LEARNING WHERE TO DRILL: DRILLING DECISIONS AND GEOLOGICAL QUALITY IN THE HAYNESVILLE SHALE

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Overview

The productivity of unconventional oil and gas wells in the U.S. has risen dramatically as firms have learned about two aspects of extraction. First, firms have learned about the production process itself, which is *how* to drill and complete wells. For example, through experience, firms have learned how much sand and water to use in hydraulic fracturing. Both industry and academic studies have focused on this type of learning. Second, firms have also learned about the spatial distribution of geology, which is *where* to drill. This information allows firms to focus drilling on the most productive locations, which the industry terms “high-grading.”

In the short run, both types of learning (how to drill and where to drill) can generate observationally similar productivity increases. However, the medium-to-long run implications are quite different. Learning *how* to drill increases the productivity of all drilling sites, delaying depletion of the resource. Learning *where* does not. Instead, new information allows firms to drill the best locations first, accelerating depletion. Long-run supply forecasts will be biased upward if we confound learning about *how* to drill with *where* to drill. These long-run implications are concerns for both industry and policy makers.

To assess the impact of firms learning about where to drill, I estimate (1) what firms know about how productive a location will be before they drill it, and (2) how what firms learn helps them concentrate drilling in more productive locations. I then assess the quantitative implications of firms' information for the dynamics of productivity and supply: (1) in the short run, is learning sufficient to increase average output per well, and (2) in the long run, how severe are the depletion effects associated with the transition from better to worse locations?

The main empirical challenge is that what firms know and learn is not observable to an econometrician. Therefore, to identify and estimate firms' information sets, I incorporate learning about geological quality into a dynamic discrete choice model of firms' investment decisions. To help identify firms' information, I augment the model with information on the royalty rates associated with each well and production outcomes that result.

The model is estimated using a data I assemble on Louisiana's Haynesville shale, a natural gas-producing area, during the 2003—2016 period. This rich, geospatial dataset draws on several public and private sources and includes each mineral lease, well, and natural gas production stream in the Haynesville.

Estimates suggest that firms' initial signals about the spatial distribution of deposits are very noisy, but initial drilling resolves much of the uncertainty. Learning about where to drill may have led to economically meaningful increases in output per well, but the long-run productivity implications of the implied acceleration in depletion appear to be mild.

Methods

Dynamic discrete choice model of firms' drilling decisions

Results

Preliminary estimates suggest that learning about where to drill has indeed contributed to increasing output per well, but the long-run decline in output per well associated with depleting sweet spots is not severe. Specifically, companies' initial signals about the quality of locations before drilling are not very informative: the correlation of these signals and the actual quality of the locations is around 0.25. This means that while firms know fairly little before drilling, an initial well provides a lot of information. A one standard deviation increase in the quality of a location implies a 26% increase in output per well. These estimates would explain a 15% increase in output per well during the 2008—2016 period. During the following 9 years, absent technology gains, the estimates imply a modest 5% decrease in output per well as firms exhaust better locations and start drilling worse ones. This could be readily offset by a 0.5% per year technology-driven improvement in well productivity.

Conclusions

Since learning about how to drill is explicitly not included in this paper, my estimates are best interpreted as a worst-case scenario for long-run supply—just as those estimates which exclude learning where to drill are best-case scenarios. While estimates suggest the effect of accelerated depletion is mild, nevertheless, if analysts confound learning how to drill versus where to drill, long-run forecasts may be over-optimistic. The paper contributes to a growing literature on learning in oil and gas, and is the first to study what firms learn about geology. It is also the first to estimate a model of joint leasing, drilling, and production outcomes.

References

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