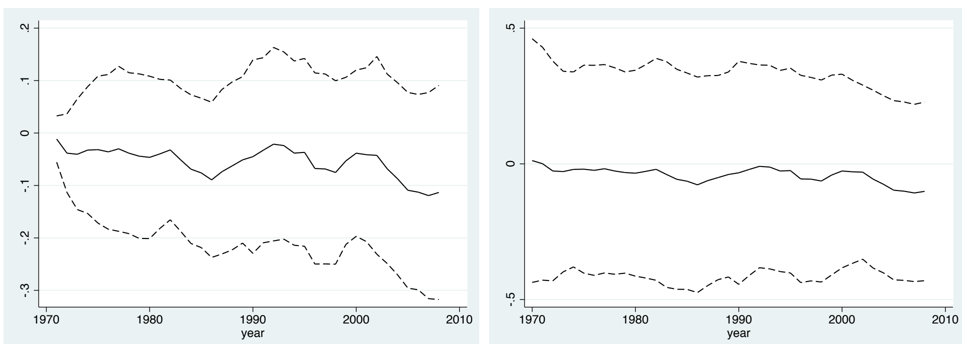
Figure 5: U.S. Regions

Figure 6: Public Edu. Exp. with (with year × region FE)



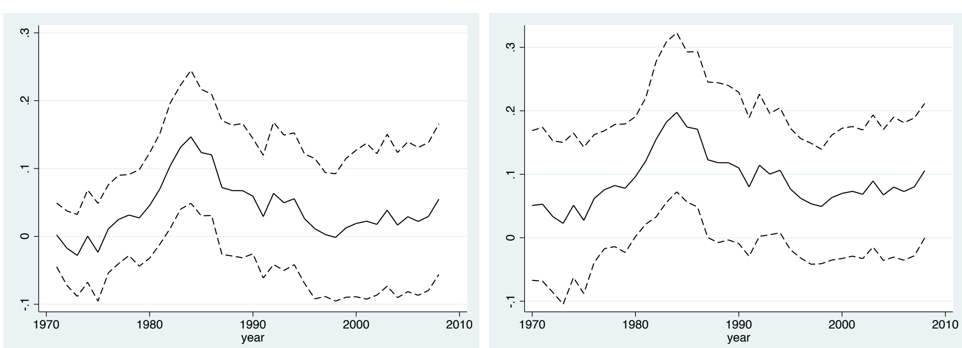
(a) Relative Treatment Effects (b) Annual Treatment Effects

Figure 7: Private Edu. Exp. with (with year × region FE)



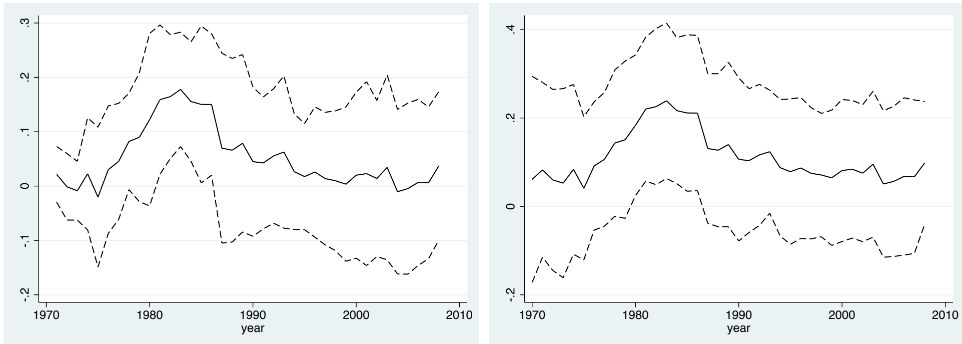
(a) Relative Treatment Effects (b) Annual Treatment Effects

Figure 8: Total Edu. Exp. with (with year × region FE)



