'Till the Wells Run Dry:
Effects of Hydraulic Fracturing on Agricultural Productivity

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Overview

Recent technological advances in unconventional gas drilling, or hydraulic fracturing, made it possible to extract energy resources that were previously inaccessible. At the same time, however, there is a growing concern that this new technology has various negative consequences for other sectors. One prominent concern is its intensive water use; without appropriate water allocation system, other sectors that heavily rely on water resources, such as agriculture, may be negatively affected through water competition with the unconventional gas drilling industry. For example, the average daily water use of a producing well for hydraulic fracturing, in Alberta, Canada, was 1700 m3 in 2014 (Well Completion & Frac Database, 2014). This value is approximately 1.5 times higher than the average daily water use of a farm for irrigation purposes, which is 1200 m^3 (Statistics Canada, 2011).

The purpose of this research is to empirically investigate whether or not hydraulic fracturing negatively affects agricultural productivity and crop composition. To quantify the effect of unconventional oil and gas drilling or hydraulic fracturing on agriculture, I use a detailed dataset available for Alberta, Canada. Alberta is the second largest field crop-producing province in Canada (Statistics Canada, 2011). It is the top province for Barley, Alfalfa, honey and cattle production. In addition to that, around 41% of the total shale gas in-place reserve of Canada is located in Alberta (EIA, 2015). These characteristics make Alberta an ideal place to examine the effects of hydraulic fracturing on agriculture. Furthermore, the two different irrigation methods, dryland production and irrigated production, make this province a unique jurisdiction to examine crop composition change at the presence of water competition among multiple sectors.[2]

Methodology

This study uses township-level crop yield data from the Agricultural Financial Services (AFSC) and hydraulic fracturing well-level data from the Well Completion and Frac Database (WCFD) by Canadian Discovery Limited, which makes a long panel data for the years 2000 to 2014 for 1786 townships. To estimate nearby hydraulic fracturing activity, number of wells within different distance intervals or donuts from each agricultural township centroid is calculated and the value of crop yields (measured in kilograms per acre) is used to measure land productivity. Exploiting the fact that Alberta has two kinds of agricultural townships, with hydraulic fracturing wells and without hydraulic fracturing wells, I employ a difference-in-differences estimation model to identify the effects of nearby hydraulic fracturing on agricultural productivity. I control

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[2] No external water is used for dryland crop production in Alberta other than the rain water (Agricultural Financial Services).

for unobserved time invariant township fixed effects and crop fixed effects by including township-crop pair fixed effects. In addition to this, year fixed effects are also included to control for time variant fixed effects, which are assumed to be common across the townships.

Results

This study suggests that nearby hydraulic fracturing wells decrease agricultural productivity, particularly of the irrigated crops. Estimation results show that land productivity of an irrigated crop goes down by 1.4% for an additional well within a 11-20 kilometer radius of a township. This effect decreases when the effect of the wells in the distant donuts are included. Additionally, a well within 21-30 kilometer decreases irrigated crop yield by 0.7 %. The effect of hydraulic fracturing activity disappears as the distance between the townships and wells increases, particularly after 30 kilometers radius. Similar effect is observed after controlling for hydraulic fracturing water use. One m^3 increase in hydraulic fracturing water use can decrease land productivity of an irrigated crop by 1.2%. Interestingly, the effect of hydraulic fracturing water use disappears after 20 km. These results indicate nearby hydraulic fracturing wells decrease productivity of the irrigated crops.

Although the estimated effects of hydraulic fracturing water use and nearby hydraulic fracturing wells seem small, this effect can be large when the intensity of production and water use is taken into account. In 2014, each township had 6 wells within 11-20 km radius. Since each well decreases irrigated crop yield productivity by 1.4%, irrigated crops' productivity decreases by 9% in each township. Due to the loss in the agricultural productivity, each township lost about $11,000 as irrigated crop revenue. After aggregating over the entire irrigated crop producing townships, results imply that Alberta lost approximately 1.6 million dollar in 2014 due to unconventional oil and gas drilling. In other words, Alberta lost approximately 2% of the average revenue earned from the irrigated crop production in 2014. However, no evidence was found that farmers in the townships with hydraulic fracturing activity are changing the irrigation-dryland crop composition, i.e., they are producing more dryland crops then the irrigated crops.

Conclusion

This study contributes to the unconventional gas drilling (UGD) effects literature by estimating the effect of hydraulic fracturing on agriculture. Although the effects of hydraulic fracturing on the environment, health, and economic development have been discussed (See Mason et al., 2015 for a review), the effect of hydraulic fracturing on other sectors through sectoral water competition has received less attention. This paper determines whether the mining industry can affect productivity of another sector when water is almost an open access resource. Moreover, Prairie province like Alberta has a long history of droughts; southern Alberta is suffering from water crisis (Alberta water portal, 2013). This study questions if "one-price-for-all" water allocation strategy, like the existing system in Albeta, is efficient during water scarce periods. If such a system is not efficient, this study suggests imposition of water use quota or water pricing by volume used on the hydraulic fracturing well operators. This research can be extended for similar jurisdictions, such as, Colorado or Texas.

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