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Is shale development drilling holes in the human capital pipeline?

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ABSTRACT

Using the Synthetic Control Method (SCM) and a novel method for measuring changes in educational attainment we examine the link between educational attainment and shale oil and gas extraction for the states of Montana, North Dakota, and West Virginia. The three states examined are economically-small, relatively more rural, and have high levels of shale oil and gas reserves. They also are varied in that West Virginia is intensive in shale gas extraction, while the other two are intensive in shale oil extraction. We find significant reductions in high school and college attainment among all three states' initial residents because of the shale booms.

1. Introduction

The intensive development of U.S. shale oil and gas resources through hydraulic fracturing (fracking) that began in earnest after 2005 dramatically increased employment and income in many state and local economies (Weber, 2012; Brown, 2014; Weinstein, 2014; Munasib and Rickman, 2015). Development of shale oil and gas resources in the lower 48 states largely drove the 35 percent increase in dry natural gas and the nearly 44 percent increase in oil production from 2005 to 2013 in the nation (U.S. Energy Information Administration, 2015). Despite numerous U.S.-based studies regarding whether areas intensive in the extraction of resources have lower long-run growth because of corresponding lower human capital, as measured by educational attainment of the labor force (Black et al., 2005; Papyrakis and Gerlagh, 2007; Michaels, 2011; Walker, 2013; Haggerty et al., 2014; Morrissette et al., 2015), little attention has been given to the effects of shale oil and gas development on educational attainment.[1]

With projections of significant long-run increases in shale oil and gas production in the U.S. (U.S. Energy Information Administration, 2015), adverse effects on human capital formation in areas rich with shale oil and gas could harm their long-run economic growth and development. Economic opportunities provided by the shale boom to younger, lesser educated workers, may cause them to drop out of high school or forego attending college; increased availability of higher paying shale oil and gas jobs increases the opportunity costs of education. Yet, the booms and busts inherent in the energy industry may cause the decision to forego education to be costly to the individual and overall economy in the long run. As Benhabib and Spiegel (1994, p. 144) state "an educated labor force is better at creating, implementing, and adopting new technologies, thereby generating growth."

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[1] Educational attainment of the labor force routinely has been used as a measure of human capital in assessing its contribution to economic growth and development (e.g., Benhabib and Spiegel, 1994; Hanuschek, 2015). This assumes that differences in educational attainment translate into differences in human capital that affect growth and development, though there also can be cognitive and noncognitive skills not reflected in educational attainment that are part of human capital (Hanuschek, 2015).

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In the only published study on the effects of fracking on educational attainment in the U.S., Weber (2014) examines 362 nonmetropolitan counties of Arkansas, Louisiana, Oklahoma, and Texas. Census 2000 provided the beginning-period estimates of educational attainment, while the average over 2007–2011 from the American Community Survey provided the ending-period educational attainment estimates. Weber estimated that increased shale gas production in these counties reduced the number of high school dropouts in the counties, increased the number of high school graduates by more than their population proportions, and increased the number of people with some college or graduated college in line with their corresponding population proportions. Weber did not find any spillover effects across counties. The study did not address the effects of shale oil production.

In a working paper, Cascio and Narayan (2015) examine the effects of fracking on high school dropout rates on local labor markets across the lower 48 states of the U.S. Local labor markets are defined as commuting zones, while data for the period of analysis come from the 2000 Census and the 2005–2013 American Community Surveys. They focus on high school dropout rates for 15- to 18-year olds to remove the potential effects of migration of educational cohorts on educational attainment in the local area. High school dropouts of male teens are found to increase in areas with higher per capita shale oil and gas reserves relative to areas with lower reserves in the same state; the high school dropout rates of females were not found to have been affected, consistent with the belief that shale oil and gas extraction primarily affected the demand for low-educated males. They did not examine college enrollment and the focus on high school dropouts precludes estimating longer term effects on educational attainment.

In this study we employ novel methods of measuring educational attainment and constructing counterfactuals to further examine the link between fracking and high school and college attainment of the affected area. First, we use educational attainment of the native born population. This removes the effect of in-migration on area educational attainment (Michaels, 2011; Weber, 2014). Focusing on educational attainment accounts for the possibility that short-term enrollment may be affected but not longer term accumulation of human capital (Emery et al., 2012). Fracking booms may increase high school dropouts in the short-run but the dropouts may later obtain GEDs, while college enrollment may simply be delayed. Second, we use the Synthetic Control Method (SCM) (Abadie and Gardeazabal, 2003; Abadie et al., 2010) to establish the counterfactual. The counterfactual is constructed as a weighted-average of comparison areas based on demonstrated likeness. The advantage is that no single match with all the comparable characteristics to the shale oil and gas area is required and it controls for both pre- and post-treatment trends unrelated to shale and oil gas development. We conduct placebo tests for statistical inference about the estimated effects of fracking on high school and college attainment.

