A Retrospective Review of Shale Gas Development in the United States: What Led to the Boom?

Zhongmin Wang and Alan Krupnick[‡]

Executive Summary

In the past decade or so, natural gas produced from shale formations (shale gas), experienced an extraordinary boom in the United States, accounting for only 1.6 percent of total US natural gas production in 2000 but an astonishing 40.4 percent by 2012. This remarkable growth has spurred interest in exploring for shale gas resources elsewhere. A number of countries, including China, Mexico, Argentina, Poland, India, and Australia are beginning to develop their own shale gas resources. Although it is difficult to know definitively the necessary or sufficient conditions for stoking a shale gas boom, a historical review of the US experience can be informative.

Our review suggests that a number of factors converged in the early 2000s—including technology innovations, high natural gas prices, favorable geology, private land and mineral rights ownership, market structure, water availability, and natural gas pipeline infrastructure—to make it profitable to produce large quantities of shale gas in the United States. Some of the key technology innovations (e.g., slick water fracturing and microseismic fracture mapping) resulted

‡ [‡] Resources for the Future, Washington, DC 20036, USA. Corresponding author: ZhongminWang: Wang@rff.org Tel. 202 238 5036; Alan Krupnick: Krupnick@rff.org

from government research and development (R&D) programs and private entrepreneurship that aimed to develop unconventional natural gas, but other important technologies (e.g., horizontal drilling and three-dimensional [3-D] seismic imaging) were largely developed by the oil industry for use in oil exploration and production.

In the late 1970s and early 1980s, the US government funded R&D programs and established tax credits and incentive pricing to encourage the development of unconventional natural gas in response to the severe natural gas shortage at the time. The fiscal policies and R&D programs stimulated the development of shale gas in the Appalachian and Michigan Basins and helped develop some key technologies. These policies were justified on the grounds that private firms lacked the incentive to make large, risky R&D investments, partly because it is difficult to keep new technologies proprietary in the oil and gas industry, where few technologies are patentable or licensable. Also, in the early years, unconventional gas sources, due to their higher risks and lower returns, could not compete with conventional oil or gas sources for investment dollars. This partly explains why major international oil firms were essentially absent from early shale gas development. In addition, most US natural gas producers were too small to have the incentive or capacity to do much R&D.

It was, however, the private entrepreneurship of Mitchell Energy & Development (Mitchell Energy, hereafter) that played the primary role in developing the Barnett Shale play in Texas, and it was the successful development of the Barnett play that jump-started the shale gas boom. Indeed, government-sponsored R&D programs did not target the Barnett play, and fiscal policies had a rather limited impact on Mitchell Energy, so the government's role was at best indirect.

What drove Mitchell Energy to develop the Barnett play? Why was Mitchell Energy essentially the only firm that made significant investments in drilling the Barnett play from the early 1980s through the late 1990s? Some of the reasons are idiosyncratic. First, Mitchell Energy had the need to find a new source of natural gas to fulfill its long-term contractual obligations. Second, Mitchell Energy had the financial resources to take on some risky investments in drilling shale gas, largely because its long-term natural gas contract guaranteed well above market average prices. Third, Mitchell Energy was drilling in an area where the geology of shale formations is relatively favorable and shale formations overlap with conventional shale gas formations. These factors helped Mitchell Energy minimize financial losses. Other reasons are more fundamental. At some stage of its development of the Barnett play, Mitchell Energy began to be motivated by the potential for large financial rewards from its innovations. The firm did this by leasing large tracts of land and its mineral rights at low prices and later selling the company—including its leases, innovations and expertise—at a higher price to Devon Energy, a much larger firm. This strategy, which is made possible by the private land and mineral rights ownership system in the United States, helps overcome the difficulty of monetizing technology innovations in the industry.

Our review suggests that the key question for policymakers in countries attempting to develop their own shale gas resources is how to generate a policy and market environment in which firms have the incentive to make investments and would eventually find it profitable to produce shale gas. Countries new to shale gas enjoy a major advantage over the United States in that the state-of-the-art shale gas technologies are much more advanced than those that existed when the United States started to develop shale gas. However, many innovations will be needed to adapt

existing technologies to geological conditions at new shale plays. For example, the current cost of drilling a shale gas well in China is widely reported to be several times higher than that in the United States. To lower cost significantly, innovations and learning-by-doing are necessary, but firms may lack the incentive to invest in innovations. The returns to innovations are uncertain, and how oil and gas firms may monetize successful technology innovations in countries new to shale gas development is also an open question, since the United States is the only country with private land and mineral rights ownership.