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

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March 24, 2015

**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. More generally, this paper highlights the importance of exploiting both spatial and temporal variation in resource wealth when studying resource-rich economies.

*Keywords:* Natural Resources, Education, Public Policy, 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, ultimately leading to a decline in the stock of human capital.

Analyzing a cross-section of countries, Gylfason (2001) documents a negative unconditional relationship between resource dependence and education expenditures and specifically argues that[1]:

> *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.*

Other studies that have utilized sub-national data have provided a mixed bag of evidence. Using county-level data from the southern United States, Michaels (2011) finds some evidence that oil discoveries are associated with a more educated labor force in the long run (measured as the share of the population with a college degree). Black, McKinnish and Sanders (2005) study the Appalachian coal boom and find that high school enrollment rates in Kentucky and Pennsylvania declined in the 1970s and increased in the 1980s as the coal boom subsided.

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.[2] They go on to say that "The schooling variable has the most significant

[1]See also Stijns (2005) who, using cross sections of international data, documents a negative relationship between resource dependence and education expenditures that is sensitive to the definition of resource dependence. 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.

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

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. 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 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.

## 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:

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

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 $t$. 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. In light of 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. Specifically, variations of equation (2) below are estimated:

$$\ln(\frac{E_{i,t}}{\text{Pop}_{i,t}}) = \alpha_2 + \sum_{t=1970}^{2008} \beta_{t,2}(Z_t \times D_i) + Z_t + \epsilon_{i,t,2}. \tag{2}$$

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

$$\ln(\frac{E_{i,t}}{\text{Pop}_{i,t}}) = \alpha_3 + \beta_3 D_i + \beta_4 \text{Oil Price}_t + \beta_5(D_i \times \text{Oil Price}_t) + \epsilon_{i,t,3}. \tag{3}$$

The direct and time-invariant effect of being a major oil producer is captured by $\beta_3$ while the effect of changes in the oil price that is not state specific is captured by $\beta_4$. The coefficient

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

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. State and year fixed effects are omitted to ease the interpretation of $\beta_3$ and $\beta_4$ but of course these omissions do not influence the estimate of $\beta_5$ given the inclusion of both $D_i$ and $\text{Oil Price}_t$.

# 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. 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 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.[4] The value of energy

[4]The price of oil is defined as the domestic first-purchase price of crude oil and the price of gas is defined

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. It is interesting to note that the treatment effect begins to increase again around 2007, likely reflecting additional government revenue generated from hydraulic fracturing.

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.

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 quite 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 provision of public education services but the effect is statistically insignificant. Turning to the annual treatment effect (Figure 3b),

as the well-head natural gas price.

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, recall that 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. Starting with the examination of public education expenditures, the direct effect of being a key energy producer, $D_i$, enters positive (.134) and is significant at the 5% confidence level. Oil $\text{Price}_t$ enters negative (-.0005) and significant implying that an increase in the price of oil increases public education spending across all types of states. However, attributing this entire effect to oil price fluctuations is likely misguided as spurious correlations between Oil $\text{Price}_t$ and unobserved factors, like business cycles for example, may bias this result. The interaction of $D_i$ and Oil $\text{Price}_t$ enters positive (.0007) and is significant at the 5% confidence level. This implies that a \$1.00 increase in the price of oil induces a .07% increase in public education spending per capita.

Turning now to the results for private education services, the coefficient on $D_i$ is negative (-.377) and significant. This supports the idea that private education spending is crowded out by public spending. Similar to the results for public education spending, Oil $\text{Price}_t$ enters negative and significant. The interaction of $D_i$ and Oil $\text{Price}_t$ enters positive, but is small (.00001) and insignificant. This suggests that any crowding-out effect is captured by the time invariant effect of being resource rich ($D_i$) and changes in the price of oil do not significantly affect private education spending within resource-rich states.

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, $D_i$ enters positive (.047) but is insignificant. Similar to the results for public spending, the interaction term enters positive (.0007) and is significant at the 5% confidence level. For oil prices above the period average ($46.00 using 2000 prices), total spending on education in oil-rich states significantly exceeds that in oil-poor ones: $.047 + .0007 \times \$46.00 = 7.8\%$, $p$-value = .096.

