Climate Change and Energy Production: The Effect of Drought on Hydraulic Fracturing Productivity

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Overview

Beginning in 2010, high global oil prices and technological innovation in hydraulic fracturing dramatically increased Texas oil production. Massive water flows were required to support this boom in hydraulic fracturing. In the summer of 2011, water became scarce in Texas as a prolonged heat wave and subsequent severe drought spread across the state. Commercial, agricultural, and residential water users in drought regions faced extraordinarily low surface water levels in 2011, and oil producers faced increased competition for groundwater. These oil producers needed to purchase either higher priced ground water near their wells or aquire water from other areas through expensive inter-basin transfers, which raised the marginal cost of oil production. Our initial research shows that producers responded to this exogenous increase in an input price by decreasing water use in wells drilled in drought areas. Producers decreased the water intensity of the wells drilled in drought counties by shortening the perforation length of wells. We estimate the effect of decreased water use in hydraulically fractured wells over the lifetime of the well's production. Initial results suggest a moderate decrease in lifetime productivity for wells drilled in drought regions. Finally, we estimate the value of production and tax revenue lost due to drought to determine whether state regulators should prohibit all hydraulic fracturing during periods of drought.

Methods

We use a fixed effects model to estimate the effect of drought on water usage by oil producers and well production. In the short run, technology is fixed and producers can only respond to drought-induced input scarcity by some combination decreasing input usage or increasing input spending. We estimate several reduced form regressions to understand the producer response to increased water scarcity. Our models include direct measures of well-level water usage (self-reported data from FracFocus) and a indirect measures of well-level water usage (perforation zone length from the state regulator) along with oil production data and drought variables. The drought variables provide the net effect of water scarcity on water prices accounting for producer responses. The reduced form parameters of interest are identified using cross sectional and intertemporal variation in drought intensity across counties in Texas which is driven by exogenous weather shocks.

This paper analyses the effect of drought on oil and gas production using data from the Texas Railroad Commission (RRC), which includes detailed data on well characteristics and production. We supplement this data with data voluntarily disclosed to FracFocus on water and chemical use by well. Our measures of weather, including drought including drought length and intensity, have substantial cross sectional and intertemporal variation. This rich dataset allows us to estimate the effects of drought on both water use by oil producers and well productivity.

Results

Initial results suggest that oil producers respond to drought conditions by moderately decreasing water use. Producers appear to compensate for decreased water use by drilling wells with shorter perforated zones and by changing the mix of chemicals injected in the well during hydraulic fracturing. Our model shows that these changes cause lifetime well productivity to decline for wells drilled during a drought. Taken together, these results suggest drought has a measurable impact on oil production. There is a welfare loss resulting from wells drilled during droughts, because these lower-productivity wells do not produce all recoverable oil in place. Drilling during drought reduces energy production and tax payments to the state relative to a counterfactual well drilled during non-drought conditions.

Conclusions

We use well-level oil production data to determine whether drilling a well during a drought impacts lifetime well productivity by reducing water use during hydraulic fracturing. We find that less water is used in wells drilled in

drought areas and this decrease in water use has a modest effect of drought on lifetime well productivity. These results suggest that energy producers respond to water scarcity during droughts, which makes their wells less productive than wells drilled in areas not experiencing drought. We explore the implications for state regulators charged with managing oil reserves. We find a small welfare loss from drilling during drought to the loss of recoverable oil in place and reduction in tax revenue from these wells.