Price Elasticity of Supply and Productivity: An Analysis of Natural Gas Wells in Wyoming

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Executive Summary

Natural-gas production in the U.S. grew from 23.5 Trillion cubic feet (Tcf) in 2005 to 32.5 Tcf in 2016. The primary cause of this growth is the shale-gas revolution resulting from the combination of horizontal drilling and hydraulic fracturing being applied to impermeable shale-gas reservoirs. Increasing production of natural gas and crude oil has reinvigorated interest in gas and oil production economics. Recent studies of crude-oil markets have indicated that there a variety of margins on which oil production decisions might be made. We expand this literature, and extend it to an application to natural-gas production.

There are three margins on which natural-gas producers might adjust their output in response to price changes. Producers might vary gas production from previously drilled and flowing wells, they might increase initial production from newly drilled wells, and they might adjust their drilling rate. There are economic and engineering reasons to believe that producers do not significantly vary output from previously drilled wells in response to price changes. Average initial production from new wells might be positively or negatively related to price, because higher prices will induce increased use of inputs, but also make relatively less productive wells profitable to drill. The drilling rate is expected to be increasing in natural-gas prices, but the pace at which new drilling will occur depends on the state of available drilling locations and technology.

The successful application of horizontal drilling combined with hydraulic fracturing to impermeable natural reservoirs has drastically increased the number of drilling prospects available to producers. This new prospect availability may lead to opposing productivity

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effects. Economic theory dictates that the most productive wells will be drilled first. If these wells are more productive than conventional wells, then we expect an initial jump in productivity followed by a slow declining average productivity. However, firms may learn to drill more productive wells over time through experiential learning. There is no ex ante reason to know which effect will dominate.

We estimate the price elasticity of intra-well production, initial production, and drilling by applying a petroleum-engineering-based model to a large dataset of natural gas wells from the state of Wyoming, while simultaneously measuring the impact of new technologies on well-level productivity. We find that intra-well production is unresponsive to price changes, as predicted, with an elasticity of just 0.02; we find that initial production tends to decrease as prices increase with an elasticity of -0.12, implying that the effect of moving to less productive wells during periods of high prices outweighs the effect of increasing the use of productivity-enhancing inputs; and we find that drilling responds robustly to prices with an elasticity of between 0.61 and 0.73. Our productivity results indicate that new technologies initially increased initial production rates, but also increased decline rates (the rate at which production from a well declines over time). Furthermore, we find that gains to initial production have diminished significantly overtime, indicating that the low-hanging fruit in Wyoming is being depleted.

This paper serves as a guide to scholars and policymakers interested in the impact of price changes and productivity changes on natural gas supply, which will become increasingly important as natural gas plays a larger and larger role in energy and manufacturing in the U.S. and globally.

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