## 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, economic recessions and booms 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. Public—and as a result total—education expenditures begin to rise in the early 2000s, perhaps reflecting early effects of hydraulic fracturing.

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).[5] Turning first to the results having defined the treatment group as top 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

[5]Models were also estimated using energy production per dollar of GDP, but the results are not reported in the appendix because they are so similar to those produced using the per capita definition.

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 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 considering the relationship between natural resources and total (private and public) education expenditures and further exploits both spatial and temporal variation in the data.

Contrary to existing conventional wisdom, 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. Applying this methodology—or a similar one that exploits both spatial and temporal data—to the international level may be a fruitful area of future research.

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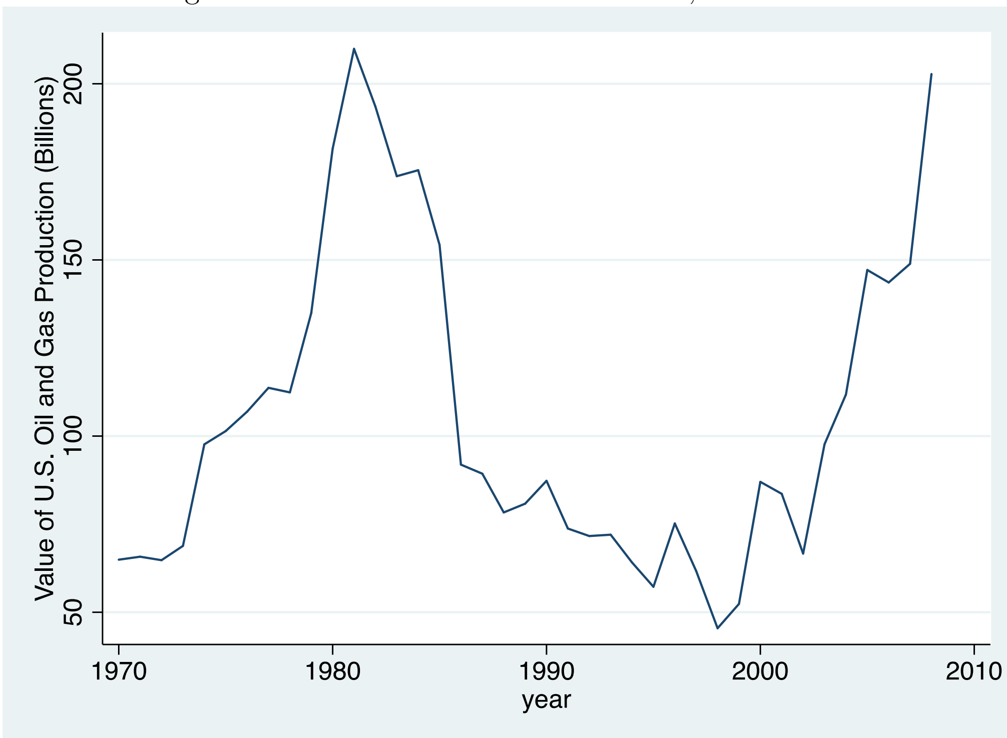
Figure 1: U.S. Oil and Gas Production, 1970 - 2008




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.

