4-1-2019

Technological Innovation and Educational Attainment: Evidence From the Fracking Boom

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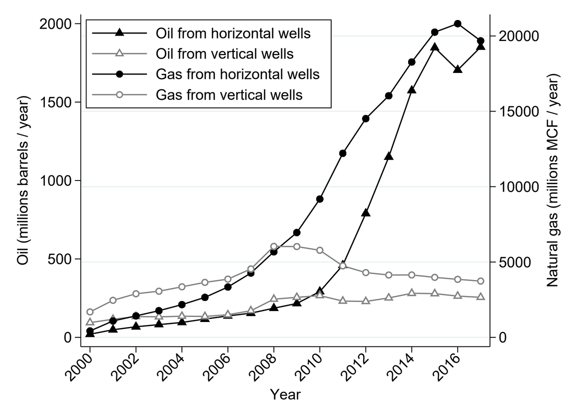
Research Question and Purpose

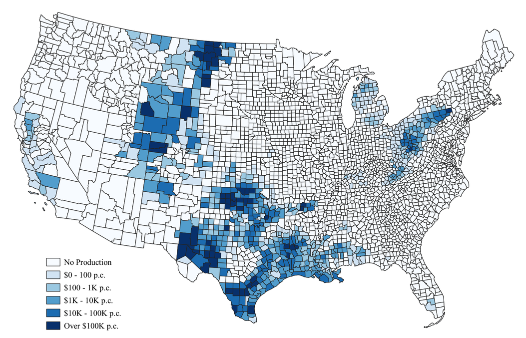
New production technologies that compliment skilled labor have been argued to generate increases in the returns to skill that have been a key driver of growth in aggregate educational attainment in the U.S.

- Do technological innovations that are complementary to less skilled labor correspondingly generate decreases in the returns to skill, resulting in a decrease in educational attainment?

This paper examines the educational, earnings, and employment responses to local labor demand shocks brought about by recent technological innovations in horizontal drilling and hydrofracturing in the oil and natural gas industry.

Setting: The Fracking Boom





Hydraulic fracturing ("fracking") involves injecting liquid at high pressure into subterranean shale rock, causing fractures that allow trapped oil or gas to be released.

Technological innovation was the primary factor leading to the boom (Wang and Krupnick, 2013).

Data

I use the following data sources for my empirics:

- Fracking Production: A private data set provided under an academic use agreement by Drillinginfo.
- Earnings and employment: 2000-2017 Quarterly Workforce Indicators.
- Educational outcomes: 2000 Census and 2005-2011 American Community Surveys.

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Empirical Strategy

To estimate the effect of unskill biased technological change on earnings, employment, and educational outcomes, I employ two strategies:

1. Differences-in-differences model:

$$Y_{py} = \beta_0 + \beta_1(new\ production_{py}) + \beta_2 X_{py} + \mu_p + \delta_y + \varepsilon_{py}$$

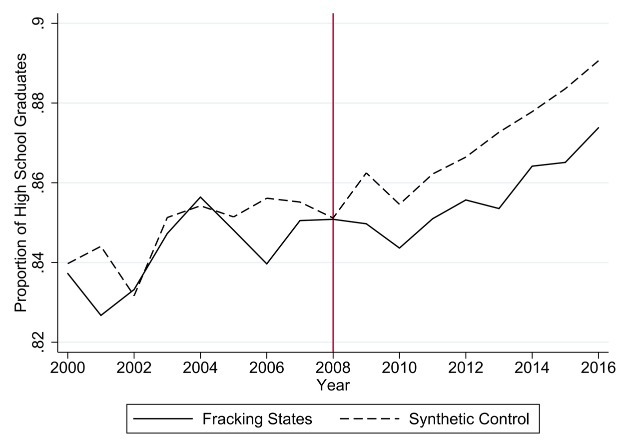
   I exploit variation in two different measures of new fracking production:
   - actual new fracking production.
   - "potential" new fracking production simulated using geographic variation in county exposure to a shale play interacted with year effects:

$$ln(new\ prod._{cy} + 1) = \alpha_c + \sum_{\tau=y}\sum_{j=1}^{J} \theta_{\tau j} I\{county\ c\ over\ play\ j\} \times I\{year = \tau\} + \nu_{cy}$$

$$\implies pot.\ new\ prod._{cy} = exp\left(\hat{\alpha}_c + \sum_{\tau=y}\sum_{j=1}^{J} \hat{\theta}_{\tau j} I\{county\ c\ over\ play\ j\} \times I\{year = \tau\}\right) - 1$$