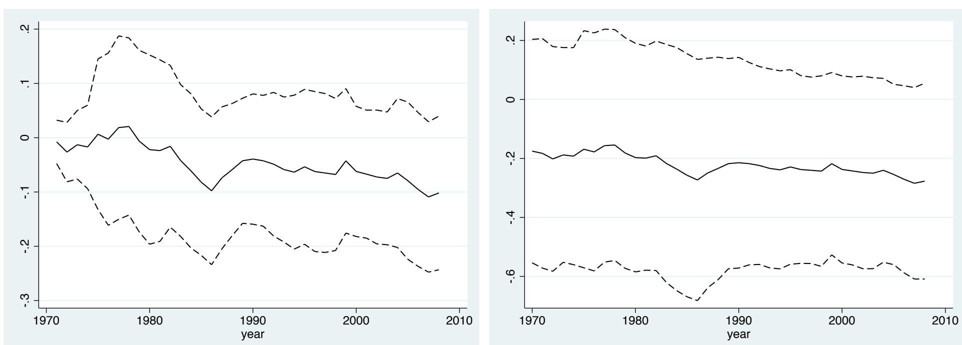
(a) Relative Treatment Effects (b) Annual Treatment Effects

Figure 9: Public Edu. Exp. (Top 5 Oil and Gas Producers)



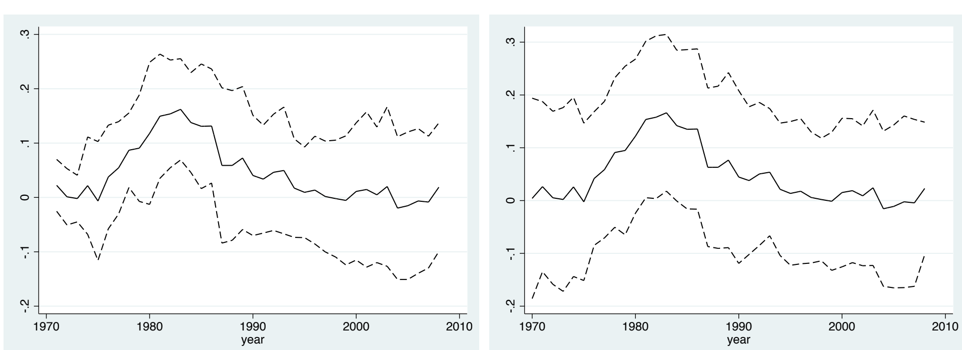
(a) Relative Treatment Effects (b) Annual Treatment Effects

Figure 10: Private Edu. Exp. (Top 5 Oil and Gas Producers)



(a) Relative Treatment Effects (b) Annual Treatment Effects

Figure 11: Total Edu. Exp. (Top 5 Oil and Gas Producers)

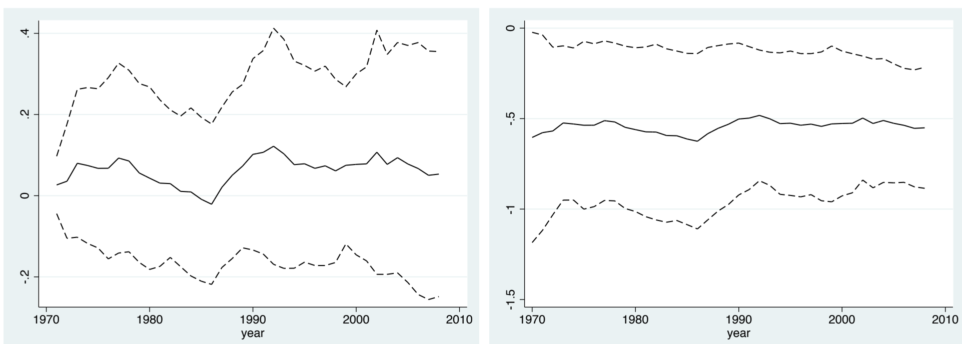


(a) Relative Treatment Effects (b) Annual Treatment Effects

Figure 12: Public Edu. Exp. (Top 5 Oil and Gas Producers Per Capita)

(a) Relative Treatment Effects (b) Annual Treatment Effects

Figure 13: Private Edu. Exp. (Top 5 Oil and Gas Producers Per Capita)

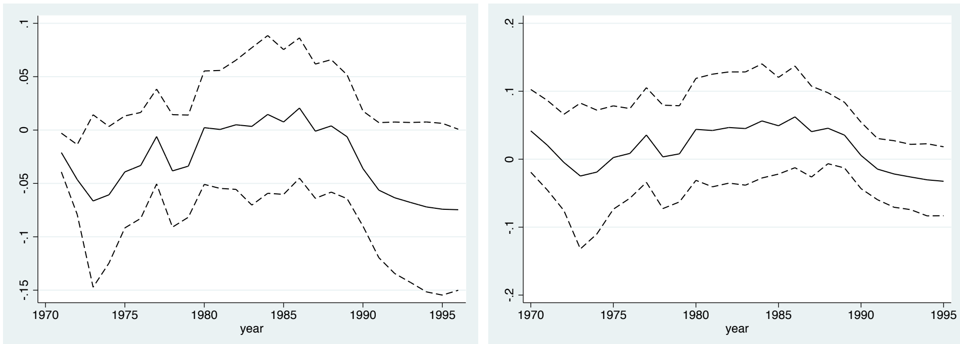


(a) Relative Treatment Effects (b) Annual Treatment Effects

Figure 14: Total Edu. Exp. (Top 5 Oil and Gas Producers Per Capita)