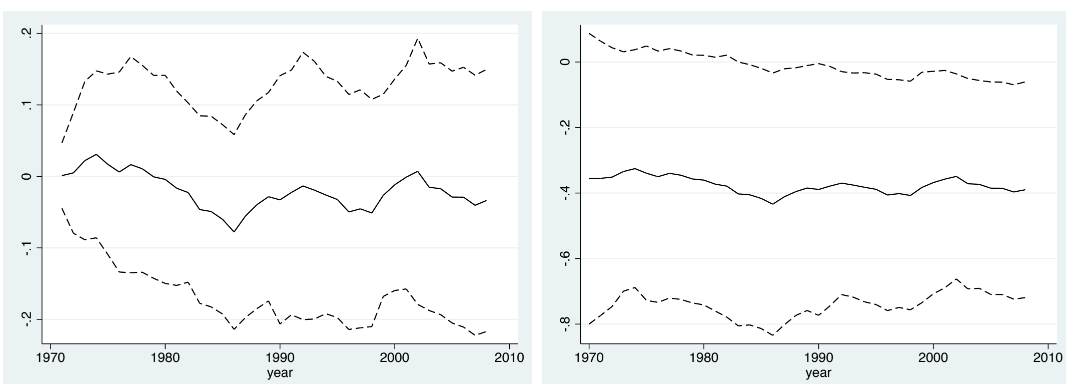
Figure 2: Public Education Expenditures


(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

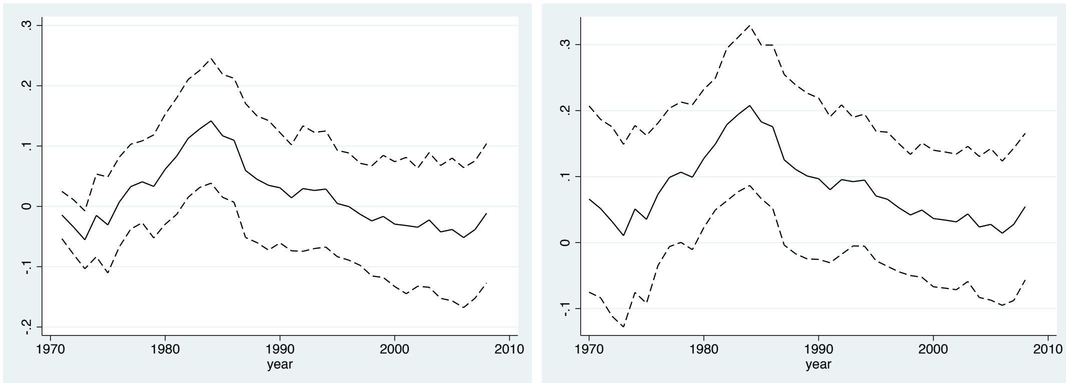



(a) Relative Treatment Effects

(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)

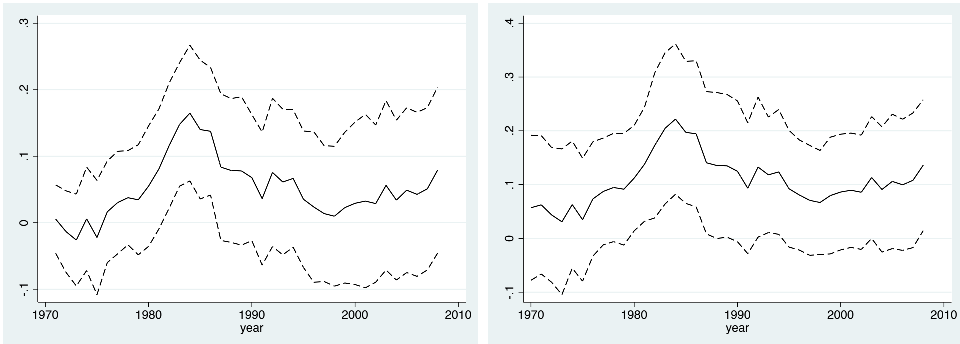
| | Public | Private | Total |
|---|---|---|---|
| $D_i$ | .134** | -.377** | .047 |
| | (.060) | (.176) | (.052) |
| Oil Price | -.0005*** | -.0018*** | -.0007*** |
| | (.0001) | (.0002) | (.0001) |
| $D_i$ × Oil Price | .0007** | .00001 | .0007** |
| | (.0003) | (.053) | (.0003) |
| $R^2$ | .051 | .087 | .011 |

