ANATOMY OF A SHALE BOOM: THE CASE OF THE EAGLE FORD SHALE

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Overview

The development of shale has coincided with an explosion in the availability and accessibility of data on prices, costs, inputs and outputs for upstream activity. Using data from a variety of sources to measure these variables, I create a quantitative history of the North American Eagle Ford shale. Given the broad features of this history, I then construct a theoretical, dynamic optimization model to understand how scarce mineral rights (leases) and long-lived capital required by production operations shape the pattern of development when prices are set exogenously in a world market.

My history of the Eagle Ford shale highlights a few important features. First, unlike the predictions of a standard Hotelling framework, drilling and leasing do not immediately take off—they take time to reach their peak. We also find that leasing, in particular, experiences a subsequent deceleration. Even with convex drilling costs that incorporate a "rush-to-drill," a standard Hotelling model cannot create such a smooth, cyclical pattern of development. Second, costs and rig-counts closely track oil price movements. Most recently, costs and rig-counts have decreased dramatically in response to the drop in oil prices. The decrease in costs, reflected in aggregate U.S. data and anecdotal evidence, has helped sustain drilling recently.

The theoretical model I write replicates the boom and bust pattern by incorporating long-lived capital and leases into a depletable resources model. Rigs are expensive and require long-lead times to build, so they are inelastically supplied in my model. Leases represent a perpetual option to drill and are transacted in a competitive market.

Methods

Descriptive analysis and graphs of proprietary data from *DrillingInfo* in addition to publicly available data from Baker Hughes, EIA and the Bureau of Labor Statistics.

Theoretical characterization and numerical solution of a dynamic optimization model.

Results

Introducing rigs (capital) into the standard model contributes two important aspects. First, the inelastic supply of capital functions as a brake on initial investment. Second, the long-lived nature of capital means that, while the long-run production function has constant returns to scale, the short run production function has increasing costs. Firms fulfil the Hotelling rule by increasing the capital-labor ratio and pushing down short-run marginal costs over time. This mirrors what we see in practice where existing capital, such as pipelines and gathering infrastructure, reduces the lifecycle investment cost during later stages.

In the modified model, E&P operators experience rising costs not through reserve-dependent costs, but through scarce leases that become more expensive as more are purchased. When stochastic prices are introduced, firms exercise the option to wait but maintain long-lived capital to take advantage of high prices.

Conclusions

Standard Hotelling models of depletable resources do not allow for a smooth boom-and-bust cycle of development. By incorporating long-lived capital into a depletable resource model, it is possible to mimic a boom and bust cycle and make predictions about the paths of costs and prices, leasing, drilling and production over the lifecycle of a shale play.

References

Dixit, A. and R. S. Pindyck. *Investment Under Uncertainty*. Princeton, N.J.: Princeton University Press, 1994

Hartley, P. and K. B. Medlock III "A Model of the Operation and Development of a National Oil Company." *Energy Economics* 30, no. 5 (2008): 2459-2485.

Hotelling, H., "The Economics of Exhaustible Resources." *Journal of Political Economy* 39, no. 2 (1931): 137-175.

Krautkraemer, J. A., "Nonrenewable Resource Scarcity." *Journal of Economic Literature* 36, no. 4 (998): 2065-2107.

Paddock, J.L., D.R. Siegel, and J.L. Smith. “Option Valuation of Claims on Real Assets: The Case of Offshore Petroleum Leases.” *The Quarterly Journal of Economics* 103, no. 3 (1988): 479-508.

Pindyck, R. S., "The Optimal Exploration and Production of Nonrenewable Resources." *Journal of Political Economy* 86 no.5 (1978): 841-861.