The Market Structure of Shale Gas Drilling in the United States

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Abstract

This paper provides the first empirical study of the market structure of the shale gas drilling industry in the United States. Modern shale gas drilling, which is a major revolution in the energy industry, was highly concentrated during its experimental stage, roughly from the early 1980s to the early 2000s, and has since become less concentrated, exhibiting a long tail of infrequent drillers. Nevertheless, even during the latter stage, the vast majority of shale gas wells have been drilled by a limited number of large independent oil and gas producers.

Key Words: shale gas, market structure, concentration, entry

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1. Introduction

In the past decade or so, the US energy industry has undergone a major transformation—the shale gas revolution. Shale gas, which is natural gas produced from shale formations, experienced an extraordinary boom, accounting for only 1.6 percent of total US natural gas production in 2000 but an astonishing 40.4 percent by 2013 (Sieminski 2014). This revolution has “dramatically changed the energy future of the United States and potentially of the world” (Joskow 2013, p. 339).

Many scholars and policymakers alike are wondering what factors led to the US shale gas boom. One frequently mentioned factor is market structure. Industry and media reports often assert, without citing any empirical evidence, that the US shale gas industry was created by thousands of small- and medium-sized firms and that shale gas drilling was dominated by so-called mom-and-pop companies. This perception has influenced policymaking in countries that are attempting to develop their own shale gas resources. China, for example, has opened its shale gas development to various new entrants, including newly established small firms without any prior experience in oil and gas drilling.

This paper provides the first empirical study of the dynamic market structure of shale gas drilling in the United States. We show that common perceptions of this industry’s market structure are inaccurate and misleading. We discuss the fundamental industry characteristics that are underlying the observed market structure.

2. Industry Background

Modern shale gas drilling has experienced two distinct stages: an experimental first stage, which began in the early 1980s, and a scaling-up second stage—the shale gas boom—which began in the early 2000s. During the experimental stage, Mitchell Energy, the largest natural gas

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producer in northern Texas, developed the first modern shale gas play, the Barnett play in Texas (a “play” is a more or less continuous area with exploitable resources). Mitchell Energy achieved a major breakthrough in hydraulic fracking. Devon Energy, one of the largest natural gas producers in the United States, acquired Mitchell Energy in 2002 and combined horizontal drilling and other technologies with Mitchell Energy’s expertise in hydraulic fracking (see Wang and Krupnick 2013 for a detailed review of the factors that led to the shale gas boom).

Low-tech shale gas drilling has a much longer history. It started in the 1920s and focused on Devonian shales, especially those in the Appalachian basin. These shales are shallower and geologically less complicated, and the extraction technology was simple but largely ineffective. Federal legislation in the late 1970s and the early 1980s promoted the development of Devonian shales and other types of unconventional natural gas. The development of Devonian shales played a role in motivating Mitchell Energy to drill the Barnett play.

3. Data and Findings

Our data come mainly from DrillingInfo, a market research firm that focuses on the oil and gas industry and whose data are often used in trade publications. We supplement DrillingInfo data with two other data sources: Louisiana Department of Natural Resources and Pennsylvania Department of Environmental Protection, government agencies that publish shale gas drilling data for their states.

Our analysis focuses on the number of wells drilled instead of the volume of shale gas produced because drilling data (i.e. which firm drilled how many wells in which area and in what year) are of much higher quality than well-level production volume data. As a reflection of our focus on drilling instead of production, the title of our paper is the market structure of shale gas drilling, not the market structure of the shale gas industry.

We examine the six major modern shale gas plays—Barnett, Marcellus, Haynesville, Eagle Ford, Woodford, and Fayetteville—and Devonian shales in the Appalachian basin. The six major modern plays accounted for nearly 92 percent of total US shale gas production in June 2013 (Sieminski 2014). Gas production from Devonian shales is quite small, but a comparison of Devonian shales with the modern plays helps explain the mechanisms underlying the observed market structure.

Mitchell Energy drilled the overwhelming majority of the shale gas wells in the Barnett play until the late 1990s. By 1999, Mitchell Energy had drilled a total of 482 Barnett wells, and its 15 competitors together drilled only 102. The disparity is even more pronounced from 1981

**Figure 1. Wells Drilled and Firms Active in Major Modern Shale Gas Plays, 2000–2012**

![Graph showing the number of wells drilled and firms active from 2000 to 2012.]

Figure 1 shows the number of wells drilled each year, from 2000 through 2012, in the six modern shale gas plays and the number of firms that were active in these plays. The number of wells drilled per year increased from 193 in 2000 to a peak of 6,266 in 2011, and then decreased to 4,388 in 2012. The number of active firms increased from 15 in 2000 to a peak of 244 in 2008, and then decreased to 149 in 2012.