**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. $D_i$ identifies the top ten average oil and gas producers.

# 8 Appendix: Results from Robustness Checks

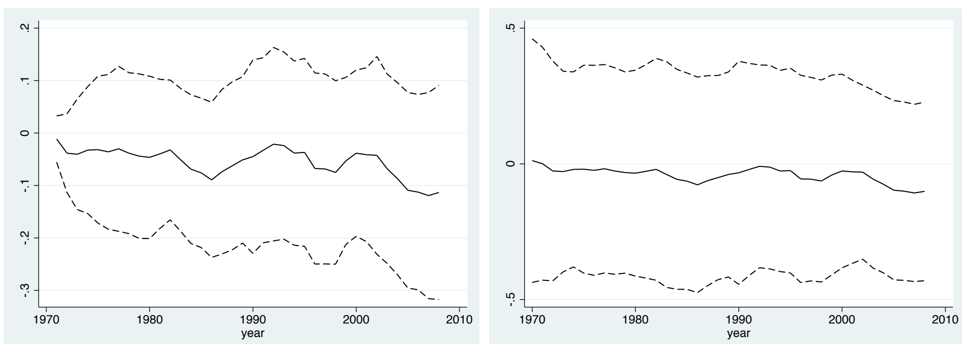
Figure 5: U.S. Regions

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



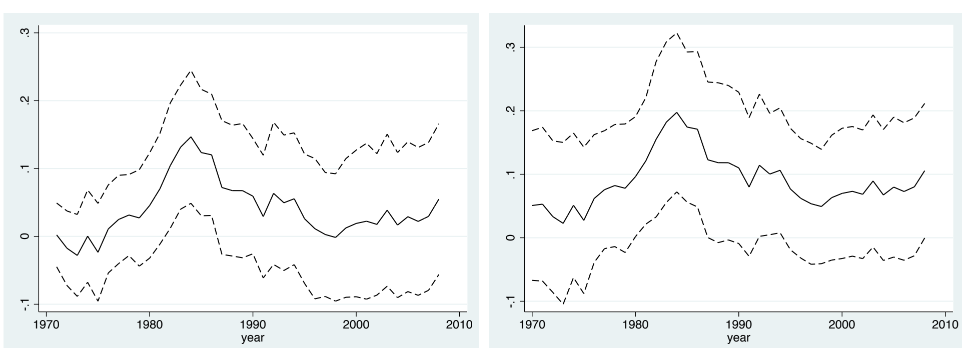

(a) Relative Treatment Effects (b) Annual Treatment Effects

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



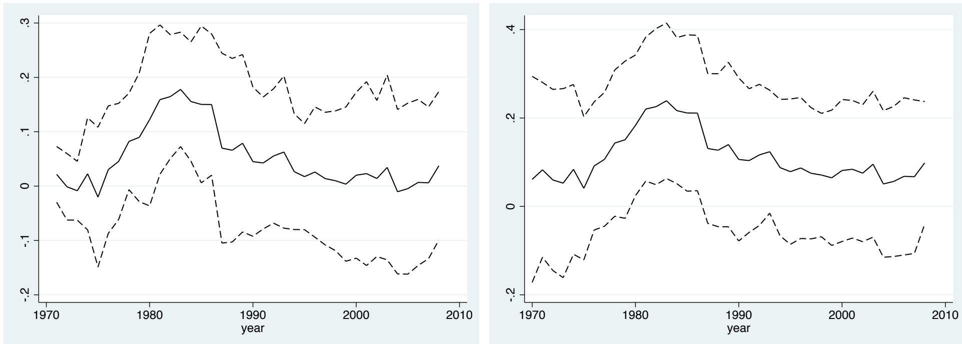

(a) Relative Treatment Effects (b) Annual Treatment Effects

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




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

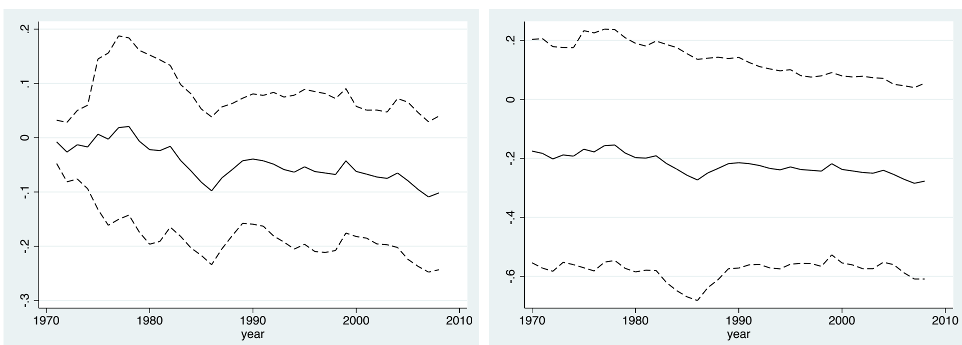
Figure 9: Public Edu. Exp. (Top 5 Oil and Gas Producers)




