Impact of low prices on shale gas production strategies

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In 2014, shale gas accounted for approximately one-third of the U.S. natural gas production as compared to a negligible contribution in 2005, and this share has been increasing despite low energy prices. However, there are concerns regarding the ability of shale production to grow further in the environment of persistently low prices.

While production has been growing, the number of drilling rigs has declined (~1,600 in September 2008 to ~220 by June 2015) in response to the falling prices from almost $14/MMBtu in 2008 to about $2.5 in April 2015. These contrasting trends of production and the number of rigs could potentially be explained by operators focusing on "sweet spots," improved drilling techniques, increased well productivity, and shifting rigs to liquid-rich areas within and across plays. So, it is commonly believed that production from higher-productivity wells and associated gas from liquids-rich locations have sustained shale gas production growth, at least in some plays.

In many cases, however, this argument about productivity is not supported by data. Looking at the individual well production across the Barnett, Fayetteville, Haynesville, and Marcellus plays, we find that per well productivity in the first three has been declining even in the best areas. The presented study is looking for a better understanding of drilling practices and well economics to explain the current trends and to predict future developments in the shale industry.

When the low prices persist, producers exhaust their high-productivity locations quickly, and then face a challenge of drilling in lower-productivity areas. Another alternative, however, has recently been presented: *infill drilling*. More wells could be "squeezed" in high-productivity areas, via placing new wells at closer spacing in-between already existing ones. The use of existing infrastructure, and the ability to complete a well with fewer inputs (namely, less water and proppant), producers have succeeded to decrease well costs compensating for lower production of infill-wells. Hence, the inventory of drilling locations is expanded and recovery per unit of surface area is increased.

In this paper, we focus on infill drilling and how it can change play development dynamics and affect long-term resource recovery. We examine whether infill wells, which tend to produce less than the original wells in the same location, may still be commercially viable thanks to cost reductions. We extend the previous studies on shale gas well profitability and show the roles of resource scarcity and product pricing on drilling decisions and final resource recovery. As compared to previous analyses, we benefit from a longer production history and additional data on water use, which provides a proxy for hydraulic fracturing costs in the absence of detailed data on proppant, chemicals and the number of fracturing stages.

We find that infill wells in the Fayetteville were attractive while locations in the Barnett and Haynesville plays were marginal at best. However, reductions in oilfield services costs since the collapse of the oil

price in October 2014 might have helped some locations. Also, lower-cost infill wells may help companies to survive during low-price periods. It is possible that some unobservable factors could be rendering their economics more viable than our analysis implies. For example, operators might have been able to further reduce their drilling and/or completion costs via arrangements with service companies (economies of scale, other technological advances). Some operators might have been realizing prices higher than our $3 assumption owing to well-managed financial hedges. Hence, the economic choice of drilling locations may boil down to a comparison of whether infill drilling in a tier with an exhausted original-well inventory is more profitable than incremental original well drilling in a lower tier where the inventory is not yet exhausted.