Figure 2 shows the (natural) log number of wells drilled by each firm in the six major shale gas plays from 1981 through 2012, sequenced from the largest to the smallest. There is a long tail of infrequent drillers, but the overwhelming majority of wells are drilled by a relatively small number of firms. Of the 655 firms that drilled wells in these modern plays, nearly 34 percent drilled a single well, and 26 percent drilled only 2 to 5 wells. These infrequent drillers drilled 756 wells in total, about 2 percent of the 38,144 wells drilled in the six modern plays. In contrast, the four most active firms (Chesapeake Energy, Devon Energy, XTO Energy, and Southwestern Energy) together drilled 15,495 wells, or 40.6 percent of the total. The top 30 firms drilled 29,679 wells, or 77.8 percent of the total. Of these 30 top drillers, 27 are independent oil and gas exploration and production companies and only 2 (SWEPI LP, a subsidiary of Shell, and Chevron) are integrated oil and gas companies. The major integrated oil and gas companies invested relatively little in shale gas drilling until recently, when they purchased some of the
independent gas drillers (e.g., ExxonMobil’s purchase of XTO in December 2009).

**Figure 2. Natural Log Number of Wells Drilled by Each Firm in Modern Shale Gas Plays, Largest to Smallest, 1981–2012**

![Graph showing the number of wells drilled by each firm in natural log scale]

Figure 3 shows, for each year between 1990 and 2012, the proportion of active firms that drilled at most five wells in the six modern plays from 1981 through 2012, and the percentage of wells drilled by the top four active firms in the year. The phenomenon of long tails does not apply to these major plays before the late 1990s, when Mitchell Energy was essentially the only driller. Since the early 2000s, there are tails of infrequent drillers in each year, but these tails are shorter than the aggregate tail for the six major plays shown in Figure 4 because infrequent drillers are spread out over the years. The annual four-firm concentration ratios experienced sharp declines in the early 2000s, when the boom in shale gas drilling started.

Why was Mitchell Energy essentially the only driller during the early years of shale gas development? Drilling in the modern plays, at that time, was not profitable, and the long-run prospect of shale gas as a viable industry was highly uncertain. The vast majority of natural gas firms were too small to have the financial resources or technical capability to make risky investments in shale gas drilling. Mitchell Energy, however, had the need to find a new source of natural gas supply, the financial resources, and the technical capability (see Wang and Krupnick 2013 for more details).
Figure 3. Proportion of Active Firms that Drilled at Most Five Wells in Major Shale Gas Plays and Proportion of Wells Drilled by the Top Four Firms in the Year, 1981–2012

Why did shale gas drilling become less concentrated during its expansion stage? The main reason is that once drilling technologies achieved profitability, the barrier to entry became low, mainly because natural gas producers, large and small, typically outsource the drilling and fracking of a well to specialized oil and gas service companies. Large gas producers have their own engineers who plan and design wells, but very small producers even outsource the planning and design function to service companies. Other than paying the service companies, these small natural gas producers only need to lease land and mineral rights from private landowners. The cost to secure a single lease can be small, and most of the costs to secure leases are not sunk: the leases can be resold to other producers.

The fact that a lease can be resold attracts some firms to speculate. A speculating firm leases land and mineral rights not to drill but to sell the land and mineral rights at a higher price later. However, a lease typically requires the leasing firm to drill at least one well within a certain period. To avoid forfeiting the lease, the leasing firm has the incentive to drill at least one well. This is perhaps why we observe a large number of firms that drilled a single well.

Infrequent drillers are more likely than frequent drillers to drill vertical wells, which are cheaper than horizontal wells. The proportion of wells that are vertical instead of horizontal is 72.6, 62.3, 43.4, 26.0, and 9.5 percent for firms that drilled 1, 2–5, 6–30, 31–500 and at least 501 wells, respectively. One interpretation is that infrequent drillers are more likely to be speculators who have little incentive to drill expensive wells. Another interpretation is that infrequent drillers may be more likely to drill in areas that do not require horizontal drilling.
Since the entry barrier to drill Devonian shales is lower, Devonian shales have a longer tail of infrequent drillers. Figure 4 shows the (natural) log number of wells drilled by each firm in Devonian shales from 1920 through 2012, sequenced from the largest to the smallest. Nearly 71 percent of the 1,818 firms that ever drilled a Devonian well drilled a single well, and 19 percent drilled only two to five wells. These infrequent drillers, 90 percent of the total, drilled merely 15.9 percent of the 14,314 Devonian wells in our sample. Figure 5 shows, for each year between 1930 and 2012, the annual number of active firms and the proportion of active firms that drilled at most five Devonian wells during our entire sample period. The sharp upswing in the number of Devonian wells drilled in the early 1980s was caused by the incentive policies the US federal government introduced in the late 1970s and the early 1980s.

**Figure 4. Natural Log Number of Wells Drilled by Each Firm in Devonian Shales, Largest to Smallest**

**Figure 5. Active Firms and Percentage of Active Firms that Drilled at Most Five Devonian Wells, 1920–2012**
4. Conclusion

Modern shale gas drilling in the United States was highly concentrated during its early experimental stage of development. It is only during the scaling-up stage that modern shale gas drilling has become less concentrated and exhibited a long tail of infrequent drillers. However, even during this second stage, the overwhelming majority of shale gas wells have been drilled by a limited number of large independent oil and gas exploration and production companies. Infrequent drillers, the mom-and-pop companies, made a negligible contribution to shale gas drilling. The large independent oil and gas producers are medium-sized companies compared with the major integrated oil and gas companies in the world, but they are large compared with the many small drillers.
References