(a) Relative Treatment Effects

(b) Annual Treatment Effects

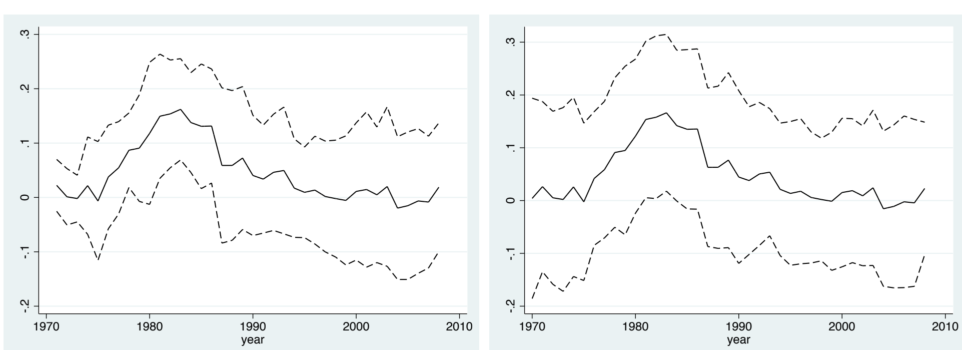
Figure 10: Private Edu. Exp. (Top 5 Oil and Gas Producers)




(a) Relative Treatment Effects

(b) Annual Treatment Effects

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




(a) Relative Treatment Effects

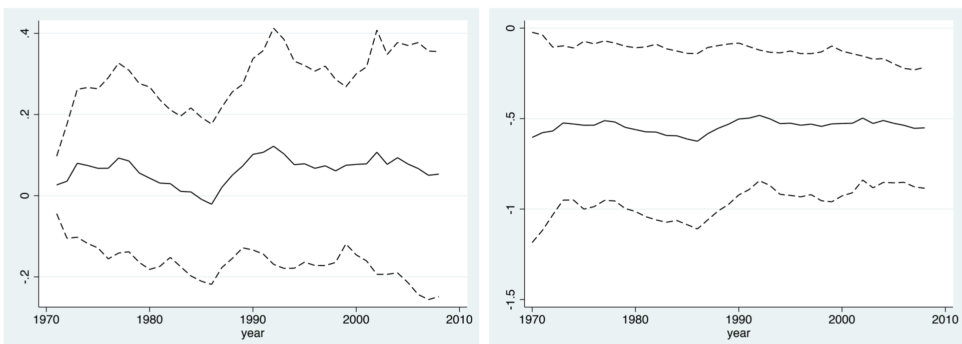
(b) Annual Treatment Effects

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

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

| | Public | Private | Total |
|---|---|---|---|
| $D_i$ | .0791 | -.0604 | .0591 |
| | (.0489) | (.1825) | (.0456) |
| Oil Price | .0006* | -.0020*** | .0002 |
| | (.0003) | (.0006) | (.0003) |
| $D_i \times$ Oil Price | .0006 | .0001 | .0006* |
| | (.0004) | (.0005) | (.0004) |
| $R^2$ | .451 | .567 | .488 |

**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. $D_i$ identifies the top ten average oil and gas producing states. Year × region fixed effects are included in all three regressions.

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

| | Public | Private | Total |
|---|---|---|---|
| $D_i$ | .0610 | -.2230 | -.0014 |
| | (.0798) | (.1645) | (.0659) |
| Oil Price | -.0004*** | -.0018*** | -.0007*** |
| | (.0001) | (.0002) | (.0001) |
| $D_i \times$ Oil Price | .0011*** | .00002 | .0011*** |
| | (.0003) | (.0005) | (.0003) |
| $R^2$ | .014 | .013 | .005 |

**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. $D_i$ identifies the top 5 average oil and gas producing states.

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

| | Public | Private | Total |
|---|---|---|---|
| $D_i$ | .1288 | -.5280** | .0343 |
| | (.0921) | (.2085) | (.0735) |
| Oil Price | -.0004** | -.0018*** | -.0006*** |
| | (.0001) | (.0002) | (.0001) |
| $D_i \times$ Oil Price | .0005* | -.0003 | .0005** |
| | (.0002) | (.0004) | (.0002) |
| $R^2$ | .024 | .062 | .006 |

**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. $D_i$ identifies the top 5 average per capita oil and gas producing states.