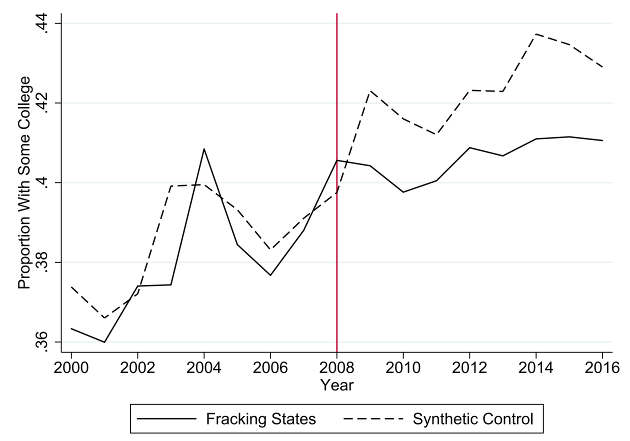
2. The synthetic control method formally introduced by Abadie et al. (2010).
   - The synthetic control method involves the construction of a weighted combination of units used as controls, to which the treatment unit is compared.
   - This comparison is used to estimate what would have happened to the treatment unit if it had not received the treatment.

Results



	Dep. Variable: $ln(Ave.\ Annual\ Earnings_{py})$				Dep. Variable: $ln(jobs/population_{py})$			
	Men		Women		Men		Women	
	All Industries	Excluding Mining	All Industries	Excluding Mining	All Industries	Excluding Mining	All Industries	Excluding Mining
Panel A. All Workers								
New Production$_{py}$	0.0750***	0.0532***	0.0403***	0.0478***	0.109***	0.0659***	0.0174***	0.00551
(in ten thous. $ per capita)	(0.00590)	(0.00658)	(0.00418)	(0.00504)	(0.0179)	(0.0129)	(0.00471)	(0.00352)
Panel B. Non-college Workers								
New Production$_{py}$	0.0900***	0.0686***	0.0524***	0.0509***	0.119***	0.0727***	0.0189***	-0.00189
(in ten thous. $ per capita)	(0.00786)	(0.00641)	(0.00671)	(0.00794)	(0.0217)	(0.0171)	(0.00647)	(0.00637)
Panel C. College Workers								
New Production$_{py}$	0.0496***	0.0398***	0.0267***	0.0414***	0.0958***	0.0527***	0.0122**	-0.00149
(in ten thous. $ per capita)	(0.00496)	(0.00687)	(0.00387)	(0.00416)	(0.0172)	(0.0141)	(0.00476)	(0.00532)

Standard errors, clustered at the PUMA level, in parentheses



1. Increased fracking production is associated with increased earnings and employment for both non-college educated and college educated men and women.
2. Earnings and employment increased relatively more for non-college educated men and women, resulting in a decrease in the college premium and college-to-non-college employment ratio.
   - i.e. fracking technology decreased the relative demand for skill.
3. Increased fracking production is associated with decreased college and high school attainment.
4. I find little evidence that changes in the composition of the population due to in-migration account for the effects of fracking on educational outcomes.
5. Decreases in the college premium and increases in the implicit opportunity cost of going to college are important mechanisms through which fracking affected educational outcomes.
6. I find significant earnings and employment effects in non-mining industries as well.

Model of College Investment

Letting $\pi_k^c = Y_k^c - Y_k^0$ denote the college income premium in some year k, then the expected lifetime payoff that a person of ability θ_i gets from attending college in year t, is:

$$R_{it}^c(\theta_i) = V_{it}^c(\theta_i) - V_{it}^0(\theta_i)$$

$$= \sum_{k=1}^{T-a_t} \frac{1}{(1+r)^k} E\left[\pi_{t+k}^c | \Omega_i\right] - (1+b)G - g(\theta_i) - Y_t^0$$

An individual with ability θ_i will go to college if their expected lifetime payoff from attending college in year t is greater than zero (i.e., when $V_{it}^c(\theta_i) > V_{it}^0(\theta_i)$).

Model prediction: An increase in the implicit opportunity cost of going to college and a decrease in the college premium would result in decreased college attainment.

Conclusion

The unskill biased nature of fracking technology caused a decrease in the relative demand for skill, resulting in a decrease in both the college premium and the employment ratio of college-to-non-college educated workers.

The increase in the earnings of non-college educated workers, together with the decrease in the college premium that resulted from increased fracking production led to a reduction in college and high school enrollment and attainment.

Important questions for future study:

- Are these individuals simply putting off their investments in education or foregoing them altogether?
- What will be the local labor market impacts if the boom is followed by a bust?

References

Wang, Z. and Krupnick, A. (2013). US Shale Gas Development. *Resources for the Future.*

Abadie, A., Diamond, A., Hainmueller, J. (2010). Synthetic control methods for comparative case studies: Estimating the effect of California's tobacco control program. *Journal of the American statistical Association*, 105(490), 493-505.