"Groundwater Regulations and Hydraulic Fracturing: Reporting Water Use in Texas"

Jesse Backstrom – Dept. of Agricultural Economics, Texas A&M University

Introduction - Hydraulic fracturing (HF) activity has increased rapidly in the U.S. over the last decade, where the arid Permian Basin in west Texas has experienced the largest growth. A growing literature in economics has studied many of the local impacts of the "shale boom," which have included effects on: the housing market (e.g. Muehlenbachs et al. 2015); employment, wage, and tax and royalty revenues (e.g. Feyrer et al. 2017); health (e.g. Currie et al. 2017); and others. Aside from these more 'general' economic studies, there is a growing literature on the localized *environmental* effects of HF, such as those on air quality and greenhouse gas emissions (e.g. Knittel et al. 2015); induced seismic activity associated with wastewater disposal (Ellsworth 2013); and agricultural production (e.g. Farah 2017). Two interrelated issues that have escaped the empirical economics literature however, are the effects of water use in HF on local groundwater availability and the reporting of water use in HF stimulations. These issues are important because water scarcity is one of the biggest constraints imposed on social and economic development, and an increasingly large volume of water in a short period of time is needed to fracture a well drilled for hydrocarbon production from shale (11,779,194 gallons was the median in our sample), yet reporting of water use in the industry is not impressively transparent.

In this paper we are the first to make use of a unique data set of hydraulically fractured wells to examine trends in the volume of water used in well stimulations in Texas from 2012-2016 and analyze spillovers of localized groundwater management regimes on HF activities. Specifically, we investigate how the propensity to report detailed water use information by operators of wells located within the jurisdiction of a groundwater conservation district (GCD) varied relative to water use reporting for wells not located within a GCD. The impacts of groundwater management on HF activities are particularly challenging to tease out due to a complex legal web of groundwater regulations in Texas, which can vary greatly between management areas (within the Permian Basin alone there are 29 different management regimes). We hypothesize that operators of hydraulically fractured wells located in a GCD area are more likely to be *less* detailed in their reporting of water use in order to limit the potential for interaction with local regulatory authorities and, since freshwater is the cheapest source of water, possibly to prevent future legislation of water use by leaving less of a paper trail. To highlight the importance of transparent water use reporting, we will also estimate the effects of water use in HF stimulations on local groundwater levels in a water-scarce region.

Data - Our data set was obtained from Primary Vision (PV), a company in Houston that provides unique analytical tools and data on the use of water, proppant, and chemicals in HF fluids. PV constructed this proprietary database by downloading data from FracFocus and combining it with data from other public sources such as the Texas Railroad Commission. The initial data set included information on nearly 124,000 hydraulically fractured wells over 2011-2017. With respect to House Bill 3328, HF operators in Texas are required to report information on the total water volume and chemical compositions used in HF stimulations as of February, 2012, so we only include records after that. Important variables for our analysis included well location within a GCD or non-GCD area, the total reported volume of water used in well stimulation, HF fluid mass (HFFM), well orientation (horizontal or vertical), and fixed effects for month of sample.

Although *some* operators report to FracFocus the proportions of freshwater, recycled wastewater, saltwater, and slickwater used to stimulate each well, PV used this water type information (where available) combined with density estimates for each water type in order to calculate reasonably accurate estimates of a total HFFM for most wells. However, when insufficient information was available to calculate a HFFM for *certain* wells in the database, PV coded the HFFM for these wells as 'unknown'. PV also verified that the unknown values were due to information on the water type not being reported by the operator and were unable to be obtained by PV in additional searches. This information is important to our analysis since it contributes to what we refer to as reporting less water use information relative to more.

Our data on groundwater levels come from two sources. The majority come from the Texas Water Development Board, but we also have some from USGS. These data are collected daily via automated monitoring stations located throughout the state. In addition to groundwater levels, other variables of interest include the aquifer the monitoring station is recording for, whether the aquifer is confined or unconfined, the well depth, total HF water volume used (within some variable radius of a monitoring station), and others such as precipitation or a drought indicator.

Methodology - Using both linear probability and logistic regression models, our outcome variable is an indicator (0 or 1) for whether HFFM was able to be calculated for a well observation, as a function of an indicator for whether the well was drilled in a GCD or non-GCD area, well orientation, total reported water volume, and month-of-sample fixed effects:

$$HFFM_i = \beta_0 + \beta_1 GCD_i + \beta_2 Orientation_i + \beta_3 WaterVol_i + \eta_t.$$

Although we have not yet analyzed the groundwater data, using a difference-in-differences approach we will treat the monitoring stations as the units of observation and estimate an average treatment effect for aquifer drawdown, which we hypothesize is due to withdrawals for HF stimulations in an environment with a dynamically changing frequency of HF activity. Treated units will be monitoring stations located in areas pre and post HF activity, and control units will be monitoring stations located in areas with no HF activity. Our proposed model is as follows:

$$WL_{it} = \beta_0 + \beta_1 S_i + \beta_2 WV_t + \beta_3 S_i \cdot WV_t + \beta_4 Precip_{it} + \mu_i + \eta_{it},$$

where WL_{it} is the water level of monitoring station i at time t, S_i is an indicator for whether shale rock exists below the designated area (e.g. county) of monitoring station i, WV_t is a summation of the total HF water volume used at time t by wells within a variable radius of monitoring station i, $S_i \cdot WV_t$ is an interaction term whose coefficient will estimate the average treatment effect, and μ_i and η_{it} are fixed effects for the area of monitoring station i and other unobserved time shocks common to both treatment and control groups, respectively. Our identifying assumption is that in the absence of HF activity, groundwater water levels in areas with HF would have trended similarly to groundwater levels in areas without HF activity.

Preliminary Results and Generating Discussion at SAAER - Our preliminary analysis provides descriptive evidence that in areas where a GCD exists, HF operators are more likely (by ~1.5 percentage points) to report *less* detailed information on water use per stimulated well. A similar relationship was found as less detailed information on water use was more likely to be reported for a marginal increase in total water volumes used in HF stimulations, and for horizontal versus vertically-drilled wells. These findings are important for groundwater management as they provide some information on the reporting tendencies of HF operators of wells located in GCDs in Texas, and allude to several policy options aimed to help make water use reporting more transparent. We believe that relevant questions might center on creating GCDs where none currently exist, and possibly expanding the water use reporting requirements of House Bill 3328 in order to better understand water sources and types used in HF stimulations and incentivize the use of alternatives to freshwater. Transparency of water use is important because if many new wells in a water-scarce area are due to be stimulated and all water is obtained from the same source, there is potential for aquifer drawdown, which becomes even more pronounced during drought and the summer months.

References

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