The next section presents the empirical approach, including discussion of the SCM and the selection of the states of Montana, North Dakota and West Virginia – three states with significant shale reserves – for the analysis. Section 3 presents the SCM results. We find that fracking booms reduced both high school attainment and college attainment in Montana, North Dakota and West Virginia. The reduction in educational attainment ranged from approximately 3 to 6 percentage points. Only in one case (West Virginia), was the estimated treatment not larger than those estimated in placebo analysis, in which only one placebo estimate exceeded the estimated treatment effect. The results are shown to be robust to alternative synthetic control specifications. Section 4 summarizes the study and discusses the key distinguishing findings.

2. Empirical approach

We examine the states of Montana, North Dakota and West Virginia. Among the states listed by Cascio and Narayan (2015) as possessing clusters of high oil and gas reserves based on btu contents, these three are small and had the largest nonmetropolitan shares of total employment in the states in 2005, which makes it more likely that the effects of the shale boom can be detected (Weinstein and Partridge, 2011; Munasib and Rickman, 2015).[2] Montana and North Dakota lie above the Bakken shale oil play, while West Virginia lies above the Marcellus shale natural gas play. Munasib and Rickman (2015) found larger employment multiplier effects from the fracking boom in North Dakota nonmetropolitan counties extracting shale oil than in the nonmetropolitan counties of Arkansas and Pennsylvania that were involved in shale gas extraction.

2.1. Implementation of the Synthetic Control Method

We use the Synthetic Control Method (SCM) to estimate a counterfactual for each of the states.[3] Rather than necessarily matching to a particular state, in the SCM the counterfactual for each state is a weighted average of the other states based on economic characteristics of the states; in weighting the comparison states, the SCM creates a synthetic control group. The weights are obtained in fitting the pre-treatment trends in educational attainment in the boom state with the synthetic of other non-boom states based on the pre-intervention state characteristics. The difference between the counterfactual and actual outcomes in the post-treatment period relative to the difference prior to the treatment period is the effect of the fracking boom in the state. We exclude other energy states, including the other fracking boom states, from consideration in the construction of the synthetic control group for each state.

An advantage of the SCM over the difference-in-differences approach is that in SCM the effects of observables are not assumed to be time-invariant. With a sufficiently long pre-intervention period, the matching on pre-intervention characteristics and outcomes in SCM implicitly matches on unobservables over time (Abadie et al., 2010). Because technical presentations of the SCM can be found elsewhere (Abadie and Gardeazabal, 2003; Abadie et al., 2010; Munasib and Rickman, 2015) we only discuss its implementation in our study.

We select the treatment year based on changes in U.S. Bureau of Economic Analysis oil and gas employment in the state. For North Dakota and West Virginia the treatment year is 2006, where for Montana it is 2007, though as discussed below changing these by one year does not affect the results. Cascio and Narayan (2015) use a common treatment year of 2006 for all labor markets examined because that is when national production from unconventional (horizontal and directional) wells began to increase dramatically; they confirmed with event analysis that significant fracking did not begin before 2006. Munasib and Rickman (2015) report that changing the treatment one year in either direction did not much change their SCM results because the intensity of fracking increased over the treatment period, producing larger effects later in the period.

Placebo analysis is performed for each state in statistical inference about the educational attainment estimates. For each fracking boom state, each state in the donor pool is assumed to be exposed to the fracking boom treatment, where the remaining states, including the fracking boom state, form the donor pool. With the absence of fracking booms in the donor states, all else equal, a reduction in educational attainment in the placebo state relative to its synthetic control is not expected. The ranking of the fracking boom treatment effect relative to the donor states serves the purpose of statistical inference. Abadie et al. (2010) consider the treatment effect to be significant if it is ranked first relative to the estimated placebo effects for the donor states.

[2] The nonmetropolitan employment shares for Montana, North Dakota and West Virginia are 0.65, 0.52 and 0.39, respectively. The other states listed by Cascio and Narayan (2015) as possessing clusters of high oil and gas reserves, with the nonmetropolitan shares presented in parentheses are Louisiana (0.17), Oklahoma (0.36), Pennsylvania (0.12) and Texas (0.13). Source of total state employment, including by metropolitan and nonmetropolitan shares: U.S. Bureau of Economic Analysis, State and Local Personal Income (www.bea.gov, accessed September 20, 2015).

[3] We use the program package Synth in STATA to perform the SCM analysis (http://web.stanford.edu/~jhain/synthpage.html).