(a) Relative Treatment Effects (b) Annual Treatment Effects

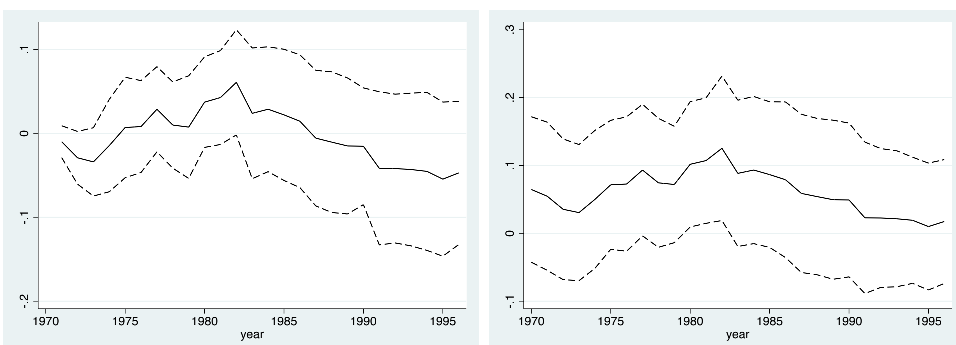
Figure 15: Teacher Salary Relative to Average State Income



(a) Relative Treatment Effects (b) Annual Treatment Effects

Note: Panel (a) gives the results from the estimation of $\beta_{t,1}$ in equation (1) which includes state and year fixed effects. Panel (b) give the results from the estimation of $\beta_{t,2}$ in equation (2) and includes year fixed effects. Both treatment effects are maximized in 1986. The dependent variable is the natural log of the average K-12 teacher salary relative to average state annual income. 5% confidence intervals are given. For both panels $N = 1,296$. For Panel (a), $R^2 = .862$, for Panel (b), $R^2 = .551$.

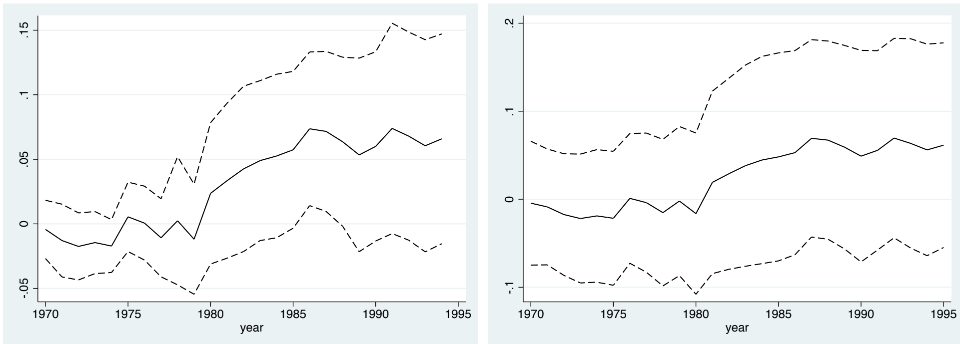
Figure 16: Teacher Salary Relative to Border State Teacher Salary



(a) Relative Treatment Effects (b) Annual Treatment Effects

Note: Panel (a) gives the results from the estimation of $\beta_{t,1}$ in equation (1) which includes state and year fixed effects. Panel (b) give the results from the estimation of $\beta_{t,2}$ in equation (2) and includes year fixed effects. Both treatment effects are maximized in 1982. The dependent variable is the natural log of the average K-12 teacher salary relative to that averaged across all bordering states. 5% confidence intervals are given. For both panels $N = 1,296$. For Panel (a), $R^2 = .828$, for Panel (b), $R^2 = .012$.

