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

By Zhongmin Wang and Alan Krupnick
Overview

First academic study of the development history of shale gas

• The boom and the technology
• Government policies (R&D, tax credit)
• Private entrepreneurship
• A number of other factors
Annual Shale Gas Production in the United States

The graph shows the annual shale gas production in the United States from 1980 to 2020, with projections up to 2020. The production is measured in billions of cubic feet (Bcf). The data includes production from EnCana, EIA, and EIA projections.
Annual Natural Gas Production by Gas Type
Hydraulic fracturing or 'Fracking'
Technology: Find and extract the gas
Key technologies

• 3-D seismic imaging

• Horizontal drilling

• Hydraulic fracturing

• Microseismic fracturing mapping
Where did the technologies come from?

- Government Policies aimed at unconventional gas
- Private entrepreneurship aimed at shale gas
  - George Mitchell
- Technologies aimed at finding oil
  - Horizontal drilling
  - 3-D seismic imaging
  - Role of government policies: “absent or minimal”
Energy Crisis before government policies

- Severe natural gas shortage in many areas of the U.S.
- Low proved natural gas reserve
  
  (Main reason: gas price was set too low by the government)
- Oil embargo in 1973-74
Government policies

As a response, U.S. federal government decided to

• Support R & D programs on unconventional natural gas

• Offer tax credit for unconventional natural gas production

• Deregulate wellhead prices of natural gas, and later, mandate open access to natural gas pipelines

Relatedly,

• Merge several governmental organizations to form Department of Energy (DOE) in 1977 to coordinate energy research and development
• Increase budget for energy research in general
Government policies: R&D

DOE’s Unconventional Gas Research Program, which includes three major research-demonstration-pilot programs

• Eastern Gas Shales Program (1976-1992)
  • Devonian-age shales in the eastern U.S.

• Western Gas Sands Program
  • Low permeability gas sandstone reservoirs of the western U.S.

• Methane Recovery from Coalbeds Program
Eastern Gas Shales Program

• Total budget in its 16 year history: slightly over $92 million

• Difficult for an economist to assess the role of this program

• DOE’s own assessment:

  • “revitalized gas shales drilling and development in the Appalachian (Devonian) Basin,”
  • “helped initiate development of other previously over-looked gas shale basins, and
  • “took the lead in demonstrating much more efficient and lower-cost gas shales production and recovery technology.”
Eastern Gas Shales Program: an Example

Massive Hydraulic Fracturing (MHF)

- Some reports in the news media make one feel that government programs developed this technology.

- However, Agarwal et al. (1979, p. 172) note that MHF was already “a proven technique for developing commercial wells in low-permeability or ‘tight’ gas formations.”

- DOE’s program applied MHF to shale gas.
Why government R&D program & tax credit?

Private firms do not have enough incentives to develop new sources of natural gas

• Hard to keep new technologies proprietary in the oil and gas industry
• Few technologies are patentable or licensable

• Safer and more profitable for oil firms to invest in oil
  • True in the 1970s in the United States
  • True now in China!

• Most US natural gas firms are small and do not have the capability to do much R&D
Impact of R&D programs and tax credit

Over 17,000 shale gas wells were drilled from 1978 to 1999
Development history of the Barnett play

Number of wells drilled in the Barnett play:

- Mitchell Energy
- Mitchell Energy Competitors
Why Did Mitchell Energy Develop the Barnett?

• Had the need (which is idiosyncratic)
• Had the financial resources, which is also idiosyncratic
• At some stage, reaping the benefits of R&D became important
  • Private land and minerals rights ownership
  • Lease large amounts of land at low prices and then sell itself (the land and the technologies together) at a much higher prices
  • This mechanism provides entrepreneurs with the incentives to invest in a new play
• Lost money for many years before selling itself to another firm (Devon Energy) in 2002 for $3.5 billion
Financial considerations did constrain Mitchell Energy

- In 1986, when the oil price crash resulted in a decline in the natural gas price, writes Steward (2007, p. 74), “Mitchell management began to redirect capital expenditures ... away from higher-risk, long-term projects.”

- In July 1995, Mitchell Energy lost its lucrative long-term contract. Afterward, says Steward (2007, p. 90), “the entire Barnett program became questionable” as the company had to sell its gas at lower spot prices/

- Mitchell Energy drilled only a few horizontal wells, due partly to financial constraints.
How did technology evolve at Mitchell energy?

• Mostly incremental improvements

• Key breakthrough: slick water/light sand fracturing
  
  • Not novel innovations.
  • Another firm already used the same technology to fracture tight gas
  • In fact, water-based fracturing was successfully used in the 1950s
How much help did Mitchell Energy get from the government?

Not much.

- Mitchell Energy did not benefit much from tax credits
- A government-funded research organization helped Mitchell Energy with horizontal drilling, microseismic fracturing mapping, and gas-reserve estimates, but these efforts largely failed.
Mitchell Energy was significantly affected by environmental lawsuits

- A number of lawsuits filed against Mitchell Energy, claiming its drilling polluted water wells

- In one case, the jury awarded the plaintiffs $4M in actual damages and $200M in punitive damages.

This “was depressing to [Mitchell Energy], in everything from investor perceptions of the company’s future through employee morale to future planning.”
What explains the recent shale gas boom? Economics!

- High natural gas price in the first decade of this century
Other key contributing factors

- Market structure
- Private land & mineral rights ownership
- Large resource base, favorable geology
- Good infrastructure (pipeline, storage, roads)
- Water generally available for fracking
- Well-established oil & gas service industry
- Environmental concerns have not stopped development except in some states (e.g., New York)
wang@rff.org

Thank You!