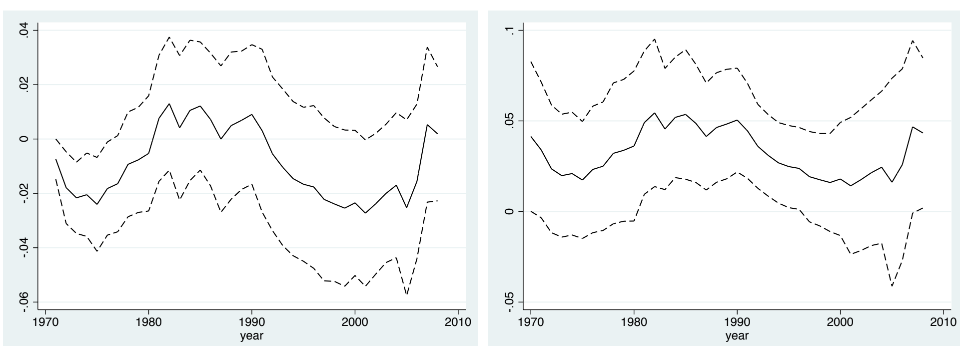
Figure 17: Public Student-Teacher Ratio



(a) Relative Treatment Effects (b) Annual Treatment Effects

Note: Panel (a) gives the results from the estimation of $\beta_{t,1}$ in equation (1) which includes state and year fixed effects. Panel (b) give the results from the estimation of $\beta_{t,2}$ in equation (2) and includes year fixed effects. The dependent variable is the natural log of publically enrolled students relative to the number of public K-12 school teachers. 5% confidence intervals are given. For both panels $N = 1,248$. For Panel (a), $R^2 = .921$, for Panel (b), $R^2 = .426$.

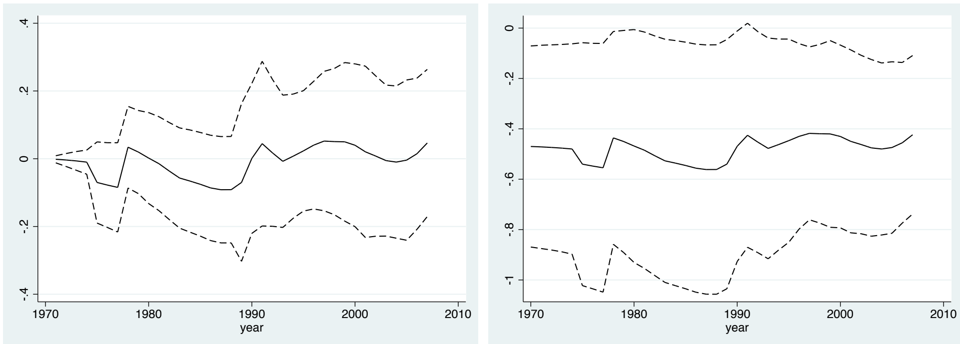
Figure 18: Public Enrollment Rates



(a) Relative Treatment Effects (b) Annual Treatment Effects

Note: Panel (a) gives the results from the estimation of $\beta_{t,1}$ in equation (1) which includes state and year fixed effects. Panel (b) give the results from the estimation of $\beta_{t,2}$ in equation (2) and includes year fixed effects. The dependent variable is the natural log of publically enrolled K-12 students relative to the state population aged 5-19 years old. 5% confidence intervals are given. For both panels $N = 1,872$. For Panel (a), $R^2 = .798$, for Panel (b), $R^2 = .280$.

Figure 19: Private Enrollment Rates

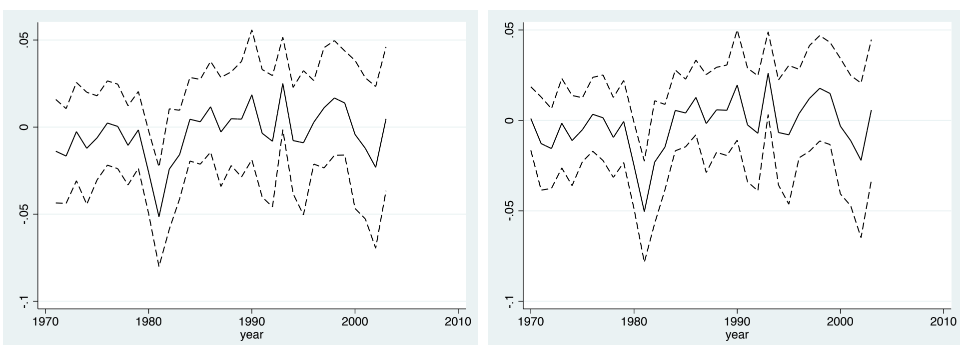


(a) Relative Treatment Effects

(b) Annual Treatment Effects

Note: Panel (a) gives the results from the estimation of $\beta_{t,1}$ in equation (1) which includes state and year fixed effects. Panel (b) give the results from the estimation of $\beta_{t,2}$ in equation (2) and includes year fixed effects. The dependent variable is the natural log of privately enrolled K-12 students relative to the state population aged 5-19 years old. 5% confidence intervals are given. For both panels $N = 1,824$. For Panel (a), $R^2 = .904$, for Panel (b), $R^2 = .184$.

Figure 20: Public Graduation Rates



(a) Relative Treatment Effects

(b) Annual Treatment Effects

Note: Panel (a) gives the results from the estimation of $\beta_{t,1}$ in equation (1) which includes state and year fixed effects. Panel (b) give the results from the estimation of $\beta_{t,2}$ in equation (2) and includes year fixed effects. Both treatment effects are maximized in 1982. The dependent variable is the natural log of public high school graduates in year t relative to the number of public high school seniors in year $t-1$. 5% confidence intervals are given. For both panels $N = 1632$. For Panel (a), $R^2 = .559$, for Panel (b), $R^2 = .224$.

Table 2: Est. of eq'n (3) (with year × region FE)

	Public	Private	Total
D_i × Oil Price	.0007**	-.0004	.0006**
	(.0003)	(.0005)	(.0003)
R^2	.909	.983	.926

Note. Errors are clustered at the state level. *,**,*** correspond to 10%, 5% and 1%, respectively. Standard errors are clustered at the state level and are given in parenthesis below the coefficient estimates. Year × region fixed effects are included in all three regressions as well as year and state fixed effects. For all regressions the sample size is 1,872.

Table 3: Est. of eq'n (3) (Top 5 Oil and Gas Producers)

	Public	Private	Total
D_i × Oil Price	.0011***	.0000	.001***
	(.0003)	(.0005)	(.0002)
R^2	.894	.982	.912

Note. Errors are clustered at the state level. *,**,*** correspond to 10%, 5% and 1%, respectively. Standard errors are clustered at the state level and are given in parenthesis below the coefficient estimates. Year and state fixed effects are included in all regressions. For all regressions the sample size is 1,872.

Table 4: Est. of eq'n (3) (Top 5 Oil and Gas Producers Per Capita)

	Public	Private	Total
D_i × Oil Price	.0005*	-.0003	.0005**
	(.0002)	(.0004)	(.0002)
R^2	.894	.982	.912

Note. Errors are clustered at the state level. *,**,*** correspond to 10%, 5% and 1%, respectively. Standard errors are clustered at the state level and are given in parenthesis below the coefficient estimates. Year and state fixed effects are included in all regressions. For all regressions the sample size is 1,872.

Table 5: Alternative Measures of Education Quality

	Teacher Salary 1	Teacher Salary 2	Student-Teacher Ratio
$D_i \times$ Oil Price	.0005	.0006*	-.0003**
	(.0004)	(.0003)	(.0001)
R^2	.856	.827	.913
N	1,296	1,296	1,248

Note. *,**,*** correspond to 10%, 5% and 1%, respectively. Standard errors are clustered at the state level and are given in parenthesis below the coefficient estimates. Teacher Salary 1 is defined as average K-12 teacher salary in state i relative to average income in state i. Teacher Salary 2 is defined as average K-12 teacher salary in state i relative to the average K-12 teacher salary in all states bordering state i.

Table 6: Education Attainment

	Pub Enr Rates	Pri Enr Rates	Grad Rates
$D_i \times$ Oil Price	.0002	-.0004	-.0003**
	(.0001)	(.0009)	(.0001)
R^2	.790	.903	.549
N	1,872	1,824	1,632

Note. *,**,*** correspond to 10%, 5% and 1%, respectively. Standard errors are clustered at the state level and are given in parenthesis below the coefficient estimates. State and year fixed effects are included in all regressions. Pub Enr Rates is defined as the total number of public K-12 students relative to the population aged 5-19. Pri Enr Rates is defined the same way except for private school students only. Grad Rates is defined as the number of graduates in year t relative to the number of seniors in year $t-1$.